8 IMPACT ASSESSMENT

8.1 INTRODUCTION

This chapter describes and assesses the significance of potential impacts related to the proposed speculative seismic survey and provides a description of the identified interactions between the project activities and the receiving environment. It also presents a project-specific Aspects and Impacts Register, which has been developed to ensure that all environmental and social aspects of the proposed operation and the associated impacts are identified.

This chapter provides an assessment of all the key impacts identified within the project's area of influence as described in Section 0.

The assessment of impacts is structed as follows:

- Section 8.3 to 8.6: Normal Operations
- Section 8.7: Unplanned Events
- Section 8.8: Cumulative Impacts
- Section 8.9: No-Go Alternative
- Section 8.10: Impact Assessment and Mitigation Summary

The methodology used to determine the significance of potential impacts is presented in Appendix 7. The application of the Mitigation Hierarchy is central to the impact assessment that was used. The identification of enhancement measures was considered in parallel to the identification of mitigation measures. The impacts that remain following mitigation are assessed and presented as residual impacts. The status of all impacts should be considered negative, unless otherwise indicated.

8.2 SCREENING OF ASPECTS AND IMPACTS

8.2.1 Environmental and Social Interaction Matrix

The environmental and social interaction matrix prepared for the proposed exploration activities is presented in Table 8-1.

The Matrix provides a list of the project activities and allows for easy checking of interaction against components of the receiving environment. Each box denotes whether or not a proposed project activity will interact with the corresponding environmental or socio-economic receptor. Interactions are screened to have a "*minor negative interaction*", "*moderate / major negative interaction*" or "*positive interaction*" on the receptor.

Most of project activities are considered to have a minor negative interaction with the environment mainly due to the offshore location of the proposed survey area and the short survey duration of up to five months (including downtime). The key project activities during normal operation that need to be investigated are related to the seismic operations themselves, specifically the noise impact on marine fauna and fishing.

8.2.2 Aspects and Impacts Register

The project-specific Aspects and Impacts Register developed for the proposed project is presented in Table 8-2. An aspects-impacts register is prepared to further elaborate the potential impacts identified through the initial screening for potential interactions. For each of the project activities, different aspects associated with

the activity and their potential impacts are tabulated. This systematic approach allowed for the planning of the scope of the specialist studies. This register lists all project activities and associated environmental aspects and impacts.

“Aspect” and “impact” are defined as follows:

- An “aspect” is the element of an organisation’s activities, products or services that can interact with the environment.
- An “impact” is any change to the environment, whether adverse or beneficial, wholly or partially resulting from the organisation’s activities, products or services.

Table 8-1: Environmental and Social Interaction Matrix

Project Phase		Project Activities / Resource / Receptors	Water Column (including Water Quality, Noise and Turbidity)	Atmosphere (including Air Quality, Noise and Lighting)	Seabed Sediment and Profile	Fish and Plankton Communities	Benthic Habitats and Communities	Sea and shore birds	Turtles and Marine Mammals	Seabed Features and Seamounts	Nearshore Habitats and Communities	Protected Area (Offshore and Coastal)	Fishing	Maritime Heritage	Marine Traffic / Navigation	Public Health and Safety	Settlements, Tourism and Recreation	Employment & Income
			Sensitive receptors in the receiving environment															
			Physical			Biological							Socio-economic					
Planned Activities (Normal Operation)																		
Seismic Surveying	Mobilisation	Transit of survey vessels to survey area, including routine discharge to sea																
		Discharge of ballast water and equipment fouling																
	Operation	Operation of survey vessels, including routine discharge to sea																
		Seismic acquisition, including the deployment of seismic equipment (sources and streamers) and acquisition operations																
		Provision of services from local service providers (e.g. catering, refuelling and berthing)																
	Demobilisation	Survey vessels leave survey area and transit to port or next destination																
Unplanned Activities (Emergency Event)																		
All		Collision with survey vessels and equipment																
Operation		Dropped objects / lost equipment																
		Hydrocarbon spills																
Colour key:																		
	No interaction		Minor negative interaction			Moderate / major negative interaction							Positive interaction					

Table 8-2: Aspects and Impacts Register

Activity Phase		Activity	Aspect	Potential Impact
1. Seismic Surveying	**Mobilisation Phase**	Transit of survey vessels to survey area	Increase in underwater noise levels during transit	Disturbance to marine fauna
			Air emissions due to exhaust gases	Local reduction in air quality and contribution to global greenhouse gas emissions
			Routine discharge to sea (e.g. deck and machinery space drainage, sewage and galley wastes) and local reduction in water quality	Physiological effect on marine fauna
				Increased food source for marine fauna
				Increased predator - prey interactions
			Discharge of ballast water and equipment fouling	Loss of biodiversity due to the introduction of invasive alien species
	Operation Phase	Operation of survey vessels	Increase in underwater noise levels during transit	Disturbance / behavioural changes to marine fauna
			Routine discharge to sea (e.g. deck and machinery space drainage, sewage and galley wastes) and local reduction in water quality	Physiological effect on marine fauna
				Increased food source for marine fauna
				Fish aggregation and increased predator - prey interactions
			Air emissions due to exhaust gases	Local reduction in air quality and contribution to global greenhouse gas emissions
			Exclusion zone around survey vessel and seismic array	Disruption of shipping routes by ships having to make detours
				Reduced fishing grounds and catch
			Increase in ambient lighting	Disorientation and mortality of marine birds
				Increased predator - prey interactions
			Local employment and local business opportunities	Income for local service providers and suppliers
		Seismic acquisition	Increase in underwater noise levels	Physiological effect on marine fauna
				Disturbance / behavioural changes to marine fauna
				Masking of environmental sounds and communication
				Effects on predators or prey interactions
				Fish avoidance of key feeding areas
				Reduced fish catch and increased fishing effort for local commercial fisheries
		Interaction with local economy	Local employment and business opportunities	Income for local service providers and suppliers (e.g. catering, refuelling and waste management)
				Income for Ports Authority and local service providers and suppliers (e.g. berthing during crew change)
				Reduced employment or income for impacted commercial fisheries
	Demobilisation Phase	Survey vessels leave survey area and transit to port or next destination	Increase in underwater noise levels during transit	Disturbance to marine fauna
			Air emissions due to exhaust gases	Local reduction in air quality and contribution to global greenhouse gas emissions
			Routine discharge to sea (e.g. deck and machinery space drainage, sewage and galley wastes) and local reduction in water quality during transit	Physiological effect on marine fauna
				Increased food source for marine fauna
				Increased predator - prey interactions

Activity Phase	Activity	Aspect	Potential Impact
2. Unplanned Activities	Vessel accident	Release of fuel into the sea and localised reduction in water quality	Effect on faunal health (e.g. respiratory damage) or mortality (e.g. suffocation and poisoning)
			Exclusion of fisheries and displacement of targeted species
		Collison with recreational fishing and pleasure vessels	Public health, safety and security impacts
	Dropped objects / Lost equipment	Obstruction on seafloor or in water column	Physical damage to and mortality of benthic species / habitats
			Obstruction to or damage of fishing gear
	Small spills	Discharge of fuel during bunkering and reduction in water quality	Effect on faunal health (e.g. respiratory damage) or mortality (e.g. suffocation and poisoning)
			Exclusion of fisheries and displacement of targeted species

8.3 OPERATION OF VESSELS (SURVEY AND SUPPORT)

8.3.1 Emissions to Atmosphere

8.3.1.1 Impacts on Air Quality and Greenhouse Gas Emissions

Source of Impact

The project activities likely to emit pollutants to the atmosphere and affect air quality are:

Project phase	Activity
Mobilisation	Transit of vessels to survey area
Operation	Operation of survey vessel and transit of vessels between the survey area and Port of Cape Town
Demobilisation	Survey vessels leave survey area and transit to port or next destination

Emissions from these activities will include:

- The principal sources of emissions to air will be exhaust gas emissions from project vessels produced by the combustion of fuel. As with any combustion engine powered by fossil fuels, some emissions of unburned hydrocarbons, volatile organic compounds and particles are also likely to be generated by the propulsion system of the vessels.
- Incineration of certain wastes onboard and compressors associated with energy sources will also produce limited occasional emissions.

Potential Impact Description

The release of gaseous pollutants, principally sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon dioxide (CO_2) and carbon monoxide (CO), together with lesser quantities of particulate matter (PM_{10}/$PM_{2.5}$) and volatile organic compounds (VOCs), from the project vessels have the potential to cause short-term reductions in local air quality close to the emissions source (**direct negative** impact).

Some of these compounds could contribute to global greenhouse gas emissions (**indirect negative** impact). Greenhouse gases are "those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere.

Project Controls

Spectrum will strive to comply with the requirements set out in MARPOL Annex VI Reg. 18.3.1, by using ISO 8217 fuel. Project vessels will be supplied with marine gasoil (MGO) or heavy fuel oil (HFO) with less 0.5% sulphur (mass). Project vessels will also use well maintained, certified incinerators to optimise the combustion of waste to minimise emissions.

Spectrum will also comply with industry good practices with regards to waste management including:

- Waste management will follow key principles: Avoidance of Waste Generation, adopting the Waste Management Hierarchy (reduce, reuse, recycle, recover, residue disposal), and use of Best Available Technology (BAT).
- An inventory will be established of all the potential waste generated, clarifying its classification (hazardous, non-hazardous or inert) and quantity, as well as identifying the adequate treatment and disposal methods.

Sensitivity of Receptors

Emissions from activities described above would primarily take place within the survey area and along the route taken by the project vessels from the Port of Cape Town. The main high vessel traffic route along the West Coast of South Africa passes through the proposed survey area and the air quality in the majority of the survey area is thus already expected to experience elevated emissions from high vessel traffic. The survey area is located more than 40 km offshore at its nearest point, and thus far removed from coastal MPAs and any sensitive coastal receptors (e.g. settlements, bird or seal colonies, etc.). The atmosphere, therefore, has the capacity to disperse relatively minor emissions without detectable alteration in local air quality and such emissions would not have a direct effect on any receptor or other activity, other than the project vessels themselves. Therefore, the sensitivity of main receptors due to changes in air quality is considered **very low**. The Project contribution to global greenhouse gas emissions is difficult to evaluate, but the effect on receptors is considered as **very low** at this scale.

Impact Magnitude (or Consequence)

The release of gaseous pollutants to the atmosphere from proposed activities may cause a short-term reduction in local **air quality**. The emission levels of the project vessels are comparable to those produced by commercial vessels sailing in South African waters. The majority of emissions will occur within the survey area, as well as along the route to and from the Port of Cape Town. The majority of solid waste will be transported to shore for disposal, however, certain non-toxic combustible wastes (e.g. galley waste, if not discharged overboard) may be incinerated on the project vessels, creating smoke (particulate matter) emissions, mainly within the survey area.

The fuel consumption by the project vessels are estimated at 1 441 Tons for a five-month survey duration (see Table 6-8). The associated project's **greenhouse gas** (GHG) emissions are estimated at 4 506 Tons of CO_2 equivalent (IPCC emission factors, see Table 6-9), thus contributing to the total greenhouse gas emissions impacting the climate. The emissions will, however, be limited in space and time resulting in a relatively small increase in greenhouse gases and contribution (<0.001 %) to South Africa's total annual GHG emissions, which was 512.383 million Tons in 2015. Thus, the project emissions will make an insignificant contribution to global warming on the global scale.

Given the offshore location of the proposed survey area, air emissions are expected to disperse rapidly and there is no potential for accumulation of air pollution leading to any detectable long-term impact. The impact of the estimated operational emissions from the proposed project is considered to be **regional** and of **limited duration** (i.e. five months) and **low intensity** (removed from any sensitive receptors and changes remain undetectable). Thus, the impact **magnitude** (or consequence) for air quality and GHG contribution is, therefore, considered to be **very low.**

Impact Significance

Based on the **very low sensitivity** of receptors and the **very low magnitude**, the potential impact on air quality and greenhouse gas emissions is considered to be of **negligible significance** without mitigation (see Table 8-3).

Identification of Mitigation Measures

In addition to compliance with MARPOL 73/78 Annex VI, the following measures will be implemented to reduce emissions at the source:

No.	Mitigation measure	Classification
1	Implement a maintenance plan to ensure all diesel motors and generators receive adequate maintenance to minimise soot and unburnt diesel released to the atmosphere.	Avoid/reduce at source
2	Optimise survey line acquisition and vessel operations/logistics to minimise the survey time and number of trips required to and from the onshore supply port.	Avoid/reduce at source
3	Ensure no incineration of waste occurs within the port limits.	Avoid

Residual Impact Assessment

This potential impact cannot be eliminated as project vessels will generate emissions during operations. The proposed mitigation does not significantly reduce the emissions associated with normal operations. Thus, with the implementation of the mitigation measures, although reducing the intensity of the air quality impact to **very low**, the residual impacts remain of **very low magnitude** and of **NEGLIGIBLE significance** (see Table 8-3).

Table 8-3: Impact of atmospheric emissions on air quality and greenhouse gas emissions

Project Phase:	**Mobilisation, Operation and Decommissioning**	
Type of Impact	**Direct and Indirect**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**VERY LOW**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	LOW	VERY LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**
Probability	**HIGHLY LIKELY**	**HIGHLY LIKELY**
Confidence	**HIGH**	**HIGH**
Reversibility	**PARTIALLY REVERSIBLE**	**PARTIALLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**VERY LOW**
Cumulative potential	**POSSIBLE**	**POSSIBLE**

8.3.2 Routine Operational Discharges to Sea

8.3.2.1 Impacts on Marine Ecology/Environment

Source of Impact

The project activities that will result in an impact on marine ecology/environment from a reduction of water quality from routine discharges to the sea from vessels are:

Project phase	Activity
Mobilisation	Transit of vessels to survey area
Operation	Operation of survey vessels and transit between the survey area and Port of Cape Town
Demobilisation	Survey vessels leave survey area and transit to port or next destination

These activities and their associated aspects are described below:

- Galley wastes, comprising mostly of biodegradable food waste, generated on board the project vessels will be discharged overboard.
- Machinery space or bilge water drainage will be occasionally discharged after treatment. Bilge water is drainage water that collects in a ship's bilge space (the bilge is the lowest compartment on a ship, below the waterline, where the two sides meet at the keel).
- Grey water and sewage will be discharged intermittently throughout the survey and will vary according to the number of persons on board. The treated sanitary effluents discharged into the sea are estimated at around 10 000 litres per day for the duration of the seismic survey based on 140-150 litres per 70-80 persons.
- Deck drainage consists of liquids from rainfall, sea spray, deck and equipment washing (using water and an approved detergent), and any spillages (chemical or fuel). Deck drainage will be variable depending on the vessel characteristics, deck activities and rainfall amounts.
- Cooling and drinking water surplus generated by the drinking water supply system are likely to contain a residual concentration of chlorine (generally less than 0.5 mg/l for freshwater supply systems).

Potential Impact Description

The routine liquid and solid discharges to sea could create local reductions in water quality, both during transit to and within the survey area. Deck and machinery space drainage may result in small volumes of oils, detergents, lubricants and grease, the toxicity of which varies depending on their composition, being introduced into the marine environment. Sewage and galley waste will place a small organic and bacterial loading on the marine environment, resulting in an increased biological oxygen demand.

These discharges will result in a local reduction in water quality, which could impact marine fauna (**indirect negative** impact) in a number of different ways:

- Physiological effects: Ingestion of hydrocarbons, detergents and other waste could have adverse effects on marine fauna, which could ultimately result in mortality.
- Increased food source: The discharge of galley waste and sewage will result in an additional food source for opportunistic feeders, speciality pelagic fish species.

- Increased predator - prey interactions: Predatory species, such as sharks and pelagic seabirds, may be attracted to the aggregation of pelagic fish attracted by the increased food source.

Project Controls

The seismic contractor will ensure that the proposed survey is undertaken in compliance with the applicable requirements in MARPOL 73/78, as summarised below.

- The discharge of biodegradable food wastes from vessels is regulated by MARPOL 73/78 Annex V, which stipulates that:
  - No disposal to occur within 3 nm (± 5.5 km) of the coast.
  - Disposal between 3 nm (± 5.5 km) and 12 nm (± 22 km) needs to be comminuted to particle sizes smaller than 25 mm.
  - Disposal overboard without grinding can occur greater than 12 nm from the coast when the vessel is sailing.
- Discharges of oily water (deck drainage, bilge and mud pit wash residue) to the marine environment are regulated by MARPOL 73/78 Annex I, which stipulates that vessels must have:
  - A Shipboard Oil Pollution Emergency Plan (SOPEP).
  - A valid International Oil Pollution Prevention Certificate, as required by vessel class.
  - Equipment for the control of oil discharge from machinery space bilges and oil fuel tanks, e.g. oil separating/filtering equipment and oil content meter. Oil in water concentration must be less than 15 ppm prior to discharge overboard.
  - Oil residue holding tanks.
  - Oil discharge monitoring and control system.
- Sewage and grey water discharges from vessels are regulated by MARPOL 73/78 Annex IV, which specifies the following:
  - Vessels must have a valid International Sewage Pollution Prevention Certificate (ISPCC).
  - Vessels must have an onboard sewage treatment plant providing primary settling, chlorination and dechlorination before discharge of treated effluent.
  - The discharge depth is variable, depending upon the draught of the project vessels at the time, but will be in accordance with MARPOL 73/78 Annex IV.
  - Discharge of sewage beyond 12 nm requires no treatment. However, sewage effluent must not produce visible floating solids in, nor cause the discolouration of, the surrounding water.
  - Sewage must be comminuted and disinfected for discharges between 3 nm (± 6 km) and 12 nm (± 22 km) from the coast. This will require an onboard sewage treatment plant or a sewage comminuting and disinfecting system.
  - Disposal of sewage originating from holding tanks must be discharged at a moderate rate while the ship is proceeding *en route* at a speed not less than 4 knots.

  Sewage will be treated using a marine sanitation device to produce an effluent with:
  - A biological oxygen demand (BOD) of <25 mg/l (if the treatment plant was installed after 1/1/2010) or <50 mg/l (if installed before this date).
  - Minimal residual chlorine concentration of 0.5 mg/l.
  - No visible floating solids or oil and grease.

The survey contractor will also comply with industry good practices with regards to waste management, which will include the development of a Waste Management Plan for all wastes generated. This plan will include / address the following:

- Environmental awareness to ensure wastes are reduced and managed as far as possible.
- Avoidance of waste generation, adopting the Waste Management Hierarchy (reduce, reuse, recycle, recover, residue disposal), and use of BAT.
- Treatment of wastes at source (maceration of food wastes, compaction, incineration, treatment of sewage and oily water separation).
- Development of a waste inventory that classifies (hazardous, non-hazardous or inert) and quantifies waste, and identifies treatment and disposal methods.
- Waste collection and temporary storage, which is designed to minimise the risk of escape to the environment (for example by particulates, infiltration, runoff or odours).
- On-site waste storage, which is limited in time and volume.
- Provision of dedicated, clearly labelled, containers (bins, skips, etc.) in quantities adequate to handle anticipated waste streams and removal frequency.
- Chemicals will be appropriately stored onboard the project vessels (segregation, temperature, ventilation, retention, etc.).

Sensitivity of Receptors

The operational discharges from the activities described above would primarily take place in the survey area and along the route taken by the project vessels between the survey area and supply port. The survey area is located in the offshore marine environment, more than 40 km offshore and far removed from coastal MPAs and any sensitive coastal receptors (e.g. key faunal breeding/feeding areas, bird or seal colonies and nursery areas for commercial fish stocks); however, discharges could still directly affect migratory pelagic species transiting through the survey area. Vessel discharges *en route* to the onshore supply base at the Port of Cape Town could result in discharges closer to shore, thereby potentially having an environmental effect on the sensitive coastal environment, MPAs and EBSAs.

The taxa most vulnerable to routine operational discharges at sea are pelagic seabirds, turtles, large migratory pelagic fish and cetaceans, some of which, potentially occurring in the survey area, are considered regionally or globally 'Critically Endangered' (e.g. southern bluefin tuna, leatherback turtle and blue whale), 'Endangered' (e.g. black-browed and yellow-nosed albatross, shortfin mako shark, whale shark, fin whale and sei whale), 'Vulnerable' (e.g. bigeye tuna, blue marlin, loggerhead turtle, oceanic whitetip shark, dusky shark, great white shark, longfin mako shark, and sperm, Bryde's and humpback whales) or 'Near threatened' (e.g. striped marlin, blue shark, longfin tuna/albacore and yellowfin tuna). Although species listed as globally Endangered or Critically Endangered may potentially occur in the survey area, their numbers are expected to be low. Based on the low numbers of listed species, the sensitivity is considered to be **medium**.

Impact Magnitude (or Consequence)

The contracted project vessels will have sewage treatment systems, oil/water separators and food waste macerators to ensure compliance with MARPOL 73/78 standards. Compliance with MARPOL 73/78 means that intermittent operational discharges introduce relatively small amounts of nutrients and organic material to oxygenated surface waters, which will result in a minor contribution to local marine productivity and possibly of

attracting some opportunistic feeders. The discharge of sewage is likely to contain a low level of residual chlorine following treatment, but this is expected to have a minimal effect on seawater quality given the relatively low total discharge and taking into account dilution in the surface waters.

Furthermore, the survey area is located approximately 40 km from the coast at its closest point and is thus suitably far removed from any sensitive coastal receptors. The dominant wind and current direction will also ensure that any discharges are rapidly dispersed in a north-westerly direction away from the coast and are unlikely to have an impact on sensitive coastal receptors. There is no potential for accumulation of wastes leading to any detectable long-term impact.

Due to the distance offshore, it is only likely to be pelagic species of fish, birds, turtles and cetaceans that may be affected by the discharges, and these are unlikely to respond to the minor changes in water quality resulting from vessel discharges. The most likely animal to be attracted to the survey vessels organic discharges will be large pelagic fish species, such as the highly migratory tuna and billfish, as well as sharks and odontocetes. Pelagic seabirds that feed primarily by scavenging might also be attracted.

A number of other types of wastes generated during the survey will not be discharged at sea but will be transported to shore for disposal at a licensed waste disposal facility approved by Spectrum. The disposal of all waste onshore will be fully traceable. General and hazardous waste landfill sites are located at Cape Town.

Based on the relatively small discharge volumes and compliance with MARPOL 73/78 standards, offshore location and high energy sea conditions, the potential impact of normal routine operational discharges from the project vessels will be of **very low intensity, short-term duration** and **regional** in extent (although localised at any one time around the project vessels). Thus, the **magnitude** (or consequence) is, therefore, considered to be **very low** (see Table 8-4).

Impact Significance

Based on the **medium sensitivity** of receptors and the **very low magnitude**, the potential impact on the marine fauna is considered to be of **very low significance** without mitigation (see Table 8-4).

The majority of these discharges are not unique to the project vessels, but common to the numerous vessels that operate in or pass through South African coastal waters on a daily basis.

Identification of Mitigation Measures

In addition to compliance with MARPOL 73/78 standards, the other project controls and monitoring, the following measures will be implemented to reduce discharges to sea at the source:

No.	Mitigation measure	Classification
1	Implement leak detection and maintenance programmes for valves, flanges, fittings, seals, hydraulic systems, hoses, etc.	Avoid/reduce at source
2	Use a low-toxicity biodegradable detergent for the cleaning of the deck and in the spillage kit.	Reduce at source

Residual Impact Assessment

This potential impact cannot be eliminated because the project vessels are needed to undertake the survey and will generate routine discharges during operations. The implementation of the few minor mitigation measures will not significantly change the discharges and thus the intensity, extent or duration of the impact. Thus, the residual impact will remain of **very low magnitude** and **VERY LOW significance** (see Table 8-4).

Table 8-4: Impacts on marine ecology/environment from operational discharges to sea

Project Phase:	Mobilisation, Operation and Decommissioning	
Type of Impact	**Indirect**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**MEDIUM**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	VERY LOW	VERY LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**VERY LOW**	**VERY LOW**
Probability	**LIKELY**	**LIKELY**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**VERY LOW**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.3.3 Discharge of Ballast Water from Vessels and Vessel / Equipment Transfer

8.3.3.1 Impact of on Marine Biodiversity

Source of Impact

The project activities that will result in the discharge of ballast water and vessel / equipment transfer, and potential introduction of alien invasive species are:

Project phase	Activity
Mobilisation	Transit of vessels to survey area and discharge of ballast water
Operation	N/A
Demobilisation	N/A

De-ballasting of the survey vessel may be undertaken during transit to or once at the survey area. This could introduce non-native species into the area, especially if the vessel is arriving from another country abroad. Similarly, vessels and the subsea use of equipment from one region to another (excluding local or national translocations) also provides for the potential translocation of introduced or alien species that are attached to vessel hulls and equipment that have been at sea for any length of time.

Potential Impact Description

Depending on where the ballast water is loaded, it may contain larvae, cysts, eggs and adult marine organisms from other region. Thus, ballasting and de-ballasting of project vessels could lead to the introduction of exotic species and harmful aquatic pathogens to the marine ecosystem. Invasive marine species are considered primary drivers of ecological change in that they create and modify habitat, consume and outcompete native fauna, act as disease agents or vectors, and threaten biodiversity and ecosystem function (**indirect negative** impact).

Project Controls

Ballast water discharged will follow the requirements of the International Maritime Organisation's (IMO) 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments. By establishing standards and procedures for the management and control of ships' ballast water and sediments, the Convention aims to prevent the spread of harmful aquatic organisms from one region to another. It stipulates that all vessels must implement a Ballast Water Management Plan, which includes a detailed description of the actions to be taken to implement the Ballast Water Management requirements. All ships using ballast water exchange should, whenever possible, conduct such exchange at least 200 nm (± 370 km) from the nearest land and in water of at least 200 m depth. Where this is not feasible, the exchange should be as far from the nearest land as possible, and in all cases a minimum of 50 nm (± 93 km) from the nearest land and preferably in water at least 200 m in depth. Ships will also have a Ballast Water Record Book to record when ballast water is taken on board; circulated or treated for Ballast Water Management purposes; and discharged into the sea. Project vessels will comply with these requirements.

Sensitivity of Receptors

The discharge of ballast water from project vessels would take place *en route* to or in the vicinity of the survey area (if not possible to undertake in international waters), which is located more than 40 km offshore, far removed from any sensitive coastal receptors (e.g. sessile benthic invertebrates, endemic neritic and demersal fish species). In addition, due to the water depths in the survey area (from 100 m to beyond 4 500 m), colonisation by invasive species on the seabed is considered unlikely. Thus, the sensitivity of benthic receptors in the offshore waters of the proposed Orange Basin survey area is considered **very low**.

Impact Magnitude (or Consequence)

Shipping has always been the primary pathway for the transfer of marine alien species from one region to another (Hewitt *et al.,* 1999; Ruiz *et al.,* 2000; Ruiz & Carlton, 2003). The principal vectors responsible for transfer of alien invasive species are ballast water and external hull fouling (Carlton, 1987, 1999; Hewitt et al., 2009).

The survey vessel, and possibly the support / escort vessel, will more than likely have spent time outside of South Africa's EEZ prior to surveying. This exposure to foreign water bodies and possible loading of ballast water, although de-ballasting is not common practice for seismic vessels, increases the risk of introducing invasive or non-indigenous species into South African waters. The risk of this impact is, however, significantly reduced by the implementation of IMO ballast water management measures. The survey area is far removed from the coast, which together with the dominant wind and current direction, will ensure that any invasive species drift mainly in a north-westerly direction away from the coast. In addition, the water depths in the survey area (100 m to beyond 4 500 m) will ensure that colonisation of invasive species on the seabed is unlikely. De-ballasting in the survey area will thus not pose an additional risk to the introduction of invasive species.

In terms of hull fouling, the survey area is located along one of the main traffic routes that pass around southern Africa (see Figure 7-55). Thus, the introduction of invasive species into South African waters due to hull fouling of project vessels is unlikely to add to the current risk that exists due to the numerous vessels that operate in or pass through South African coastal waters, through inshore of the survey area, on a daily basis.

Considering the location of the survey area with pre-existing international marine activity, and compliance with the IMO guidelines for ballast water, the impact related to the introduction of alien invasive marine species is

considered to be of **medium intensity** in the **short-term** (due to it having a minimal effect on receptors) and of **regional extent**. Thus, the **magnitude** (or consequence) is considered to be **low** (see Table 8-5).

Impact Significance

Based on the **very low sensitivity** of receptors and the **low magnitude**, the potential impact on the marine biodiversity is considered to be **VERY LOW** without mitigation (see Table 8-5).

Identification of Mitigation Measures

In addition to compliance with the requirements of the IMO 2004 Ballast Water Management Convention, the following measures will be implemented to reduce and manage the potential introduction of alien species in ballast water and hull or equipment fouling:

No.	Mitigation measure	Classification
1	Avoid the unnecessary discharge of ballast water.	Reduce at source
2	Use filtration procedures during loading in order to avoid the uptake of potentially harmful aquatic organisms, pathogens and sediment that may contain such organisms	Avoid/reduce at source
3	Ensure that routine cleaning and maintenance of ballast tanks is carried out, where practicable, in mid-ocean or under controlled arrangements in port or dry dock, in accordance with the provisions of the ship's Ballast Water Management Plan	Avoid/reduce at source
4	Ensure all infrastructure (e.g. arrays, streamers, tail buoys, etc.) that has been used in other regions is thoroughly cleaned prior to deployment	Avoid/reduce at source

Residual Impact Assessment

This potential impact cannot be eliminated because the project vessels will more than likely have spent time outside of South Africa's EEZ prior to surveying and need to de-ballast. With the implementation of the mitigation measures, the residual impact would reduce to **NEGLIGIBLE** (see Table 8-5).

Table 8-5: Impact on marine biodiversity from ballast water discharge and equipment fouling

Project Phase:	**Mobilisation**	
Type of Impact	**Indirect**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**VERY LOW**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**LOW**	**VERY LOW**
Intensity	MEDIUM	LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**VERY LOW**	**NEGLIGIBLE**
Probability	**UNLIKELY**	**UNLIKELY**
Confidence	**MEDIUM**	**MEDIUM**
Reversibility	**IRREVERSIBLE**	**IRREVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**VERY LOW**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.3.4 Underwater Noise from Vessel Operations and Transit

8.3.4.1 Impact on Marine Fauna

Source of Impact

The project activities that will result in an increase in underwater ambient noise levels (non-seismic) are:

Project phase	Activity
Mobilisation	Transit of vessels to survey area
Operation	Operation of survey vessels and transit of vessels between the survey area and supply port
Demobilisation	Survey vessels leave survey area and transit to port or next destination

The presence and operation of the project vessels will introduce a range of underwater noises from their engines into the surrounding water column that may potentially contribute to and/or exceed ambient noise levels in the area.

Impact Description

Elevated noise levels could impact marine fauna (**direct negative** impact) by:

- Causing direct physical injury to hearing or other organs;
- Masking or interfering with other biologically important sounds (e.g. communication, echolocation, signals and sounds produced by predators or prey); and
- Causing disturbance resulting in behavioural changes or displacement from important feeding or breeding areas.

Project Controls

The seismic contractor will ensure that the proposed survey is undertaken in a manner consistent with good international industry practice and BAT.

Sensitivity of Receptors

Refer to Section 8.3.2.1 for a description of receptor sensitivity. Although species listed as globally or regionally Endangered or Critically Endangered may potentially occur in the area, the proposed survey area is located along a main marine traffic route and thus is in an area already experiencing increased marine traffic and operational noise. Thus, the overall sensitivity of receptors to vessel noise is considered to be **medium**.

Impact Magnitude (or Consequence)

The ocean is a naturally noisy place and marine animals are continually subjected to sounds from physical sources such as wind, rainfall, breaking waves and natural seismic noise, or biologically produced sounds generated during reproductive displays, territorial defence, feeding, or in echolocation. Such acoustic cues are thought to be important to many marine animals in the perception of their environment, as well as for navigation purposes, predator avoidance, and in mediating social and reproductive behaviour. Anthropogenic sound sources in the ocean can be expected to interfere directly or indirectly with such activities affecting the physiology and behaviour of marine organisms (NRC, 2003). Of all human-generated sound sources, the most persistent in the ocean is the noise of shipping. An overview of the noise levels produced by various natural and anthropogenic sources, relative to typical background or ambient noise levels is provided in Figure 8-1.

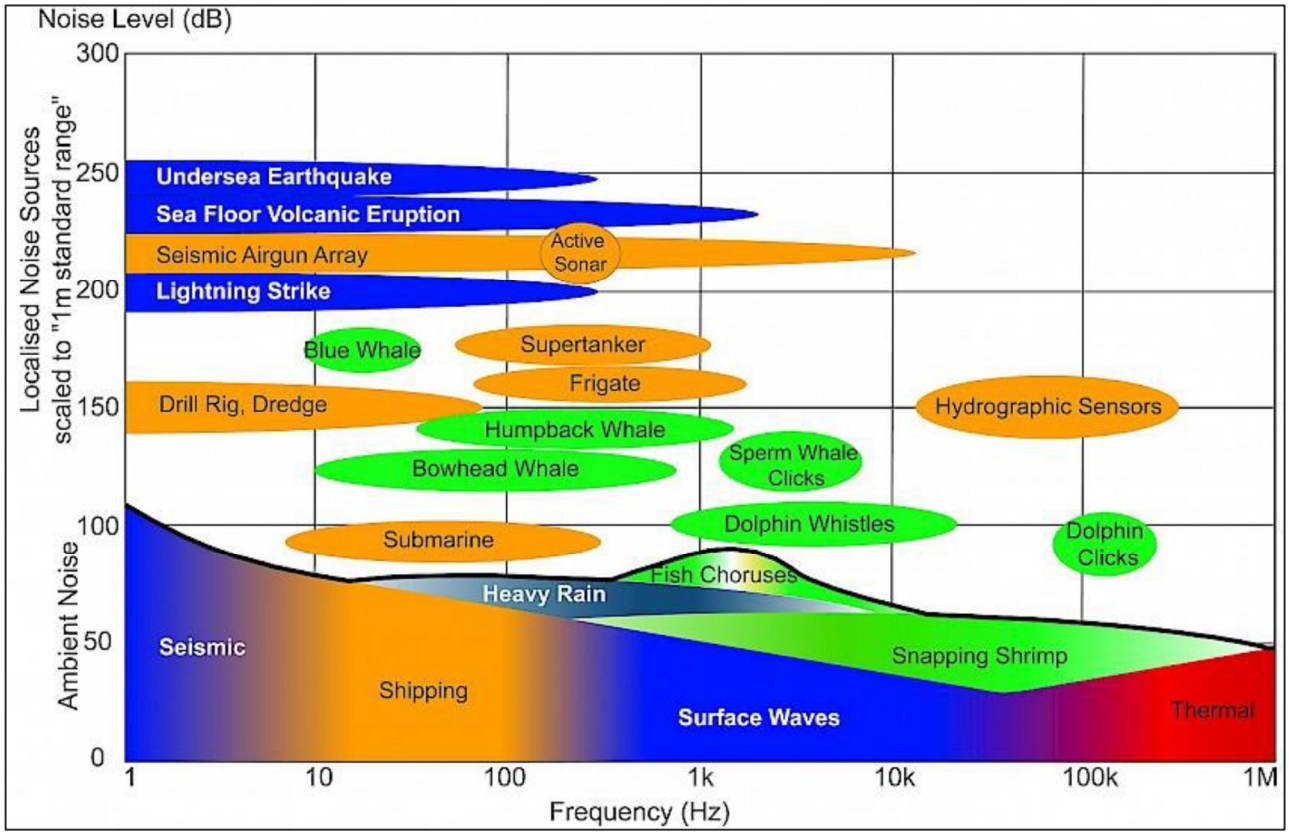

Figure 8-1: Comparison of noise sources in the ocean

Source: https://www.ospar.org/work-areas/eiha/noise

Depending on size and speed, the sound levels radiating from vessels range from 160 to 220 dB re 1 µPa at 1 m (NRC, 2003) at frequencies of 5 to 500 Hz. As the proposed survey area is located along a main traffic route passing around southern Africa (see Figure 7-55) and the high density of fishing vessel traffic, the shipping noise component of the ambient noise environment is expected to be significant within and around the survey area. Given the significant local shipping traffic and relatively strong metocean conditions in the area surrounding the survey area, the ambient noise levels are expected to be in the range of 80 - 120 dB re 1 µPa for the frequency range 10 Hz – 10 kHz (SLR, 2021).

The noise generated by the survey vessel, which travels at a low and regular speed of between four and five knots (i.e. 2 to 3 metres per second), and support vessel fall within the hearing range of most fish and marine mammals, and would be audible for considerable ranges before attenuating to below threshold levels. However, unlike the noise generated by airguns (see Section 8.4.1), underwater noise from vessels is not considered to be of sufficient amplitude to cause direct harm to marine life, even at close range (SLR, 2020). Due to their extensive distributions, the numbers of pelagic species (large pelagic fish, turtles and cetaceans) encountered during the proposed survey is expected to be low. Consequently, the **intensity** of potential physiological injury or behavioural disturbance as a result of vessel noise is considered to be **low**. The duration of the impact would be limited to the **short-term** (five months) and would be **regional** between the survey area and the supply base at Cape Town (although localised at any one time). The potential physiological injury or behavioural disturbance as a result of vessel noise would thus be of **very low magnitude** (see Table 8-6).

Impact Significance

Based on the **medium sensitivity** of receptors and the **very low magnitude**, the potential impact on the marine fauna is considered to be **very low significance** without mitigation (see Table 8-6).

Identification of Mitigation Measures

No mitigation measures are proposed or deemed necessary.

Residual Impact Assessment

The generation of noise from project vessels cannot be eliminated. Without mitigation, the intensity, extent or duration of the impact remains unchanged. Thus, the potential impact remains of **VERY LOW significance** with very minor effects on receptors (see Table 8-6).

Table 8-6: Impact on marine fauna from vessel noise

Project Phase:	**Mobilisation, Operation and Decommissioning**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**MEDIUM**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	LOW	LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**VERY LOW**	**VERY LOW**
Probability	**POSSIBLE**	**POSSIBLE**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**VERY LOW**
Cumulative potential	**LIKELY**	**LIKELY**

8.3.5 Lighting from Vessels

8.3.5.1 Impact on Marine Fauna

Source of Impact

The project activities likely to result in increased ambient lighting are:

Project phase	Activity
Mobilisation	-
Operation	Operation of survey vessels and transit of vessels between the survey area and supply port
Demobilisation	-

The operational lighting of project vessels during transit and operation can be a significant source of artificial light in the offshore environment increasing the ambient lighting in offshore areas.

Potential Impact Description

The strong operational lighting used to illuminate the project vessels at night will increase ambient lighting in offshore areas. Increased ambient lighting may disturb and disorientate pelagic seabirds feeding in the area (**direct negative** impact). Operational lights may also result in physiological and behavioural effects on fish and cephalopods (**direct negative** impact), as these maybe drawn to the lights at night where they maybe more easily preyed upon by other fish and seabirds.

Project Controls

The seismic contractor will ensure that the proposed survey is undertaken in a manner consistent with good international industry practice and BAT.

Sensitivity of Receptors

Refer to Section 8.3.2.1 for a description of receptor sensitivity. Although species listed as globally or regionally Endangered or Critically Endangered may potentially occur in the area, the survey area is located along a main marine traffic route and thus in an area already experiencing increased marine traffic and operational lighting. Thus, the overall sensitivity of receptors to vessel lighting is considered to be **medium**.

Impact Magnitude (or Consequence)

The survey area is located in a marine environment, more than 40 km offshore, far removed from any sensitive coastal receptors (e.g. bird or seal colonies). Most of the seabird species breeding along the West Coast feed relatively close inshore (10-30 km from the coast), with African Penguins recorded as far as 60 km offshore and Cape Gannets up to 140 km offshore. Pelagic species occurring further offshore would be unfamiliar with artificial lighting and may be attracted to the survey vessel. Fish and squid may also be attracted to the light sources potentially resulting in increased predation on these species by higher order consumers. It is expected, however, that seabirds and marine mammals in the area would become accustomed to the presence of the survey vessel within a few days. Since the survey area is located within the main traffic routes that pass around southern Africa, which experience high vessel traffic, animals in the area should be accustomed to vessel traffic.

Operational lights may also result in physiological and behavioural effects of fish and cephalopods, as these may be drawn to the lights at night where they may be more easily preyed upon by other fish, marine mammals and seabirds. As seals are known to forage up to 120 nautical miles (~220 km) offshore, the inshore portions of the proposed survey area therefore fall within the foraging range of seals from the West Coast colonies. Odontocetes are also highly mobile, with various species likely to occur in the Orange Basin and thus potentially attracted to the area.

Although little can be done on the survey vessel to prevent seabird collisions, reports of collisions or death of seabirds on seismic vessels are rare, possibly due to the relatively slow speed of seismic vessels when acquiring data. It is expected that seabirds and marine mammals in the area will become accustomed to the presence of the project vessels within a few days.

Due to their extensive distributions, the numbers of pelagic species (large pelagic fish, turtles and cetaceans) encountered during the proposed survey is expected to be low. Due to the anticipated low number of species

expected to be encountered and the location of the proposed survey area along a main traffic route, the **intensity** of impact is expected to be **low**. The extent of impact is **regional** (although limited to the local visual stimulus of the project vessels at any one time), while the duration will be **short-term** (five months). Thus, the **magnitude** (or consequence) is considered to be **very low** (see Table 8-7).

Impact Significance

Based on the **medium sensitivity** of receptors and the **very low magnitude**, the potential impact on the marine fauna is considered to be **very low significance** without mitigation (see Table 8-7).

Identification of Mitigation Measures

The following measures will be implemented to mitigate lighting impact:

No.	Mitigation measure	Classification
1	Reduce the lighting on the project vessels to a minimum compatible with safe operations whenever and wherever possible.	Avoid/reduce at source
2	Position light sources, if possible and consistent with safe working practices, in places where emissions to the surrounding environment can be minimised.	Avoid/reduce at source
3	Keep disorientated, but otherwise unharmed, seabirds in dark containers (e.g. cardboard box) for subsequent release during daylight hours.	Repair or restore

Residual Impact Assessment

The use of lighting on the project vessels cannot be eliminated due to safety, navigational and operational requirements. With the implementation of the few minor mitigation measures, which would reduce the intensity of the impact to very low, the residual impact remains of **VERY LOW significance** (see Table 8-7).

Table 8-7: Impact on marine fauna from vessel lighting

Project Phase:	**Mobilisation, Operation and Decommissioning**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**MEDIUM**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	LOW	VERY LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**VERY LOW**	**VERY LOW**
Probability	**POSSIBLE**	**POSSIBLE**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**VERY LOW**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.4 SEISMIC ACQUISITION

8.4.1 Underwater Noise from Airguns

A Sound Transmission Loss Modelling Study (see Appendix 4) was undertaken to predict the received noise levels of various metrics (e.g. Sound Exposure Levels (SELs) from single pulses, cumulative SELs from multiple pulses over 24 hours, peak Sound Pressure Levels (SPL) and Root-Mean-Square SPL (RMS SPL)) at locations within and adjacent to the survey area. These noise levels were then used to estimate the threshold distances to potential sound effects on marine fauna species of interest. The assessment of potential impacts on marine fauna and commercial fishing are presented in Sections 8.5.1.1 and 8.5.1.2, respectively.

8.4.1.1 Impact on Marine Fauna

Source of Impact

Seismic acquisition will increase the underwater ambient noise levels during operation, as presented below:

Project phase	Activity
Mobilisation	N/A
Operation	Seismic acquisition / Firing of the airguns
Demobilisation	N/A

The operation of the airguns during surveying will introduce underwater noise into the surrounding water column that will contribute to and/or exceed ambient noise levels in the area.

The airgun array for the proposed seismic survey is assumed to be the 4 230 cubic inch (CUI) Sercel G-Gun Source Array. The array consists of 30 active airgun units and has a towing depth of 8 m and an operating pressure of 2 000 pounds per square inch (PSI).

The primary output of an airgun source typically has most of the energy in the frequency bandwidth between 5 and 300 Hz. The source modelling result shows that the peak sound pressure level (Pk SPL) is 256.4 dB re 1 µPa @ 1m, the root-mean-square sound pressure level (RMS SPL) 252.8 dB re 1 µPa @ 1m with a 90%-energy pulse duration of 12.5 milliseconds, and the sound exposure level (SEL) 234.2 dB re $\mu Pa^2 \cdot s$ @ 1m.

One of the required characteristics of a seismic shot is that it is of short duration (the main pulse is usually between 5 and 30 milliseconds in duration with a shot interval of 18.75 m). The main pulse is followed by a negative pressure reflection from the sea surface of several lower magnitude bubble pulses (see Figure 6-7).

Potential Impact Description

Project activities will increase the ambient noise levels in the vicinity of the survey vessel / airguns. Elevated noise levels could impact marine fauna by:

- Causing direct physical injury to hearing or other organs (**direct negative** impact), including permanent (PTS)[9] or temporary threshold shifts (TTS)[10];

[9] A permanent threshold shift is a permanent shift in the auditory threshold, which results in permanent hearing loss.
[10] A temporary threshold shift is a temporary shift in the auditory threshold, which results in temporary hearing loss.

- Causing disturbance to the receptor resulting in behavioural changes or displacement from important feeding or breeding / spawning areas (**direct negative** impact).
- Masking or interfering with other biologically important sounds (e.g. communication, echolocation, signals and sounds produced by predators or prey) (**indirect negative** impact).

The assessment of potential impacts on the various faunal groups due to increased underwater ambient noise levels is presented in Sections 8.4.1.1.1 to 8.4.1.1.7 below.

Project Controls

The seismic contractor will ensure that the proposed survey is undertaken in a manner consistent with good international industry practice (e.g. JNCC guidelines) and BAT.

8.4.1.1.1 Cetaceans (Whales and Dolphins)

Sensitivity of Receptors

Thirty-three species or sub species/populations of cetaceans (whales and dolphins) are known or likely to occur off the West Coast (refer to Section 7.4.10). The majority of migratory cetaceans in South African waters are baleen whales (mysticetes), while toothed whales (odontocetes) may be resident or migratory. Of the 33 species, the blue whale is listed as 'Critically Endangered', the fin and sei whales are 'Endangered' and the sperm, Bryde's (inshore) and humpback (B2 population) whales are considered 'Vulnerable' (South African Red Data list Categories). Due to its location offshore and overlap with important seabed features such as Child's Bank and the Cape Canyon, and proximity to Tripp Seamount and the Southeast Atlantic Seamounts, the sensitivity of migratory cetaceans is considered to be **high**. The numbers of individuals encountered during the proposed survey are, however, likely to be low because of the extensive distributions of the various species concerned

Impact Magnitude (or Consequence)

In the wide diversity of cetaceans (whales and dolphins) occurring off the West Coast, there are marked differences in the hearing capabilities of odontocete and mysticete (baleen) cetaceans. Mysticetes hearing is centred at below 1 kHz (Low Frequency (LF)), overlapping the highest peaks of the power spectrum of airgun sounds and consequently these animals may be more affected by disturbance from seismic surveys. Odontocetes hearing is centred at frequencies of between 10 and 100 kHz (High Frequency (HF) or Very High Frequency (VHF)). These species may react to seismic shots at long ranges but hearing damage from seismic shots is only likely to occur at closer range.

Review of the available literature suggests that potential impacts of seismic pulses to whales and dolphins could include physiological injury, behavioural avoidance of the survey area, masking of environmental sounds and communication and indirect impacts due to effects on prey, as presented below.

Physiological Injury and Mortality

Exposure to high sound levels can result in physiological injury to cetaceans through a number of avenues, including shifts of hearing thresholds (PTS or TTS), tissue damage, acoustically induced decompression sickness (particularly in beaked whales), and non-auditory physiological effects (including elevated blood pressures, increased heart and respiration rates, and temporary increases in blood catecholamines and glucocorticoids), which may have secondary impacts on reproduction.

Available information suggests that the animal would need to be in close proximity to operating airguns to suffer physiological injury and, being highly mobile, it is assumed that they would avoid sound sources at distances well beyond those at which injury is likely to occur. The cumulative zones of impact presented below are conservative, and since cetaceans are highly mobile, they are likely to have moved considerable distances away from the source over the cumulative survey period. Thus, cumulative effects would only be expected where the animals do not move away from the area, e.g. from specific coastal areas used as breeding and calving sites. As the survey area is located more than 40 km from the coast, cumulative effects would not be expected.

Deep-diving cetacean species (e.g. sperm whales) may, however, be more susceptible to acoustic injury, as a seafloor-focussed seismic survey where the downward focussed impulses could trap these cetaceans within the survey pulse, as escaping towards the surface would result in exposure to higher sound level pulses.

Mysticetes: The Sound Transmission Loss Modelling Study undertaken for this project predicted that the mysticetes (or LF cetaceans) expected to occur in proposed survey area (e.g. Southern right, humpback, fin, sei, blue, Bryde's and minke whales) will experience PTS due to a single seismic pulse exposure effects within approximately 70 m from the source array at all assessed water depth scenarios, with the zone of a TTS predicted within approximately 180 m from the source array. LF cetaceans have the highest zones of PTS and TTS impact from multiple pulses (cumulative impact). The zones of PTS impact are predicted to range up to 450 m (L1 & L2 modelling sites[11]) from the adjacent survey lines for the typical 24-hour survey operation scenario considered, with the zones of TTS impact predicted to be around 12 000 m (L1 & L2 modelling sites) from the adjacent survey lines (see Table 8-8). For the L3 modelling site at a water depth of over 4 500 m, TTS onset for LF cetaceans was estimated at 8 000 m. It must be kept in mind that the cumulative zones of impact are conservative, and that being highly mobile, whales and dolphins are thus likely to have moved considerable distances over the cumulative 24-hr period. Cumulative effects would only be expected where the animals do not move away from the area, e.g. from specific coastal areas used as calving sites or from mid-ocean focal sites such as Child's Bank, Tripp Seamount or the Southeast Atlantic Seamounts.

The majority of mysticete whales migrate to the southern African subcontinent to breed during winter months. Humpback whales migrating north strike the coast at varying places mostly north of St Helena Bay resulting in increasing whale density on shelf waters and into deeper pelagic waters northwards, but with no clear migration corridor. The northern migration would begin passing through the proposed survey area around April, continuing through to September / October when the southern migration begins and continues through to January / February. Southern Right whales arrive in coastal waters in June, building up to a maximum in August / September and departing again in November. The survey area lies within the migration paths of Humpback and Southern Right whales, but well offshore of the inshore coastal areas frequented by Southern Right whales for mating and breeding. As the survey is proposed for the austral summer months (December to May) encounters with migrating whales should be minimal, although some Humpbacks on their return journey in November / December and those remaining on the summer feeding grounds off Cape Columbine may still be encountered. The current distribution of the offshore population of Bryde's whales implies that it is highly likely to be encountered in the proposed survey area during the summer survey period as its seasonality on the West Coast is opposite to the majority of the balaenopterids with abundance likely to be highest in the broader project area in January to March.

[11] Modelling Sites – L1: near Child's Bank, L2: near Cape Canyon, L3: deep offshore region in > 4 500 m depth

Should the proposed survey be undertaken during the key migration and breeding period (beginning of June to end of November, although not proposed) when there is a high likelihood of encountering migrating Humpback whales, the impact of potential physiological injury to mysticete cetaceans as a result of seismic sounds would be deemed to be of **high intensity**. Furthermore, as the duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional extent**), the potential for physiological injury would be considered to be of **medium magnitude** for mysticetes.

Table 8-8: Zones of immediate impact from single pulses and multiple pulses (cumulative) for cetaceans

Type of animal	Zones of impact – maximum horizontal distances from source to impact threshold levels			
	Injury (PTS) onset		TTS onset	
	Immediate Impact from Single Pulses	Cumulative Impact from Multiple Pulses	Immediate Impact from Single Pulses	Cumulative Impact from Multiple Pulses
LF cetaceans	70 m	L1 & L2: 450 m L3: 300 m	180 m	L1 & L2: 12 000 m L3: 8 000 m
HF cetaceans	25 m	-	40 m	< 10 m
VHF cetaceans	530 m	70 m	1 070 m	L1 & L2: 2 000 m L3: 1 000 m

Notes:
- A dash indicates the threshold is not applicable.
- If the zone of impact for cumulative is smaller than that for the single pulse, then the marine species are likely to be more sensitive to pressure impact than energy impact.

Odontocetes: Although for HF cetaceans (e.g. Sperm, Killer and Beaked whales and the diversity of dolphins) it was predicted that the cumulative PTS criteria for the 24-hour survey operation scenario would not to be reached, the zones of TTS impact were predicted to be <10 m from the adjacent survey lines for the cumulative scenario considered (see Table 8-8). In the case of VHF cetaceans (e.g. Heaviside's Dolphins, Pygmy Sperm Whale and Dwarf Sperm Whale), the zones of PTS impact for the cumulative scenario are predicted to range up to 70 m from the adjacent survey lines for the typical 24-hour survey operation scenario considered, with the zones of TTS impact predicted to range from 1 000 m (L3) to 2 000 m (L1 & L2) from the adjacent survey lines (see Table 8-8).

The survey is likely to frequently encounter resident odontocetes such as Common Dolphins and Pilot whales, which are present year-round, and will likely encounter Sperm whales in the deeper offshore areas.

The impact of potential physiological injury to **odontocetes** as a result of seismic sounds is deemed to be of **high intensity**. As the duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional extent**), the potential for physiological injury is considered to be of **medium magnitude** for resident **odontocetes**.

Behavioural Avoidance

Avoidance of seismic survey activity by cetaceans, particularly mysticete species, begins at distances where levels of approximately 150 to 180 dB re 1µPa are received, while subtle behavioural responses have been noted at received levels of 120 dB. The sound transmission loss modelling undertaken for this project identified that the zones of behavioural disturbance for cetaceans caused by the immediate exposure to individual seismic pulses was within 4.5 km from the array source.

Mysticetes: Although behavioural avoidance of seismic noise in the survey area by mysticete whales is highly likely, such avoidance is generally considered of minimal impact in relation to the distances of migrations of the majority of mysticete whale species.

The timing of the survey relative to seasonal breeding cycles (such as those observed in migrating mysticete whales) may influence the degree of stress induced by noise exposure. Displacement from critical habitat is particularly important if the sound source is located at an optimal feeding or breeding ground or areas where mating, calving or nursing occurs. The survey area overlaps with the migration routes of Humpback whales to and from their breeding grounds, but is located well offshore of the coastal migration route for Southern Right whales. Although encounter rates peak in migration periods, humpback whales are found off South Africa year-round. For other species, the paucity of fine scale data from offshore waters on the distribution and seasonal occurrence of most cetacean species prevents prediction where such critical habitat might be with any certainty. Other mysticete whale species are also found year-round or have seasonal occurrences, which confirms year-round presence of mysticetes. However, if the survey is scheduled to occur outside of the main winter migration periods (June - November), interactions with migrating whales should be low.

Of greater concern than general avoidance of migrating whales is avoidance of critical breeding habitat or area where mating, calving or nursing occurs. Humpback whales have their winter breeding concentrations off tropical west Africa, between Angola and the Gulf of Guinea and, therefore, over 1 000 km to the north of the survey area. Southern Right whales currently have their most significant winter concentrations on the South Coast between Port Elizabeth and Cape Town, but are regularly seen off the southern half of Namibia and would therefore pass along the West Coast. As the proposed survey area is located in excess of 40 km from the coast, there should be no overlap with potential coastal nursery areas for this species.

Assuming the survey is undertaken during the key migration period (early June to late November; not proposed) when there is a high likelihood of encountering migrating Humpback whales and due to the increasing numbers of Southern Right and Humpback whales year round and the resident Bryde's whales, the potential impact of behavioural avoidance of seismic survey areas by mysticete cetaceans is considered to be of **high intensity**, across the survey area (**regional**) and for the **short term** duration of the survey (five months). Thus, the **magnitude** is considered to be **medium** for resident and migrating mysticete cetaceans.

Odontocetes: Information available on behavioural responses of toothed whales and dolphins to seismic surveys is more limited than that for baleen whales. No seasonal patterns of abundance are known for odontocetes occupying the survey area, but several species are considered to be year-round residents. Furthermore, a number of toothed whale species have a more pelagic distribution thus occurring further offshore, with species diversity and encounter rates likely to be highest on the shelf slope. The impact of seismic survey noise on the behaviour of toothed whales is considered to be of **high intensity** across the survey area (**regional**) and for the **short-term** duration of the survey (four to five months). The overall **magnitude** will however not vary between species and is considered to be **medium**.

Masking of Environmental Sounds and Communication

Mysticetes: Mysticete whales appear to vocalise almost exclusively within the frequency range of the maximum energy of seismic survey noise. In the migratory mysticete whale species, vocalisation increases once they reach the breeding grounds and on the return journey in November/December when accompanied by calves. Although most mother-calf pairs tend to follow a coastal route southward, there is no clear migration corridor and humpbacks can be spread out widely across the shelf and into deeper pelagic waters. Vocalisation of southward

migrating whales may thus potentially be regionally comparatively high on commencement of operations in December, reducing thereafter. However, masking of communication signals is likely to be limited by the low duty cycle of seismic pulses.

Assuming the survey is undertaken during the key mitigation and breeding period when there is a high likelihood of encountering migrating Humpback whales (including possible mother-calf pairs), the **intensity** of impacts on baleen whales is likely to be **high**. Furthermore, as the duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional**), the **magnitude** is considered to be **medium** for mysticetes.

Odontocetes: Toothed whales vocalise at frequencies higher than the frequency range of the maximum energy of seismic survey noise. As the by-product noise in the mid- and high frequency range (up to and exceeding 15 kHz) can travel far (at least 8 km), masking of communication sounds produced by whistling dolphins and blackfish[12] is likely.

The **intensity** of impacts on **toothed whales** is likely to be **medium**. As the duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional**), the **magnitude** is considered to be **medium** for resident odontocetes.

Effects on Prey

Mysticetes: Although the majority of mysticete whales will undertake little feeding within breeding-ground waters along the southern African west coast and rely on blubber reserves during their migrations, there is increasing evidence that some species (fin, southern rights and humpback whales) are using upwelling areas off the South African West Coast as summer feeding grounds. The upwelling zone off Cape Columbine has become an important summer feeding area, and mysticete whales have been reported to feed in the inshore portion of the proposed survey area between St Helena Bay and Cape Town.

Any indirect effects on mysticete food source would thus be of **very low intensity**. The duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional**). Thus, the **magnitude** is considered to be **very low** for mysticetes.

Odontocetes: As with other vertebrates, the assessment of indirect effects of seismic surveys on resident odontocete cetaceans is limited by the complexity of trophic pathways in the marine environment. Although the fish and cephalopod prey of toothed whales and dolphins may be affected by seismic surveys, impacts will be highly localised and small in relation to the feeding ranges of cetacean species.

The broad ranges of prey species (in relation to the avoidance patterns of seismic surveys of such prey species) suggest that indirect impacts due to effects on prey would be of **low intensity**. The duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional**). Thus, the **magnitude** is considered to be **very low** for odontocetes.

[12] The term blackfish refers to the delphinids: melon-headed whale, killer whale, pygmy killer whale, false killer whale, long-finned pilot whale, short-finned pilot whale.

Impact Significance

Based on the **high sensitivity** of receptors and the **medium magnitude** of most of the effects, the worst potential impacts of seismic surveys on mysticete and odontocete cetaceans are of **medium significance** (see Table 8-9), except effects on prey which is of very low magnitude and, then, of **LOW** significance (see Table 8-9).

Identification of Mitigation Measures

In order to minimise the impact of the seismic operations on cetaceans, the following mitigation measures are recommended:

No.	Mitigation measure	Classification
1. Survey Planning		
1.1	Ensure that survey plans exclude all data acquisition in declared Marine Protected Areas;	
1.2	Plan seismic survey to avoid the periods of movement of migratory cetaceans (particularly baleen whales) from their southern feeding grounds into low latitude waters (June to November inclusive) and ensure that migration paths are not blocked by seismic operations. Thus, surveying should, therefore, be undertaken between December and May (inclusive). If possible, the survey should be undertaken from North to South.	Avoid
1.3	Coordinate survey design and timing with marine authorities and other operators, if required and as far as possible, to avoid potential cumulative noise impacts associated with more than one survey occurring at the same time in adjacent areas.	Avoid
1.4	Plan survey, as far as possible, so that the commencement of airgun firing in the survey area for the first time (including gun tests) is undertaken during daylight hours.	Abate on site
1.5	Prohibit the use of airguns (including airgun tests) outside the area of operation (which includes line turns).	Avoid
2. Key Equipment		
2.1	**Passive Acoustic Monitoring (PAM)**	
2.1.1	Ensure seismic vessel is fitted with PAM technology, which detects animals through their vocalisations.	Abate on site
2.1.2	As the survey area would largely be in waters deeper than 1 000 m where sperm whales and other deep-diving odontocetes are likely to be encountered, implement PAM 24-hr a day when airguns are in operation.	Abate on site
2.1.3	Ensure the PAM streamer is fitted with at least four hydrophones, of which two are HF and two LF, to allow directional detection of cetaceans.	Abate on site
2.1.4	Ensure the PAM hydrophone streamer is towed in such a way that the interference of vessel noise is minimised.	Abate on site
2.1.5	Ensure spare PAM hydrophone streamers (e.g. 4 heavy tow cables and 6 hydrophone cables) are readily available in the event that PAM breaks down, in order to ensure timeous redeployment.	Abate on site
2.2	**Acoustic Source**	
2.2.1	Define and enforce the use of the lowest practicable airgun volume for production.	Abate on site
2.2.2	Ensure a display screen for the acoustic source operations is provided to the marine observers. All information relating to the activation of the acoustic source and the power output levels must be readily available to support the observers in real time via the display screen and to ensure that operational capacity is not exceeded.	Abate on site
2.2.3	Ensure the ramp-up noise volumes do not exceed the production volume.	Abate on site

No.	Mitigation measure	Classification
3. Key Personnel		
3.1	Ensure that at least two qualified MMO are on board at all times. As a minimum, one must be on watch during daylight hours for the pre-shoot observations and when the acoustic source is active. Refer to Section 9.4.3 for the roles and responsibilities of the MMOs.	Abate on site
3.2	Ensure that at least two qualified, PAM operators are on board at all times. As a minimum, one must be on "watch" during the pre-shoot observations and when the acoustic source is active. Refer to Section 9.4.4 for the roles and responsibilities of the PAM operators.	Abate on site
3.3.	Ensure MMOs and PAM operators are briefed on the area-specific sensitivities and on the seismic survey planning (including roles and responsibilities, and lines of communication).	Abate on site
4. Airgun Testing		
4.1	Maintain a pre-shoot watch of 60-minutes before any instances of airgun testing. If only a single lowest power airgun is tested, the pre-shoot watch period can be reduced to 30 minutes	Avoid / Abate on site
4.2	Implement a "soft-start" procedure if testing multiple airguns. • The "soft-start" should be carried out over a time period proportional to the number of guns being tested and not exceed 20 minutes; airguns should be tested in order of increasing volume. • If testing all airguns at the same time, a 20 minute "soft-start" is required. • If testing a single lowest power airgun a "soft-start" is not required.	Avoid / Abate on site
5. Pre-Start Protocols		
5.1	Implement a dedicated MMO and PAM pre-shoot watch of at least 60 minutes (to accommodate deep-diving species in water depths greater than 200 m).	Avoid / Abate on site
5.2	Implement a "soft-start" procedure of a minimum of 20 minutes' duration on initiation of the seismic source if: • **during daylight** hours it is confirmed: – visually by the MMO during the pre-shoot watch (60 minutes) that there are no cetaceans within 500 m of the seismic source, and – by PAM technology that there are no vocalising cetaceans detected in the 500 m mitigation zone. • **during times of poor visibility or darkness** it is confirmed by PAM technology that no vocalising cetaceans are present in the 500 m[13] mitigation zone during the pre-shoot watch (60 minutes).	Avoid / Abate on site
5.3	Delay "soft-starts" if cetaceans are observed within the mitigation zone. A "soft-start" should not begin until 30 minutes after cetaceans depart the mitigation zone or 30 minutes after they are last seen or acoustically detected by PAM in the mitigation zone.	Avoid / Abate on site
5.4	As noted above for planning, when arriving at the survey area for the first time, survey activities should, as far as possible, only commence during daylight hours with good visibility. However, if this is not possible due to prolonged periods of poor visibility (e.g. thick fog) or unforeseen technical issue which results in a night-time start, the initial acoustic source activation (including	Avoid / Abate on site

13 Although for the most sensitive hearing group (very high frequency cetaceans) the maximum zone of impact for PTS and TTS from a single seismic pulse extends beyond the recommended 500 m mitigation zone (as per JNCC), it is recommended that the mitigation zone remain at 500 m despite the 2D survey area overlapping with Child's Bank where the animals are known to congregate and may not move away. Thus, although VHF cetaceans may experience PTS at a distance of up to 530 m and TTS at a distance of up to 1 070 m at full power, this is unlikely when implementing the soft-start procedure which, provides them the opportunity to leave the area.

No.	Mitigation measure	Classification
	gun tests) may only be undertaken if the normal 60-minute PAM pre-watch and "soft-start" procedures have been followed.	
5.5	Schedule "soft-starts" so as to minimise, as far as possible, the interval between reaching full power operation and commencing a survey line. The period between the end of the soft start and commencing with a survey line must not exceed 20 minutes. If it does exceed 20 minutes, refer to breaks in firing below.	Abate on site
6. Line Turns		
6.1	If line changes are expected to take **longer** than 40 minutes: • Terminate airgun firing at the end of the survey line and implement a pre-shoot search (60 minutes) and "soft-start" procedure (20 minutes) when approaching the next survey line. • If line turn is shorter than 80 minutes (i.e. shorter than a 60-minute pre-shoot watch and 20-minute "soft-start" combined), the pre-shoot watch can commence before the end of the previous survey line.	Abate on site
6.2	If line changes are expected to take **less** than 40 minutes, airgun firing can continue during the line change if: • The power is reduced to 180 cubic inches (or as close as is practically feasible) at standard pressure. Airgun volumes of less than 180 cubic inches can continue to fire at their operational volume and pressure; • The Shot Point Interval (SPI) is increased to provide a longer duration between shots, with the SPI not to exceed 5 minutes; • The power is increased and the SPI is decreased in uniform stages during the final 10 minutes of the line change (or geophone repositioning), prior to data collection re-commencing (i.e. a form of mini soft start); and • Normal MMO and PAM observations continue during this period when reduced power airgun is firing.	Abate on site
7. Shut-Downs		
7.1	Terminate seismic shooting on: • Observation and/or detection of cetaceans within the 500 m mitigation zone. • Observation of any obvious mortality or injuries to cetaceans when estimated by the MMO to be as a direct result of the survey.	Abate on site
7.2	For cetaceans, terminate shooting until such time as there has been a 30-minute delay from the time the animal was last sighted within the mitigation zone before the commencement of the normal soft start procedure	Abate on site
8. Breaks in Airgun Firing		
8.1	If after breaks in firing, airguns can be restarted **within 5 minutes**, no soft-start is required and firing can recommence at the same power level provided no marine mammals have been observed or detected in the mitigation zone during the break-down period.	Abate on site
8.2	For all breaks in airgun firing of **longer than 5 minutes, but less than 20 minutes**, implement a "soft-start" of similar duration, assuming there is continuous observation by the MMO and PAM operator during the break.	Abate on site
8.3	For all breaks in firing of **20 minutes or longer**, implement a 60-minute pre-shoot watch and 20-minute "soft-start" procedure prior to the survey operation continuing.	Abate on site

No.	Mitigation measure	Classification
8.4	For planned breaks, ensure that there is good communication between the seismic contractor and MMOs and PAM operators in order for all parties to be aware of these breaks and that early commencement of pre-watch periods can be implemented to limit delays.	Abate on site
9. PAM Malfunctions		
9.1	If the PAM system malfunctions or becomes damaged during **night-time operations or periods of low visibility**, continue operations for 30 minutes without PAM if no marine mammals were detected by PAM in the mitigation zones in the previous 2 hours, while the PAM operator diagnoses the issue. If after 30 minutes the diagnosis indicates that the PAM gear must be repaired to solve the problem, reduce power to 180 cubic inches. Firing of the reduced power gun may continue for 30 minutes while PAM is being repaired, the last 10 minutes of which is a ramp up to full power (mini "soft-start"). If the PAM diagnosis and repair will take longer than 60 minutes, stop surveying until such time as a functional PAM system can be redeployed and tested.	Abate on site
9.2	If the PAM system breaks down during **daylight hours**, continue operations for 20 minutes without PAM, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM gear must be repaired to solve the problem, operations may continue for an additional 2 hours without PAM monitoring as long as: • No marine mammals were detected by PAM in the mitigation zones in the previous 2 hours; • Two MMOs maintain watch at all times during operations when PAM is not operational; and • The time and location in which operations began and stop without an active PAM system is recorded.	Abate on site

Residual Impact Assessment

The potential impacts cannot be eliminated due to the nature of the seismic sound source required during surveying. The proposed mitigation measures, which are designed to keep animals out of the immediate area of impact and thereby reduce the risk of deliberate injury to marine mammals would reduce the intensity of most impacts from high to medium for both mysticetes and odontocetes. Thus, the residual impacts will reduce to **low magnitude** and **LOW significance** (see Table 8-9) reflecting the most conservative case), except for the effects on prey which remains of **VERY LOW significance**.

Table 8-9: Impact on cetaceans from seismic noise

Project Phase:	**Operation**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**HIGH**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**MEDIUM**	**LOW**
Intensity	HIGH	MEDIUM
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**MEDIUM**	**LOW**
Probability	**HIGHLY LIKELY**	**POSSIBLE**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**

Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.4.1.1.2 Seals

Sensitivity of Receptors

Cape Fur seals (classified as Least Concern) occur at numerous breeding and non-breeding sites on the mainland along the West Coast, namely at Bucchu Twins near Alexander Bay, at Cliff Point (~17 km north of Port Nolloth), at Kleinzee (incorporating Robeiland), Strandfontein Point (south of Hondeklipbaai), Paternoster Rocks and Jacobs Reef at Cape Columbine, Vondeling Island, Robbesteen near Koeberg, Seal Island in False Bay and Geyser Rock at Dyer Island, Quoin Point and Seal Island in Mossel Bay. Non-breeding colonies and haul-out sites occur at Doringbaai south of Cliff Point, Rooiklippies, Swartduin and Noup between Kleinzee and Hondeklipbaai, at Spoeg River and Langklip south of Hondeklip Bay, on Bird Island at Lambert's Bay, at Paternoster Point at Cape Columbine and Duikerklip in Hout Bay. These colonies all fall well inshore and to the east of the proposed survey area. Seals are highly mobile animals covering the continental shelf up to approximately 220 km offshore and could thus be encountered in the inshore areas of the proposed survey area. Their sensitivity to the proposed seismic survey operations is, however, considered to be **low**.

Impact Magnitude (or Consequence)

Review of the available literature suggests that potential impacts of seismic pulses to Cape Fur seals could include physiological injury, behavioural avoidance of the seismic survey area, masking of environmental sounds and underwater communication and indirect impacts due to effects on predators or prey.

Physiological Injury and Mortality

The physiological effects of loud low frequency sounds on seals are not well documented, but include cochlear lesions following rapid rise time explosive blasts and TTS with recovery to baseline threshold levels within 24 hr of noise exposure. Due to the high level of impulsive signal emissions from seismic arrays, seals are predicted to experience a permanent auditory threshold shift (PTS) at close proximity to the sound source due to the immediate exposure to individual pulses.

The potential for physiological injury to seals from seismic noise is expected to be low as it is assumed that highly mobile creatures such as fur seals would avoid severe sound sources at levels well below those at which discomfort occurs, although Cape fur seals have been recorded to approach operational seismic survey gear. Their tendency to swim at or near the surface would expose them to reduced sound levels when in close proximity to an operating airgun array.

Based on the noise exposure criteria provided by Southall *et al.* (2019), the Sound Transmission Loss Modelling Study predicts that the maximum horizontal threshold distance for potential mortal injury (PTS) and TTS from a single pulse to other marine carnivores (seals) is within 25 m and 35 m of the airgun, respectively. Maximum threshold distance for injury or TTS from multiple pulses were not reached but for TTS the maximum threshold distance for the cumulative scenario was < 10 m. The zones of impact for PTS and TTS are presented in Table 8-10.

As seals are known to forage up to 220 km offshore, the inshore half of the proposed survey area would fall within the foraging range of seals from all the West Coast colonies. The **intensity** of potential physiological injury is rated as **high**. The duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional extent**). The potential physiological injury or mortality of seals is considered to be of **medium magnitude**.

Table 8-10: Zones of immediate impact from single pulses and multiple pulses (cumulative) for other marine carnivores (seals)

Type of animal	Zones of impact – maximum horizontal distances from source to impact threshold levels			
	Injury (PTS) onset		**TTS onset**	
	Immediate Impact from Single Pulses	**Cumulative Impact from Multiple Pulses**	**Immediate Impact from Single Pulses**	**Cumulative Impact from Multiple Pulses**
Other marine carnivores in water	25 m	-	35 m	< 10 m

Notes:
- A dash indicates the threshold is not applicable.
- If the zone of impact for cumulative is smaller than that for the single pulse, then the marine species are likely to be more sensitive to pressure impact than energy impact.

Behavioural Avoidance

Reports of studies conducted with Harbour and Grey seals include initial startle reaction to airgun arrays, and range from partial avoidance of the area close to the vessel (within 150 m) to fright response (dramatic reduction in heart rate), followed by a clear change in behaviour, with shorter erratic dives, rapid movement away from the noise source and a complete disruption of foraging behaviour. In most cases, however, individuals quickly reverted to normal behaviour once the seismic shooting ceased and did not appear to avoid the survey area. Seals seem to show adaptive responses by moving away from airguns and reducing the risk of sustaining hearing damage.

Although partial avoidance (to less than 250 m) of operating airguns has been recorded for some seal species, Cape Fur seals appear to be relatively tolerant to loud noise pulses and, despite an initial startle reaction, individuals quickly reverted back to normal behaviour. The potential impact of seal foraging behaviour changing in response to seismic surveys is thus considered to be of **very low intensity**, as they are known to show a tolerance to loud noises. Furthermore, as the duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional**). The potential for behavioural avoidance of seals is considered to be of **very low magnitude**.

Masking of Environmental Sounds and Communication

The use of underwater sounds for environmental interpretation and communication by Cape Fur seals is unknown, although masking is likely to be limited by the low duty cycle of seismic pulses (18.75 m interval between consecutive shot-points). The potential impact of masking of sounds and communication in seals due to seismic noise is considered to be of **very low intensity**, as they are known to show a tolerance to loud noises. As the duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional**), the potential for masking of sounds is considered to be of **very low magnitude.**

Effects on Predators or Prey

As with other vertebrates, the assessment of indirect effects of seismic surveys on Cape Fur seals is limited by the complexity of trophic pathways in the marine environment. The impacts are difficult to determine and depends on the diet make-up of the species (and the flexibility of the diet), and the effect of seismic surveys on the diet species. Seals typically forage on small pelagic shoaling fish prey species that occur inshore of the 200 m depth contour or associated with oceanic features such as Child's Bank. Furthermore, the broad ranges of fish prey species (in relation to the avoidance patterns of seismic surveys of such prey species) and the extended foraging ranges of Cape Fur seals suggest that indirect impacts due to effects on predators or prey would be of **very low intensity**, would be limited to the **short-term** (five months) and be restricted to the survey area (**regional**). The potential for effects of seismic surveys on prey species is thus considered to be of **very low magnitude**.

Impact Significance

Based on the **low sensitivity** of receptors and the **medium** to **very low magnitude,** potential impacts on seals range from **low significance** (physiological injury and mortality) (see Table 8-11 reflecting the most conservative case) to **negligible significance** (behaviour, masking and effects on prey).

Identification of Mitigation Measures

In addition to the mitigation recommended for cetaceans (see Section 8.4.1.1.1), the following is recommended for seals during a seismic survey:

No.	Mitigation measure	Classification
1	Implement a "soft-start" procedure of a minimum of 20 minutes' duration on initiation of the seismic source if during daylight hours it is confirmed visually by the MMO during the pre-shoot watch (60 minutes) that there are no seals within 500 m of the seismic source.	Avoid / Abate on site
2	In the case of fur seals being observed within the mitigation zone, which may occur commonly around the vessel, delay "soft-starts" for at least 10 minutes until it has been confirmed that the mitigation zone is clear of all seal activity. However, if after a period of 10 minutes seals are still observed within 500 m of the airguns, the normal "soft-start" procedure should be allowed to commence for at least a 20-minute duration. Seal activity should be carefully monitored during "soft-starts" to determine if they display any obvious negative responses to the airguns and gear or if there are any signs of injury or mortality as a direct result of the seismic activities.	Avoid / Abate on site
3	Terminate seismic shooting on observation of any obvious mortality or injuries to seals when estimated by the MMO to be as a direct result of the survey.	Abate on site

Residual Impact Assessment

The potential impacts cannot be eliminated due to the nature of the seismic sound sources required during surveying. With the implementation of the mitigation measures, the intensity of the impact of physiological injury and mortality reduces to medium, thereby reducing **magnitude** to **low** and overall **significance** to **VERY LOW**. All other impacts on seals remain of **NEGLIGIBLE significance** (see Table 8-11).

Table 8-11: Impact on seals from seismic noise

Project Phase:	Operation
Type of Impact	**Direct**
Nature of Impact	**Negative**

Sensitivity of Receptor	LOW	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**MEDIUM**	**LOW**
Intensity	HIGH	MEDIUM
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**LOW**	**VERY LOW**
Probability	**POSSIBLE**	**POSSIBLE**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.4.1.1.3 Turtles

Sensitivity of Receptors

The leatherback and loggerhead turtles that occur in offshore waters around southern Africa, and likely to be encountered in the proposed survey area, are considered regionally 'Critically Endangered' and 'Endangered', respectively. The breeding areas for Leatherback turtles occur over 1 500 km north of the proposed survey area in Gabon and on the northeast coast of South Africa. Turtles possibly encountered in the survey area are thus likely to be migrating vagrants. Due to their extensive distributions and feeding ranges, the number of turtles encountered in the survey area is expected to be low, even in the Child's Bank and Orange Shelf Edge MPAs, and the Orange Seamount and Canyon Complex transboundary EBSA (may be frequented by migrating leatherbacks). Consequently, the sensitivity of turtles is considered to be **medium**.

Impact Magnitude (or Consequence)

Available data on marine turtle hearing is limited but suggest highest auditory sensitivity at frequencies of 250 - 700 Hz, and some sensitivity to frequencies at least as low as 60 Hz. More recent studies using electrophysiological and behavioural techniques have found that turtles can detect frequencies between 50 Hz and 1 600 Hz, indicating that their hearing ranges overlap with the peak amplitude, low frequency sound emitted by seismic airguns (10–500 Hz). The overlap of this hearing sensitivity with the higher frequencies produced by airguns, suggest that turtles may be significantly affected by seismic noise.

Potential impacts of seismic pulses to turtles could include physiological injury and mortality, behavioural avoidance of seismic survey areas, masking of environmental sounds and communication and indirect impacts due to effects on prey.

Physiological Injury and Mortality

Evidence suggests that turtles only detect airguns at close range (<10 m) or are not sufficiently mobile to move away from approaching airgun arrays (particularly if basking). Initiation of a sound source at full power in the immediate vicinity of a swimming or basking turtle would thus be expected to result in physiological injury. This applies particularly to hatchlings and juveniles as they would be unable to avoid seismic sounds whilst being

transported in the ocean currents. The abundance of adult turtles along the West Coast is considered low in relation to the extent of the proposed survey area.

If subjected to seismic sounds at close range, temporary or permanent hearing impairment may result, but it is unlikely to cause death or life-threatening injury. As with other large mobile marine vertebrates, it is assumed that sea turtles will avoid seismic noise at levels/distances where the noise is a discomfort. Juvenile turtles may be unable to avoid seismic sounds in the open ocean, and consequently may be more susceptible.

Based on the noise exposure criteria provided by Popper *et al.* (2014), the Sound Transmission Loss Modelling Study predicts that the maximum horizontal threshold distance for mortality or potential mortal injury (PTS) to sea turtles for single pulse is within 350 m of the airgun. The zone of cumulative impact from multiple pulses is estimated as < 10 m for mortality and potential mortal injury. Maximum threshold distances for recoverable injury and TTS from multiple pulses are not reached. The zones of seismic impact for PTS, TTS and recovery injury are presented in Table 8-12. It must be kept in mind that the cumulative zones of impact are conservative, as any turtles likely to be encountered in the Orange Basin area are the highly migratory, and are likely to have moved considerable distances over the cumulative 24-hr period.

Table 8-12: Zones of immediate impact from seismic single pulses and multiple pulses (cumulative) for turtles

Type of animal	Zones of impact – maximum horizontal distances from source to impact threshold levels				
	Mortality & Mortal Injury		**Recovery injury**		**TTS**
	Immediate Impact from Single Pulses	**Cumulative Impact from Multiple Pulses**	**Immediate Impact from Single Pulses**	**Cumulative Impact from Multiple Pulses**	**Cumulative impact From Multiple Pulses**
Sea turtles	350 m	< 10 m	-	-	-

Notes:
- A dash indicates the threshold is not applicable.
- If the zone of impact for cumulative is smaller than that for the single pulse, then the marine species are likely to be more sensitive to pressure impact than energy impact.

As the breeding areas for Leatherback turtles occur over 1 000 km to the north of the proposed survey area in Gabon and on the northern KwaZulu Natal coast, turtles encountered during the survey(s) are likely to be migrating vagrants. Despite their extensive distributions and feeding ranges and that the number of turtles encountered in the survey area is expected to be low, the **intensity** of potential physiological injury would be rated as **high**. Furthermore, the duration of the impact on the population would be limited to the **short-term** (five months) and be restricted to the survey area (**regional extent**). The potential physiological injury or mortality of turtles is considered to be of **medium magnitude**.

Behavioural Avoidance

Behavioural changes in response to anthropogenic sounds have been reported for some sea turtles. Controlled exposure experiments on captive turtles found an increase in swim speed and erratic behaviour indicative of avoidance, at received airgun sound levels of 166 – 176 dB re 1 µPa. Sounds of frequency of 250 and 500 Hz resulted in a startle response from a loggerhead turtle, and avoidance by 30 m of operating airguns where the received level would have been in the order of 175 - 176 dB re 1 µPa. Further trials carried out on caged Loggerhead and Green Turtles indicated that significant avoidance response occurred at received levels ranging between 172 and 176 dB re 1 µPa at 24 m.

Based on the noise exposure criteria provided by Popper *et al.* (2014), the Sound Transmission Loss Modelling Study predicts that the zone of behavioural disturbance for sea turtles caused by the immediate exposure to individual pulses is predicted to be within 3 km from the array source. Turtles can, therefore, hear seismic sounds at a considerable distance and may respond by altering their swimming/basking behaviour or alter their migration route However, as the number of turtles encountered in the survey area is expected to be low, the impact of seismic sounds on turtle behaviour would be of **low intensity**, and would persist only for the **short-term** duration of the survey (five months), and be restricted to the survey area (**regional**). The impact of seismic noise on turtle behaviour is thus deemed to be of **very low magnitude**.

Masking of Environmental Sounds and Communication

Breeding sea turtles undertake large migrations between distant foraging areas and their nesting sites (within the summer months October to March, with peak nesting during December and January). Although it is speculated that turtles may use acoustic cues for navigation during migrations, information on turtle communication is lacking. The effect of seismic noise in masking environmental cues such as surf noise (150-500 Hz), which overlaps the frequencies of optimal hearing in turtles, is unknown and speculative. As the breeding areas for Leatherback turtles occur over 1 000 km north of the proposed survey area in Gabon and on the northern KwaZulu Natal coast, turtles encountered during the survey(s) are likely to be migrating vagrants.

Their low abundance in the survey area would suggest that the impact, should it occur, would be of **very low intensity**. As the impact would persist only for the **short-term** duration of the survey (five months) and be restricted to the survey area (**regional**), the impact is deemed to be of **very low magnitude**.

Effects on Predators or Prey

As with other vertebrates, the assessment of indirect effects of seismic surveys on turtles is limited by the complexity of trophic pathways in the marine environment. The Leatherback Turtles eat pelagic prey, primarily jellyfish. The low numbers and the broad ranges of potential prey species and extensive ranges over which most turtles feed suggest that indirect impacts would be of **very low intensity**, persisting only for the **short-term** duration of the survey (five months) and restricted to the survey area (**regional**). The impact would therefore be of **very low magnitude**.

Impact Significance

Based on the **medium sensitivity** of receptors and the **medium** to **very low magnitude,** potential impacts on turtles range from **medium significance** (physiological injury and mortality) (see Table 8-13 reflecting the most conservative case) to **very low significance**.

Identification of Mitigation Measures

In addition to the mitigation recommended for cetaceans (see Section 8.4.1.1.1), the following is recommended for sea turtles during a seismic survey:

No.	Mitigation measure	Classification
1	Implement a “soft-start” procedure of a minimum of 20 minutes’ duration on initiation of the seismic source if during daylight hours it is confirmed visually by the MMO during the pre-shoot watch (60 minutes) that there are no turtles within 500 m of the seismic source.	Avoid / Abate on site
2	In the case of turtles being observed within the mitigation zone, delay the “soft-start” until animals are outside the 500 m mitigation zone.	Avoid / Abate on site

No.	Mitigation measure	Classification
3	Terminate seismic shooting on: • observation of turtles within the 500 m mitigation zone. • observation of any obvious mortality or injuries to turtles when estimated by the MMO to be as a direct result of the survey. For turtles, terminate shooting until such time as the animals are outside of the 500 m mitigation zone (seismic "pause", no soft-start required).	Abate on site

Residual Impact Assessment

The potential impacts cannot be eliminated due to the nature of the seismic sound source required during surveying. With the implementation of the mitigation measures, the intensity of the impact of physiological Injury reduces to medium, thereby reducing **magnitude** to **low** and overall **significance** to **LOW**. All other impacts on turtles remain of **VERY LOW significance** (see Table 8-13)

Table 8-13: Impact on sea turtles from seismic noise

Project Phase:	**Operation**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**MEDIUM**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**MEDIUM**	**LOW**
Intensity	HIGH	MEDIUM
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**MEDIUM**	**LOW**
Probability	**LIKELY**	**POSSIBLE**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.4.1.1.4 Diving Seabirds

Sensitivity of Receptors

Among the marine avifauna of the West Coast of South Africa, it is only diving birds or birds which rest on the water surface that may be affected by the underwater noise of seismic surveys.

The African Penguin occurs along the southwestern Cape coastline and would be particularly susceptible to impacts from underwater seismic noise. Similarly, Cape Gannets dive for their pelagic prey and would be susceptible to seismic noise. Penguins from the Robben Island colony have been tracked feeding up to 70 km offshore of the island and Cape Gannets are known to forage within 200 km offshore and both species may therefore be encountered in the inshore portions of the proposed 2D survey area. Both species are considered 'endangered' on a national and global scale. Of the pelagic seabirds likely to occur in the offshore regions

characterising the Orange Basin, many are considered regionally 'vulnerable' (e.g. white-chinned petrel), 'endangered' (e.g. black-browed albatross, Atlantic yellow-nosed albatross, subantarctic skua) and 'critically endangered' (Leach's storm petrel). However, due to their extensive distributions and feeding ranges, the numbers of individuals encountered during the survey are likely to be low, even in the Child's Bank and Orange Shelf Edge MPAs and associated with Tripp Seamount, the Orange Seamount and Canyon Complex transboundary EBSA and the Southeast Atlantic Seamounts. Consequently, the sensitivity for both coastal and pelagic seabirds is considered to be **medium**.

Impact Magnitude (or Consequence)

Birds are well known for their acoustic communication and hearing abilities, but psychophysical or behavioural data on how birds hear or react to sound underwater is currently lacking. Potential impacts of seismic pulses to diving birds could include physiological injury, behavioural avoidance of seismic survey areas and indirect impacts due to effects on prey.

Physiological Injury and Mortality

Based on available evidence, diving seabird would be able to hear seismic sounds at considerable distances and consequently, being all highly mobile, would be able to flee from approaching seismic noise sources at distances well beyond those that could cause physiological injury. Thus, the potential for physiological injury to diving seabirds from seismic surveys in the open ocean is deemed to be low, particularly given the extensive feeding range of the potentially affected species. However, the initiation of a sound source at full power in the immediate vicinity of feeding diving seabirds could result in injury or mortality where feeding behaviour override a flight response to seismic survey sounds.

Of the plunge diving species that occur along the West Coast, the Cape Gannet regularly feeds as far offshore as 100 km, the rest foraging in nearshore areas up to 40 km from the coast, although Cape Cormorants have been reported up to 80 km from their colonies. The nearest Cape Gannet nesting grounds are at Lambert's Bay and Malgas Island, ~100 km and 40 km inshore of the eastern boundary of the proposed 2D survey area, respectively. The nearest African Penguin nesting sites are similarly at Lambert's Bay, on the Saldanha Bay Islands and at Robben Island all ~100 km or less inshore and to the east of the survey area. This species forages at sea with most birds being found within 20 km of the coast, although individuals have been recorded as far as 70 km offshore. As the survey area is situated ~40 km from the coast at its nearest point, encounters with both Cape Gannets and African penguins are possible. In the offshore environment, pelagic seabirds that dive for their prey may, however, be encountered, particularly in the portions of the survey area closest to Tripp Seamount, Child's Bank and the Southeast Atlantic Seamounts.

Should an encounter with diving pelagic seabirds occur, the potential impact on individual pelagic and coastal diving birds would be of high intensity, but as the likelihood of encountering large numbers of diving seabirds is low, due to their extensive distributions and feeding ranges the intensity is considered **medium**. The duration of the impact on the population would be limited to the **short-term** (five months) and be restricted to the survey area (**regional extent**). The potential for physiological injury is therefore considered to be of **low magnitude**.

Behavioural Avoidance

Diving birds would be expected to hear seismic sounds at considerable distances as they have good hearing at low frequencies (which coincide with seismic shots). Response distances are speculative as no empirical evidence is available. However, evidence from studies on the interaction of African Penguins with seismic operations

within 100 km of their colonies at Bird and St Croix Islands in Algoa Bay, suggest that behavioural avoidance of preferred foraging areas by diving individuals, could extend to as far as 100 km from the survey vessel. Birds were found to revert to normal foraging behaviour after seismic operations ceased.

For penguins who spend considerable time underwater while hunting, the impact zone for behavioural disturbance may, however, be larger than for plunge diving species that undertake short dives only before returning to the sea surface.

Due to the extensive distribution and feeding ranges of pelagic seabirds, the impact is considered to be of **low intensity**. For African penguins and Cape gannets, the impact would be of high intensity, but as the likelihood of encountering large numbers is low, the intensity is considered as **medium**. The duration of the impact on diving seabirds would be limited to the **short-term** (five months) and be restricted to the survey area (regional). The potential for behavioural avoidance is therefore considered to be of **very low magnitude** for pelagic diving seabirds and **low magnitude** for coastal diving seabirds.

Effects on Prey

As with other vertebrates, the assessment of indirect effects of seismic surveys on diving seabirds is limited by the complexity of trophic pathways in the marine environment. The impacts are difficult to determine and depend on the diet make-up of the bird species concerned and the effect of seismic surveys on the diet species. With few exceptions, most plunge-diving birds forage on small shoaling fish prey species that typically occur relatively close to the shore (<200 m depth) or associated with oceanic features such as the Child's Bank, Tripp Seamount or the Southeast Atlantic Seamounts. No information is available on the feeding success of diving seabirds in association with seismic survey noise. Although, seismic surveys have been reported to affect fish catches up to 30 km from the sound source, with effects persisting for a duration of up to 10 days, for the proposed Orange Basin survey relatively low behavioural risks are expected for fish species at far-field distances (thousands of metres). This could have implications for plunge-diving seabirds such as African penguins that forage in restricted areas within a given radius of their breeding sites. Similarly, pelagic seabirds that feed around seamounts may also be affected.

The broad ranges of potential fish prey species (in relation to potential avoidance patterns of seismic surveys of such prey species) and extensive ranges over which most seabirds feed, however, suggest the **intensity** of the impact is **very low** within the survey area (**regional**) over the **short-term** duration of the survey period (five months). Thus, the **magnitude** is **very low**.

Impact Significance

Based on the **medium sensitivity** of receptors and the **low magnitude**, the potential physiological impact on diving seabirds and behaviour avoidance of coastal diving seabirds (African penguins and Cape gannets) is of **low significance** (see Table 8-14 reflecting the most conservative case). The remainder of the impacts, considering a **medium sensitivity** and **very low magnitude**, are of **very low significance**.

Identification of Mitigation Measures

In addition to the mitigation recommended for cetaceans (see Section 8.4.1.1.1), the following is recommended for penguins and feeding aggregations of diving seabirds during seismic survey:

No.	Mitigation measure	Classification
1	Implement a "soft-start" procedure of a minimum of 20 minutes' duration on initiation of the seismic source if during daylight hours it is confirmed visually by the MMO during the pre-shoot watch (60 minutes) that there are no penguins or feeding aggregations of diving seabirds within 500 m of the seismic source.	Avoid / Abate on site
2	In the case of penguins and diving seabirds being observed within the mitigation zone, delay the "soft-start" until animals are outside the 500 m mitigation zone.	Avoid / Abate on site
3	Terminate seismic shooting on observation of penguins or feeding aggregations of diving seabirds within the 500 m mitigation zone. For penguins and feeding aggregations of diving seabirds, terminate shooting until such time as the animals are outside of the 500 m mitigation zone (seismic "pause", no soft-start required).	Abate on site

Residual Impact Assessment

The potential impacts cannot be eliminated due to the nature of the seismic sound source required during surveying. With the implementation of the mitigation measures, the intensity of the impact of physiological injury and behavioural avoidance reduces to low, thereby reducing **magnitude** to **very low** and overall significance to **VERY LOW** (see Table 8-14). All other impacts on feeding aggregations of diving seabirds remain of **VERY LOW significance**.

Table 8-14: Impact on penguins and feeding aggregations of diving seabirds from seismic noise

Project Phase:	**Operation**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**MEDIUM**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**LOW**	**VERY LOW**
Intensity	MEDIUM	LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**LOW**	**VERY LOW**
Probability	**LIKELY**	**POSSIBLE**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.4.1.1.5 Fish

Sensitivity of Receptors

The greatest risk of physiological injury from seismic sound sources is for species that establish home ranges on shallow- or deep-water reefs or congregate in areas to spawn or feed, and those displaying an instinctive alarm response to hide on the seabed or in the reef rather than flee. Such species would be associated with the seabed (at >200 m) or with Child's Bank, Tripp Seamount or the Southeast Atlantic Seamounts. The fish most likely to be encountered on the shelf, beyond the shelf break and in the offshore waters of proposed survey area are the large migratory pelagic species. In many of the large pelagic species, the swim-bladders are either underdeveloped or absent, and the risk of physiological injury through damage of this organ is therefore lower.

Many of the large pelagic fish and shark species likely to occur in the offshore regions characterising the Orange Basin are considered globally 'vulnerable' (e.g. bigeye tuna, blue marlin, oceanic whitetip shark, dusky shark, great white shark, longfin mako), 'endangered' (e.g. shortfin mako, whale shark) and 'critically endangered' (Southern bluefin tuna). However, the numbers of individuals encountered during the survey are likely to be low, even when these species are *en route* to or from recognised nursery or feeding grounds associated with Tripp Seamount, Child's Bank or the Southeast Atlantic Seamounts where greater concentrations of pelagic fish can be expected. The sensitivity of fish to seismic noise is considered to be **high**.

Impact Magnitude (or Consequence)

The potential impact of seismic noise on fish eggs and larvae is discussed under Section 8.4.1.1.7 related to Plankton below. Thus, this section discusses the impact on adult fish only.

Most species of fish and elasmobranchs are able to detect sounds from well below 50 Hz to upward of 500 - 1 000 Hz, and consequently can detect sounds within the frequency range of most widely occurring anthropogenic noises. Within the frequency range of 100 - 1 000 Hz at which most fish hear best, hearing thresholds vary considerably (50 and 110 dB re 1 µPa). They are able to discriminate between sounds, determine the direction of a sound, and detect biologically relevant sounds in the presence of noise. In addition, some clupeid fish can detect ultrasonic sounds to over 200 kHz. Fish that possess a coupling between the ear and swim-bladder have probably the best hearing of fish species, primarily based on pressure detection. As hearing thresholds differ among group of species, the impacts of seismic sounds are therefore specific.

The sound waves produced during seismic surveys are low frequency, with most energy at 20 - 150 Hz (although significant contributions may extend up to 500 Hz) and overlap with the range at which fish hear well. A review of the available literature suggests that potential impacts of seismic pulses to fish species (including sharks) could include physiological injury and mortality, behavioural avoidance of the seismic survey area, masking of environmental sounds and communication, disturbance to spawning and recruitment and indirect impacts due to effects on predators or prey.

Physiological Injury and Mortality

Studies have shown that fish can be exposed directly to the sound of seismic survey without lethal effects, outside of a very localised range of physiological effects. Physiological effects of impulsive airgun sounds on fish species include swim-bladder damage, transient stunning, short-term biochemical variations in different tissues typical of primary and secondary stress response, and temporary hearing loss due to destruction of the hair cells in the hearing maculae and haemorrhaging, eye damage and blindness.

Thus, there is a wide range of susceptibility among fish to seismic sounds, with those with a swim-bladder will be more susceptible to anthropogenic sounds than those without this organ. In many of the large pelagic species, which are most likely to be encountered in the study area, the swim-bladders are either underdeveloped or absent (e.g. many of the pelagic sharks and tunas), and the risk of physiological injury through damage of this organ is, therefore, lower. The vast majority of fish exposed to seismic sounds will in all likelihood be some distance from the source, where the sound level has attenuated considerably, only a very small number of animals in a large population can ever be directly killed or injured by sounds from seismic airgun arrays.

Based on the noise exposure criteria provided by Popper *et al.* (2014), the Sound Transmission Loss Modelling Study predicts that the maximum horizontal threshold distance for mortality or potential mortal injury (PTS) to fish species with a swim bladder is within 350 m of the airgun for a single pulse. However, fish species without swim bladders have higher injury impact thresholds, and therefore have smaller zones of potential injuries within 180 m from the array source. For recoverable injury, the zones of cumulative impact from multiple pulses are predicted to be within 10 m from the adjacent survey lines for fish without a swim bladder, and within 40 m for fish with a swim bladder. The zones of TTS effect for fish species with and without swim bladders are predicted to be within 2 000 m from the adjacent survey lines for the cumulative scenario at L1 and L2 and 1 200 m for L3 in deep water. It must be kept in mind that the cumulative zones of impact are conservative as most fish likely to be encountered in the Orange Basin are the highly migratory pelagic sharks, tunas and billfish, and are likely to have moved considerable distances over the cumulative 24-hr period. The zones of impact for PTS, TTS and recovery injury are presented in Table 8-15.

Table 8-15: Zones of immediate impact from single pulses and multiple pulses (cumulative) for fish

Type of animal	Zones of impact – maximum horizontal distances from source to impact threshold levels				
	Mortality & Mortal Injury		**Recovery injury**		**TTS**
	Immediate Impact from Single Pulses	**Cumulative Impact from Multiple Pulses**	**Immediate Impact from Single Pulses**	**Cumulative Impact from Multiple Pulses**	**Cumulative impact From Multiple Pulses**
Fish: no swim bladder (particle motion detection)	180 m	< 10 m	180 m	< 10 m	L1 & L2: 2 000 m L3: 1 200 m
Fish: swim bladder is not involved in hearing (particle motion detection)	350 m	< 10 m	350 m	40 m	L1 & L2: 2 000 m L3: 1 200 m
Fish: swim bladder involved in hearing (primarily pressure detection)	350 m	15 m	300 m	40 m	L1 & L2: 2 000 m L3: 1 200
Note: if the zone of impact for cumulative is smaller than that for the single pulse, then the marine species are likely to be more sensitive to pressure impact than energy impact.					

Child's Bank and Tripp Seamount lie within and approximately 25 km to the north of the northern boundary of the proposed survey area, respectively, and any demersal fish species associated with these important fishing banks would receive the seismic noise within the far-field range, and outside of distances at which physiological

injury or avoidance would be expected. The Southeast Atlantic Seamounts lie over 100 km south of the southern extreme of the proposed survey area. The potential impact of seismic noise on physiological injury of **demersal species** is thus rated as of **very low intensity**.

Possible injury or mortality in pelagic species could occur on initiation of a sound source at full pressure in the immediate vicinity of fish, or where reproductive or feeding behaviour override a flight response to seismic survey sounds. The potential impact of seismic noise on the injury or mortality of **pelagic species** is thus considered to be of **high intensity**.

Overall, as a conservative approach, the physiological injury and mortality impact on fish is thus considered to be of **high intensity**, limited to the survey area (**regional extent**) and for the **short-term** duration of the survey (five months). Thus, the **magnitude** of the impact would be **medium**.

Behavioural Avoidance

Behavioural responses to impulsive sounds are varied and include leaving the area of the noise source, changes in depth distribution, spatial changes in schooling behaviour and startle response to short range start up or high-level sounds. Behavioural responses, such as avoidance of seismic survey areas and changes in feeding behaviours of some fish to seismic sounds, have been documented at received levels of about 160 dB re 1 µPa, with disturbance ceasing at noise levels below this. In some cases, behavioural responses were observed at up to 5 km distance from the firing airgun array. Based on the noise exposure criteria provided by Popper *et al.* (2014), relatively high to moderate behavioural risks are expected at near to intermediate distances (tens to hundreds of meters) from the source location. Relatively low behavioural risks are expected for fish species at far field distances (thousands of meters) from the source location.

Behavioural effects are generally short-term, however, with duration of the effect being less than or equal to the duration of exposure, although these vary between species and individuals, and are dependent on the properties of the received sound. In some cases, behaviour patterns returned to normal within minutes of commencement of surveying indicating habituation to the noise. The ecological significance of such effects is, therefore, expected to be low, except in cases where they influence reproductive activity or result in delayed mortality.

Seismic activities have been predicted to possibly affect the migration patterns of tuna leading to substantially reduced catches of Tuna in southern Namibia. In the Benguela region it has been suggested that the seasonal movement of Longfin Tuna northwards from the West Coast of South Africa into southern Namibia may be disrupted by the noise associated with seismic surveys. Longfin Tuna and other tuna species migrations are known to be highly variable from year to year and are associated with prey availability, as well as favourable oceanographic conditions. Links between changes in migration patterns and subsequent catches remain speculative.

Behavioural effects are generally short-term, however, with duration of the effect being less than or equal to the duration of exposure, although these vary between species and individuals, and are dependent on the properties of the received sound. The potential impact on individual fish behaviour is considered to be of **high intensity**. The behavioural impact on fish is limited to the survey area (**regional**) and for the **short-term** duration of the survey (five months). Thus, the **magnitude** of the impact would be **medium**.

Spawning and Recruitment

Although the effects of airgun noise on spawning behaviour of fish have not been quantified to date, it is predicted that if fish are exposed to powerful external forces on their migration paths (as discussed above) or

spawning grounds, they may be disturbed or even cease spawning altogether. The deflection from migration paths may be sufficient to disperse spawning aggregations and displace spawning geographically and temporally, thereby affecting recruitment to fish stocks. The magnitude of effect in these cases will depend on the biology of the species and the extent of the dispersion or deflection. Depending on the physical characteristics of the area, the range of the impact may extend beyond 30 km and could thus potentially affect subsequent recruitment to fish stocks if spawning is displaced geographically or temporally. Dalen *et al.* (1996), however, recommended that in areas with concentrated spawning or spawning migration, seismic shooting be avoided at a distance of approximately 50 km from these areas, particularly when subjected to repeated, high intensity surveys.

The spawning areas of the small pelagic shoaling species are distributed on the continental shelf and along the shelf edge from Lambert's Bay to Mossel Bay, with the major spawning grounds for most species (anchovy, round herring, horse mackerel, chub mackerel) located east of Cape Point. There is therefore some overlap of the eastern sections of the proposed 2D survey area with the migration routes and spawning areas of these commercially important small pelagic species (see Figure 7-16).

If behavioural responses to seismic noise result in deflection from coastal migration routes or disturbance of spawning, further impacts may occur that may affect recruitment to fish stocks. The intensity of effect in these cases will depend on the biology of the species and the extent of the dispersion or deflection. Considering the current low biomass of sardine, particularly west of Cape Agulhas, recent successive years of low recruitment and the dependence of future recruitment on successful West Coast spawning (Shabangu *et al.* 2019) the intensity of the potential impact of the proposed 2D survey can be considered as **medium**. Despite the wide range over which the potentially affected shoaling species occur, the duration of the proposed survey (up to 5 months) could result in the impact on the spawning success extending into the **medium term**, while of **regional** extent. Thus, the **magnitude** of the impact would be considered as **medium**.

Masking of Environmental Sounds and Communication

While some nearshore reef species are known to produce isolated sounds or to call in choruses, communication and the use of environmental sounds by fish in the offshore environment off the South African West Coast are unknown. Demersal species in abyssal and continental slope habitats or associated with Child's Bank or Tripp Seamount would receive the seismic noise in the far field and vocalisation, should it occur, is unlikely to be masked. Impacts arising from masking of sounds are thus expected to be of **very low intensity** due to the duty cycle of seismic surveys in relation to the more continuous biological noise. Such impacts would occur across the survey area (**regional**) and for the **short-term** duration of the survey (five months). Thus, the impact is considered to be of **very low magnitude**.

Effects on Predators or Prey

The assessment of indirect effects of seismic surveys on fish is limited by the complexity of trophic pathways in the marine environment. The impacts are difficult to determine are depend on the diet make-up of the fish species concerned and the effect of seismic surveys on the diet species.

Indirect impacts of seismic surveying could include attraction of predatory species such as sharks, tunas or diving seabirds to pelagic shoaling fish species stunned or injured by seismic noise. In such cases, where feeding behaviour overrides a flight response to seismic survey sounds, injury or mortality could result if the seismic sound source is initiated at full power in the immediate vicinity of the feeding predators. Little information is available on the feeding success of large migratory fish species in association with seismic survey noise. The pelagic shoaling species that constitute the main prey item of migratory pelagic species typically occur

inshore of the 200 m depth contour. Considering the extensive range over which large pelagic fish species can potentially feed in relation to the survey area, and the likely low abundance of pelagic shoaling species in the offshore regions, the **intensity** of the impact would be **low**, restricted to the survey area (**regional**) and persisting over the **short-term** only (five months). Thus, the impact is of **very low magnitude**.

Impact Significance

Based on the **high sensitivity** of receptors and the **medium magnitude**, the impact of physiological injury and behaviour are of **medium significance** (see Table 8-16 reflecting the most conservative case), while the remainder are of **low significance**.

Identification of Mitigation Measures

In addition to the mitigation recommended for cetaceans (see Section 8.4.1.1.1), the following is recommended for fish during seismic survey:

No.	Mitigation measure	Classification
1	Implement a "soft-start" procedure of a minimum of 20 minutes' duration on initiation of the seismic source if during daylight hours it is confirmed visually by the MMO during the pre-shoot watch (60 minutes) that there are no shoaling large pelagic fish within 500 m of the seismic source.	Avoid / Abate on site
2	Undertake the survey from the North to South in order to avoid the spring and summer spawning along the shelf edge and on the continental shelf south of St Helena Bay.	Avoid / Abate on site
3	In the case of shoaling large pelagic fish being observed within the mitigation zone, delay the "soft-start" until animals are outside the 500 m mitigation zone.	Avoid / Abate on site
4	Terminate seismic shooting on: • observation of slow swimming large pelagic fish (including whale sharks, basking sharks, manta rays and devil rays) within the 500 m mitigation zone. • observation of any obvious mass mortalities of fish (specifically large shoals of tuna or surface shoaling small pelagic species such as sardine, anchovy and mackerel) when estimated by the MMO to be as a direct result of the survey. For slow swimming large pelagic fish, terminate shooting until such time as the animals are outside of the 500 m mitigation zone (seismic "pause", no soft-start required).	Abate on site

Residual Impact Assessment

The potential impacts cannot be eliminated due to the nature of the seismic sound source required during surveying. The proposed mitigation measures, which are designed to avoid key spawning areas and keep animals out of the immediate area of impact and thereby reduce the risk of deliberate injury to fish, reduce the intensity of the impacts relating to physiological injury to medium, the residual impacts will reduce to **low magnitude** and of **LOW significance** (see Table 8-16). All other impacts on fish remain of **LOW significance**.

Table 8-16: Impact on fish from seismic noise

Project Phase:	**Operation**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**HIGH**	
	Pre-Mitigation Impact	**Residual Impact**

Magnitude (Consequence)	MEDIUM	LOW
Intensity	HIGH	MEDIUM
Extent	REGIONAL	REGIONAL
Duration	MEDIUM TERM	SHORT TERM
Significance	**MEDIUM**	**LOW**
Probability	**LIKELY**	**POSSIBLE**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.4.1.1.6 Marine Invertebrates

Sensitivity of Receptors

The proposed survey area lies well offshore where the pelagic and benthic ecosystem threat status is considered of 'Least concern', with the exception of the shelf edge and Cape Canyon, which is considered 'Vulnerable' with isolated portions being rated as 'Endangered' (Cape Upper Canyon and Southern Benguela Muddy Shelf Edge). Most ecosystem types outside the offshore MPAs are either poorly protected or not protected at all.

Pelagic invertebrates that may occur in the Orange Basin are the giant squid, which is a deep dwelling species confined to the continental slopes. This species could thus potentially occur in the survey area, although the encounter likelihood is extremely low.

The sensitivity of benthic invertebrates is considered to be very low, whereas for neritic and pelagic invertebrates the sensitivity can be considered low. Following the precautionary principle, the sensitivity is considered to be **low**.

Impact Magnitude (or Consequence)

Many marine invertebrates have tactile organs or hairs (termed mechanoreceptors), which are sensitive to hydro-acoustic near-field disturbances, while some have highly sophisticated statocysts, which are thought to be sensitive to the particle acceleration component of a sound wave in the far-field. Potential impacts of seismic pulses on invertebrates would include physiological injury or mortality in the immediate vicinity of the airgun sound source and behavioural avoidance (direct impact). Masking of environmental sounds and indirect impacts due to effects on predators or prey have not been documented and are highly unlikely and are, thus, not discussed below.

Physiological Injury or Mortality

Although there is little published information on the effects of seismic surveys on invertebrate fauna, lethal and sub-lethal effects have been observed under experimental conditions where invertebrates were exposed to airguns at close range. These include reduced growth and reproduction rates in crustaceans. Other field-based studies on adult invertebrate populations (including scallops, clams or lobsters, a variety of reef-associated invertebrates, snow crabs and shrimp) have shown a range of results from no physiological damage or evidence of increased mortality in response to airgun exposure to effects on egg and embryo development and larvae size.

As the survey would largely be undertaken at depths beyond 100 m, the received noise by benthic invertebrates at the seabed would be within the far-field range, and outside of distances at which physiological injury would be expected. Thus, potential physiological injury or mortality to benthic invertebrates is considered to be of very low intensity.

Exposure of various species of caged cephalopods to low frequency sounds revealed lesions in the statocysts, consistent with a massive acoustic trauma. Potential physiological injury or mortality of pelagic cephalopods is considered to be of low intensity, since the distribution of mobile neritic and pelagic squid is naturally spatially highly variable and the numbers of giant squid likely to be encountered is low.

Overall, as a conservative approach, the impact on invertebrates is considered to be of **low intensity**, limited to the survey area (**regional extent**) and for the **short-term** duration of the survey (five months). Thus, the **magnitude** of the impact would be **very low**.

Behavioural Avoidance

Behavioural responses of invertebrates to particle motion of low frequency stimulation has been measured by numerous researchers. A wide range of responses have been reported ranging from no avoidance by free ranging invertebrates (crustaceans, echinoderms and molluscs) of reef areas to no reduction in catch rates of shrimp, prawns or rock lobsters in the near-field during or after seismic surveys. Startle responses and alarm behaviour in decapods has been observed when animals in close proximity to the sound source (<0.10 m). Other research has shown that low frequency noise being successful in deterring barnacle larvae from settling on ship hulls. Changes in predator avoidance behaviours may, however, have population-level implications if predation rates increase due to sound-induced behavioural changes in prey. The received noise at the seabed, considering a water depth of more than 100 m as in the survey area, would be within the far-field range and outside of distances at which avoidance of benthic invertebrates would be expected. Thus, the potential behavioural avoidance by benthic invertebrates could be of very low intensity.

Cephalopods, in contrast, may be receptive to the far-field sounds of seismic airguns, with reported responses including alarm response (e.g. jetting of ink), changes in behaviour (aggression and spawning), position in the water column and swimming speeds. Behavioural changes have been observed in squid at 2 to 5 km from an approaching large seismic source, although recent research has shown that a gradual increase in signal intensity and prior exposure to airgun noise would decrease the severity of the alarm responses, suggesting that animals became accustomed to the noise at low levels. The potential impact of seismic noise on behavioural avoidance of pelagic cephalopods could potentially be of low intensity, as distribution of mobile neritic and pelagic squid is naturally spatially highly variable and the numbers of giant squid likely to be encountered is low.

Overall, as a conservative approach, the impact on invertebrates is thus considered to be of **low intensity**, limited to the survey area (**regional**) and for the **short-term** duration of the survey (five months). Thus, the **magnitude** of the impact would be **very low**.

Impact Significance

Based on the **low sensitivity** of receptors and the **very low magnitude**, the potential impacts on marine invertebrates (both physiological injury or mortality and behavioural avoidance) are considered to be of **negligible significance** without mitigation (see Table 8-17).

Identification of Mitigation Measures

In addition to the mitigation recommended for cetaceans (see Section 8.4.1.1.1), the following is recommended for invertebrates during seismic survey:

No.	Mitigation measure	Classification
1	Terminate seismic shooting on observation of any obvious mass mortalities of squid when estimated by the MMO to be as a direct result of the survey.	Abate on site

Residual Impact Assessment

The potential impacts cannot be eliminated due to the nature of the seismic sound source required during surveying. With the implementation of the mitigation measures, which would reduce the intensity of the impact to very low, the residual impact will remain of **very low magnitude** and of **NEGLIGIBLE significance** (see Table 8-17).

Table 8-17: Impact on marine invertebrates from seismic noise

Project Phase:	**Operation**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**LOW**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	LOW	VERY LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**
Probability	**POSSIBLE**	**UNLIKELY**
Confidence	**MEDIUM**	**MEDIUM**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**LOW**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.4.1.1.7 Plankton species

Sensitivity of Receptors

The proposed survey area lies on the outer edge of the Namaqua and Cape Columbine upwelling cells (see Figure 7-9). Phytoplankton and zooplankton abundance in the clear offshore waters of the Benguela Current are thus expected to be low, although seasonal peaks may occur associated with Child's Bank and Tripp Seamount. The major spawning areas of the small pelagic shoaling species are on the continental shelf and along the shelf edge from Lambert's Bay to Mossel Bay. The eggs and larvae are carried around Cape Point and up the coast in northward flowing surface waters. At the start of winter every year, the juveniles recruit in large numbers into coastal waters across broad stretches of the shelf between the Orange River and Cape Columbine to utilise the shallow shelf region as nursery grounds before gradually moving southwards in the inshore southerly flowing

surface current, towards the major spawning grounds east of Cape Point. There is therefore some overlap of the eastern sections of the proposed 2D survey area with the West Coast spawning areas and the northward egg and larval drift of commercially important species, and the return migration of recruits (see Figure 7-16). Ichthyoplankton abundance in the inshore portions of the proposed survey area is thus likely to be seasonally high.

Phytoplankton are not known to be affected by seismic surveys and are unlikely to show any significant effects of exposure to airgun impulses outside of a 1 m distance (Kosheleva 1992; McCauley 1994).

Zooplankton comprises meroplankton (organisms which spend a portion of their life cycle as plankton, such as fish and invertebrate larvae and eggs) and holoplankton (organisms that remain planktonic for their entire life cycle, such as siphonophores, nudibranchs and barnacles). The abundance and spatial distribution of zooplankton is highly variable and dependent on factors such as fecundity, seasonality in production, tolerances to temperature, length of time spent in the water column, hydrodynamic processes and natural mortality. Zooplankton densities are therefore generally patchily distributed.

Invertebrate members of the plankton that have a gas-filled flotation aid, may be more receptive to the sounds produced by seismic airgun arrays, and the range of effects may extend further for these species than for other plankton.

Phytoplankton, zooplankton and ichthyoplankton abundances in the survey area are expected to be low, and (if they occur) have a highly patchy distribution and seasonally high abundances. Although plankton distribution is naturally temporally and spatially variable and natural mortality rates are high, the overall sensitivity is considered **medium** due to the potential reduced reproductive success in some of the small pelagic species.

Impact Magnitude (or Consequence)

Potential impacts of seismic pulses on plankton and fish eggs / larvae would include physiological injury or mortality in the immediate vicinity of the airgun sound source. The amount of exposure that plankton can withstand due to the influence of seismic sound is dependent on a wide range of variables, namely (1) the presence of gas-filled flotation aids (as plankton with gas filled cavities may be more receptive to the sounds produced by seismic airgun arrays), (2) temporal and spatial variability in occurrence (due to plankton abundance varying in time and space) , and (3) proximity to the sound source.

Due to their importance in commercial fisheries, numerous studies have been undertaken experimentally exposing the eggs and larvae of various zooplankton and ichthyoplankton species to airgun sources. These studies generally identified that for a large seismic array, mortalities and physiological injuries occurred at very close range (<5 m) only. Changes have also been observed in the buoyancy of the organisms, in their ability to avoid predators and effects that affect the general condition of larvae, their growth rate and thus their ability to survive. Temporary disorientation juvenile fry was recorded for some species.

There has been conflicting research in terms of the impact on the total plankton population. McCauley (1994) initially concluded that when compared with total population sizes or natural mortality rates of planktonic organisms, the relative influence of seismic sound sources on these populations can be considered insignificant. However, more recently McCauley *et al.* (2017) demonstrated significant declines in zooplankton abundance within a maximum range of 1.2 km of the airguns' passage. This is contrary to the findings of Sætre & Ona (1996) who calculated that, under the "worst case" scenario, the number of larvae killed during a typical seismic survey was 0.45% of the total larvae population. Richardson *et al.* (2017) estimated that while zooplankton populations

declined 22% within the survey area, biomass recovery occurred within three days following survey completion and any effects on zooplankton by seismic noise would endure in the very short term only. The authors stressed that impacts in areas of dynamic ocean circulation are likely to be even less.

Based on the noise exposure criteria provided by Popper *et al.* (2014), the Sound Transmission Loss Modelling Study predicts that the maximum horizontal threshold distance for mortality or potential mortal injury (PTS) to fish eggs and larvae is 350 m for a single pulse and < 10 m for multiple pulses (cumulative)[14]. Maximum threshold distances for recoverable injury and TTS for fish eggs and larvae were not reached. Areas with high plankton productivity (e.g. in inshore spawning areas) are thus located well beyond the influence of seismic pulses from within the proposed survey area, and is unlikely to result in significant declines in zooplankton abundance.

As the proposed survey is scheduled for the summer survey window (start December to end May) over a five-month period, there will be some temporal overlap with the spawning products of commercially important species. As plankton distribution is naturally temporally and spatially variable and natural mortality rates are high, and most of the survey area lies west of the West Coast northward egg and larval drift and return migration of recruits, any impacts would be of **low intensity** for phytoplankton and zooplankton, but of **medium intensity** for ichthyoplankton. Although the impact is restricted to within a few hundred metres of the airguns, it would extend over the entire survey area (**regional extent**). The impact would be of **short-term** duration (five months) in the case of phytoplankton and zooplankton due to the naturally rapid turn-over rate of these plankton communities, but could persist over the medium term in the case of ichthyoplankton (particularly the sardine stock, which is experiencing successive years of low recruitment). The **magnitude** of the impact would therefore be **very low** for phytoplankton and zooplankton, but **medium** for ichthyoplankton.

Impact Significance

Based on the **medium sensitivity** of receptors and the **very low to medium magnitude**, using the precautionary approach, the potential impact on plankton fauna is considered to be of **medium significance** without mitigation (see Table 8-18).

Identification of Mitigation Measures

The mitigation recommended for cetaceans and fish species, namely undertaking the survey from North to South would help to avoid the spring and summer spawning periods in the inshore areas of the proposed survey area. No other measures to mitigate the impacts of seismic sounds on plankton are deemed necessary or practical.

Residual Impact Assessment

This potential impact cannot be eliminated due to the nature of the seismic sound source required during surveying. With the implementation of the recommended mitigation measure, the **intensity** would **reduce to low**, and the duration to the **short term**, while the extent remains **regional**. Thus, the residual impact reduces to of **VERY LOW significance** (see Table 8-18).

[14] Note: if the zone of impact for cumulative is smaller than that for the single pulse, then the marine species are likely to be more sensitive to pressure impact than energy impact.

Table 8-18: Impact on plankton from seismic noise

Project Phase:	Operation	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**Medium**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**MEDIUM**	**VERY LOW**
Intensity	LOW	LOW
Extent	REGIONAL	REGIONAL
Duration	MEDIUM TERM	SHORT TERM
Significance	**MEDIUM**	**VERY LOW**
Probability	**LIKELY**	**LIKELY**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**MEDIUM**	**LOW**
Mitigation Potential	**-**	**NONE**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.4.1.2 Impact on Commercial Fishing

Source of Impact

The project activities that are likely to affect commercial fishing resource due to noise are provided below:

Project phase	Activity
Mobilisation	N/A
Operation	Seismic acquisition, including the deployment of equipment (sources and streamers) and acquisition operations
Demobilisation	N/A

The operation of the airguns during surveying will introduce underwater noise into the surrounding water column that will contribute to and/or exceed ambient noise levels in the area.

Impact Description

Elevated noise levels could impact fish (**direct negative** impact) by (also refer to Section 8.4.1.1.5):

- Causing direct physical injury to hearing or other organs;
- Masking or interfering with other biologically important sounds (e.g. communication, echolocation, signals and sounds produced by predators or prey);
- Causing disturbance to the receptor resulting in behavioural changes or displacement from important feeding or breeding areas; and
- Disruption of spawning and recruitment.

These could have an impact on commercial fisheries that operate in the area through the reduction in catch rates and/or an increase in fishing effort (**indirect negative** impact). Information on the spatial distribution and catch effort of the commercial fishing sectors that operate off the West Coast region is presented in Section 7.7.

Project Controls

The seismic contractor will ensure that the proposed surveys are undertaken in a manner consistent with good international industry practice and BAT regarding fisheries management.

Sensitivity of Receptors

Several fisheries operate within the Orange Basin and could, therefore be affected by a reduction in catch rates or required increase in fishing effort related to direct noise impacts on commercial fish species. The seven main fishing sectors that operate within the proposed survey area are demersal trawl, mid-water trawl, small pelagic purse-seine, demersal long-line, large pelagic long-line, tuna pole and traditional line fish. The area of noise impact does not overlap with fishing grounds of the west coast rock lobster, small-scale fishing and beach-seine and gillnet fisheries along the West Coast.

Sensitivity and hearing range is highly variable amongst fish species. Data indicates that fish possessing a swim bladder are more sensitive to impulsive sounds, such as those generated by an acoustic source, than fish without swim bladders (Popper *et al.,* 2014). The sensitivity of each of the fishing sectors active in the proposed survey area depends on the vulnerability of the fish species being targeted. The greatest risk of physiological injury and related behavioural avoidance from seismic sound sources is for species with swim-bladders (e.g. hake and other demersal species targeted by demersal long-line and demersal trawl fisheries). In many of the large pelagic species, however, the swim-bladders are either underdeveloped or absent, and the risk of physiological injury through damage of this organ is therefore lower. Two of the four tuna species targeted in South African waters (yellowfin and bigeye) do, however, have swim bladders and may thus be more vulnerable.

Consequently, the sensitivity of the demersal trawl, midwater trawl, demersal long-line, small pelagic purse-seine, large pelagic long-line and tuna pole sectors is considered to be **medium** whereas the sensitivity of the traditional linefish sector is considered to be **low**.

Impact Magnitude (or Consequence)

The potential impacts of seismic pulses to fish species could include physiological injury / mortality and behavioural avoidance of the seismic survey area.

Studies have shown that physical damage to fish caused from acoustic sources occurs only in their immediate vicinity, in distances of less than a few meters. Based on the noise exposure criteria provided by Popper et al. (2014), the Sound Transmission Loss Modelling Study predicts that the maximum horizontal threshold distance for mortality or potential mortal injury (PTS) to fish species with a swim bladder is within 350 m of the airgun for a single pulse. However, fish species without swim bladders have higher injury impact thresholds, and therefore have smaller zones of potential injuries within 180 m from the array source. Multiple pulses TTS in fish could be experienced up to 2 000 m from the airgun (see Table 8-15).

Behavioural responses to impulsive sounds are varied and any changes in spawning, migration and feeding behaviour of fishes in response to seismic shooting could affect fisheries through reduced catches resulting

from changes in feeding behaviour, abundance and vertical distribution. Such behavioural changes could lead to decreased commercial catch rates if fish move out of important fishing grounds.

Reports on observed declines in catch rates differ considerably between studies, however, behavioural effects are generally short-term in nature, with duration of the effect being less than or equal to the duration of exposure, although these vary between species and individuals, and are dependent on the properties of the received sound. In some cases, behaviour patterns returned to normal within minutes of commencement of surveying indicating habituation to the noise.

Behavioural responses, such as avoidance of seismic survey areas and changes in feeding behaviours in response to seismic sounds, have been documented to occur at received levels of about 160 dB re 1 µPa, with disturbance ceasing at noise levels below this level. Based on the noise exposure criteria provided by Popper *et al*. (2014), relatively high to moderate behavioural risks are expected at near to intermediate distances (tens to hundreds of meters) from the source location. Relatively low behavioural risks are expected for fish species at far field distances (thousands of meters) from the source location. In some cases, behavioural responses have been observed at up to 5 km distance from the firing airgun array (Santulli *et al*. 1999; Hassel *et al*. 2004; Dalen *et al*. 2007). Considering the immediate exposure from single pulse, a sound level (Root-Mean-Square Sound Pressure Level) of about 160 dB re 1 µPa (i.e. the level at which fish disturbance is believed to cease) would be experienced at about 4 km from the source array.

As described in Section 8.4.1.1.5, behavioural responses to impulsive sounds are varied and include leaving the area of the noise source, changes in depth distribution and feeding behaviour, spatial changes in schooling behaviour, and startle response to short range start up or high-level sounds.

Due to the variability in research on changes in catch rates caused by seismic surveys, the commercial fisheries specialist has rated the intensity of the impact as medium in accordance with a precautionary approach.

Based on the overlap of fishing grounds with the affected area (to a distance of 4 000 m around the licence area), the impact has been rated as being of regional extent.

Behavioural effects are generally short-term, with duration of the effect being less than or equal to the duration of exposure, although these vary between species. The effects on catch rates have been shown to persist for up to 10 days after noise exposure. The potential impact on catch rates could therefore be considered to be of temporary or short-term duration.

Taking the above into account, the magnitude of the impact on all the fishing sectors operating in the area have been assessed as **low**.

Impact Significance

Based on the sensitivity of receptors and impact magnitude, the potential impacts on the fishing sectors along the West Coast are considered to be of **low** significance.

Identification of Mitigation Measures

In addition to the mitigation listed for the impact on fish (see Section 8.4.1.1.5), the following is recommended to reduce the disruption of fishing activities related to the resource availability for seismic survey:

No.	Mitigation measure	Classification
1	At least three weeks prior to the commencement of the seismic survey, notify via email or other means the following key stakeholders of the proposed activity (including navigational co-ordinates of the vessel operational area (inclusive of the acquisition area, run-ins and vessel turning circles), timing and duration of proposed activities) and the likely implications thereof (specifically the safety clearance requirements around the vessel and towed array): • Fishing industry / associations: SA Tuna Association; SA Tuna Longline Association, Fresh Tuna Exporters Association, South African Deepsea Trawling Industry Association (SADSTIA), South African Hake Longline Association (SAHLLA), South African Pelagic Fishing Industry Association (SAPFIA), South African Midwater Trawling Association, South African Linefish Associations (various) and South African Marine Linefish Management Association (SAMLMA). • Other key stakeholders: SAN Hydrographer, South African Maritime Safety Association, Ports Authority and the DFFE Vessel Monitoring, Control and Surveillance Unit in Cape Town. These stakeholders should again be notified when the seismic survey vessel and support vessels are off location.	Avoid
2	Request, in writing, the HydroSAN to broadcast a navigational warning via Navigational Telex (Navtext) for the duration of the activity. Distribute a Notice to Mariners prior to the commencement of the seismic survey operations. The Notice to Mariners should give notice of (1) the co-ordinates of the survey area, (2) an indication of the proposed survey timeframes, (3) the dimensions of the towed gear array and dimensions of the safety zone around the seismic vessel, and (4) provide details on the movements of support vessels servicing the project. This Notice to Mariners should be distributed timeously to fishing companies and directly onto vessels where possible.	Avoid
3	Ensure at a minimum, one Fisheries Liaison Officer (FLO) person (speaking English and Afrikaans) is on board each escort vessel to facilitate communication in the local language with the fishing vessels that are in the area.	Abate on site
4	For the duration of the survey, circulate a daily survey schedule (look-ahead), via email, to key fishing associations.	Avoid
5	Establish a functional grievance mechanism that allows stakeholders to register specific grievances related to operations, by ensuring they are informed about the process and that resources are mobilized to manage the resolution of all grievances, in accordance with the Grievance Management procedure.	Abate on site
6	Avoid surveying over the Cape Canyon during December during which the tuna pole line sector shows an increase in fishing activity in this area.	Avoid

Residual Impact Assessment

The residual impact of underwater sound produced by the seismic survey on relative catch rates are assessed as of **low** significance (see Table 8-19)

Table 8-19: Impact of underwater noise on catch rates of commercial fisheries

Project Phase:	Operational
Type of Impact	**Direct**
Nature of Impact	**Negative**
Sensitivity of Receptor	**MEDIUM (fish with swim bladders)**

	Pre-Mitigation Impact	Residual Impact
Magnitude (Consequence)	**LOW**	**LOW**
Intensity	MEDIUM (precautionary approach)	MEDIUM
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**LOW**	**LOW**
Probability	**POSSIBLE TO PROBABLE**	**POSSIBLE TO PROBABLE**
Confidence	**MEDIUM**	**MEDIUM**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**NONE**
Cumulative potential	**POSSIBLE**	**POSSIBLE**

8.5 TEMPORARY EXCLUSION ZONE

8.5.1.1 Impact on Commercial Fishing

Source of Impact

The project activities that may reduce fishing grounds are:

Project phase	Activity
Mobilisation	N/A
Operation	Operation of seismic survey vessel and seismic array
Demobilisation	N/A

Under the Convention on the International Regulations for Preventing Collisions at Sea (COLREGS, 1972, Part A, Rule 10), a seismic vessel that is engaged in surveying is defined as a "vessel restricted in its ability to manoeuvre" which requires that power-driven and sailing vessels give way to a vessel restricted in her ability to manoeuvre. In addition to a statutory 500 m safety zone, a seismic contractor will request a safe operational area (that is greater than the 500 m safety zone) that it would like other vessels to stay beyond. The dimension of the exclusion zone to other vessels would be approximately 7 km ahead, 4 km to either side and 11 km astern. Unauthorised vessels may not enter the exclusion zone.

Potential Impact Description

The implementation of a safe operational zone around the seismic vessel and survey array will effectively temporarily exclude fishing from portions of the survey area at any one time. The temporary exclusion of fisheries from the safety zone will effectively reduce fishing grounds, which in turn could potentially result in a loss of catch and/or increased fishing effort (**direct negative** impact).

Project Controls

At least one escort vessel with appropriate radar and communications will patrol the area during the seismic survey to ensure that other vessels adhere to the safe operational limits. This vessel would assist in alerting

other vessels (e.g. fishing, cargo vessels, etc.) about the survey and the lack of manoeuvrability of the survey vessel.

Sensitivity of Receptors

An overview of each commercial fishing sector operating off the West Coast region is presented in Section 7.7, with the proportional percentage catch and effort within the proposed survey area summarised in Table 8-20 below.

Several fisheries operate within portions of the proposed survey area and could, therefore be affected by the temporary exclusion from fishing grounds. Of the 10 fishing sectors that operate off the West Coast, the pelagic long-line, demersal trawl, mid-water trawl, demersal long-line, small pelagic purse-seine, tuna pole and traditional linefish fishing grounds overlap with the proposed survey area. The proposed survey area does not overlap with the inshore fishing grounds of the West Coast rock lobster, small-scale fishery and beach-seine and gillnet fisheries.

The sensitivity of a particular fishing sector to the impact of an exclusion zone would differ according to the degree of disruption to fishing operations. Disruption would largely depend on the type of gear used by the particular fishery and the probability that the fishing operation can be relocated away from the affected area (the exclusion zone) into alternative fishing areas. For instance, those that set fishing gear for extended periods (i.e. longlines anchored at the seabed or drifting longlines) are more susceptible to exclusion than those more mobile operations (i.e. trawl nets towed directly behind the vessel). Pelagic longline vessels set a drifting mainline, which may be up to 100 km in length, and while setting or hauling a longline the vessel's manoeuvrability is restricted. Thus, a vessel cannot easily manoeuvre out of the way of an approaching survey vessel. Similarly, demersal longline vessels are severely restricted when hauling a line. In the case of the large pelagic longline sector, the targeted fish stock may only be available in a specific area for a specific period of time. Relocation to an alternative area may not be viable as the preferred area is predicated on the resource being available at a specific time and place.

For this reason, demersal long-line, large pelagic long-line and tuna pole sectors have been categorised as having **high** sensitivity. The sensitivity of the demersal trawl and mid-water trawl sectors are considered to be **medium**, while the sensitivity of the small pelagic purse-seine and traditional line fish sectors is considered to be **low**.

Table 8-20: Summary of proportional catch and effort by fishing sector within the proposed survey area

Sector	% of National Catch	% of National Effort	Seasonality of fishing effort M = low to moderate, H = high
Demersal trawl	35.1	25.2	H – entire year
Mid-water trawl	4.1	11.9	M – December to March H – April to November
Small pelagic purse-seine	1.9	1.8	M – October to January H – February to September
Demersal longline	27.3	27.6	M – June to September H – October to May
Large pelagic longline	15	18.6	M – December to April H – May to November
Tuna pole	51.6	44.1	M – January to October H – November to December
Traditional line fish	0.01	0.02	M – January to September

Sector	% of National Catch	% of National Effort	Seasonality of fishing effort M = low to moderate, H = high
			H – October to December

Impact Magnitude (or Consequence)

Based on the location and overlap of the fishing grounds for the different sectors, the impact on the demersal longline, large pelagic longline and tuna pole sectors have been assessed as similar, with the impact on demersal trawl and mid-water trawl assessed as similar and pelagic purse-seine and traditional line fish assessed as similar.

Demersal trawl

The demersal trawl sector (i.e. trawling for fish on the seafloor) targets primarily hake and is the sector with the highest economic value in South Africa. This fishery comprises an offshore and inshore fleet. The offshore fleet operates along the shelf edge between the 200 m and 1 000 m bathymetric contours, although most effort is expended in the 300 m to 600 m depth range. The proposed survey area covers approximately 55.31% of the total trawlable ground used by the sector in South African waters (see Figure 7-35). Average annual catch and effort expended within the proposed survey area between the 200 m and 1 000 m depth contours for the period 2008 to 2016 amounted to approximately 35.1% (3 828 tons) and 25.2% (2 530 trawl hours), respectively. The fishery operates continuously throughout the year with no clear seasonality.

Midwater trawl

The mid-water trawl fishery targets adult horse mackerel and operates predominantly in water depths from 100 m to 400 m with isolated trawls occasionally recorded up to 650 m. Fishing grounds overlap with inshore areas of the proposed survey area between Saldanha Bay and Cape Point between the 200 m and 500 m depth contours (see Figure 7-37). The proposed survey area coincides with approximately 11.1% of the total trawlable ground used by the sector in South African waters. Average annual catch and effort expended within the proposed survey area between 2000 and 2016 amounted to approximately 4.1% (790 tons) and 11.9% (229 trawl hours), respectively. The fishery operates continuously throughout the year, with no clear seasonality.

Small pelagic purse-seine

The small pelagic purse-seine fishery targets pilchard, anchovy and round herring and operates up to a maximum offshore distance of around 100 km. The busiest fishing areas are located inshore of the proposed survey area, with limited activity recorded in the eastern extent of the proposed survey area between St Helena Bay and Cape Point where the proposed survey area extends into shallower areas that approach the 200 m depth contour (see Figure 7-39). Average annual catch and effort expended within the proposed survey area between 2000 and 2016 amounted to approximately 1.9% (8 107 tons) and 1.8% (196 sets), respectively. The fishery operates throughout the year with a short seasonal break from mid-December to mid-January. There is an increase in fishing effort and landings during the winter months.

Demersal longline

The demersal long-line fishery targets bottom-dwelling species, predominantly hake and is expected to occur in similar areas used by the hake-directed demersal trawl sector, i.e. concentrated between the 200 m and 1 000 m depth contour (see Figure 7-41). Annual catch and effort expended within the proposed survey area between 2000 and 2017 amounted to approximately 27.3% (2 184 tons per year) and 27.6% (9.4 million hooks per year), respectively. The fishery operates throughout the year with a decrease in effort during January.

Large pelagic longline

This sector utilises surface long-lines to target migratory pelagic species including albacore tuna, yellowfin tuna, bigeye tuna and swordfish. The fishery operates across the majority of the proposed survey area year-round with a relative increase in effort during winter and spring months. Over the period 2017 to 2019, an average of 1 073 tons of catch per year (15% of the total catch) was taken within the proposed survey area, while effort expended amounted to 765 lines set (18.6% of the total effort) (see Figure 7-44).

Tuna pole

Polling for tuna is predominantly based on the southern Atlantic longfin tuna (albacore). The fishery is seasonal with vessels predominantly active between November and May and peak catches recorded from November to January. Fishing activity takes place along the entire West Coast beyond the 200 m depth contour, along the shelf break with favoured fishing grounds including areas north of Cape Columbine and between 60 km and 120 km offshore of Saldanha Bay (see Figure 7-48). Fishing activity might be encountered within the proposed survey area, particularly over the Cape Canyon. Over the period 2017 to 2019, an average of 1 131 fishing events annually were reported in the proposed survey area, yielding 1 469 tons of albacore tuna. This is equivalent to 51.6% of the total catch and 44.1% of the overall effort recorded annually by the sector.

Traditional line fish

The traditional line fish sector is a nearshore fishery based largely on snoek, Cape bream, geelbek, kob and yellowtail off the West Coast. Fishing effort is primarily coastal, with vessels operating in water shallower than 100 m, with exceptions in the vicinity of Cape Canyon, approximately 55 km offshore of Saldanha Bay within the proposed survey area (see Figure 7-49). Over the period 2017 to 2019, an average of 924 kg of albacore tuna was caught. This amounts to 0.01% of the total catch and 0.02% of the total effort expended by the sector. The fishing activity within the area is seasonal from November to December.

Based on the above, the intensity of the impact on catch rates due to temporary exclusion from fishing grounds is rated as **high** for the demersal trawl, demersal longline and tuna pole sectors, of **medium** intensity for the mid-water trawl and large pelagic longline sectors and of **low** intensity to the small pelagic purse-seine and traditional line fish sectors.

Based on the overlap of fishing grounds with the proposed survey area, the extent of the impact ranges from **local** for the traditional line fish sector to **regional** for the rest of the affected sectors.

Taking the above into account, the magnitude of the impact on the demersal trawl, demersal longline and tuna pole sectors is assessed as **medium**, as **low** for the mid-water trawl and large pelagic longline sectors and as **very low** for the small pelagic purse-seine and traditional line fish sectors.

Impact Significance

Based on the sensitivity of receptors and impact magnitudes, the potential impacts on the demersal trawl, demersal longline and tuna pole sectors is assessed as of **medium** overall significance, for the mid-water trawl and large pelagic longline sectors as of **low** significance and of **negligible** significance for the small pelagic purse-seine and traditional line fish sectors (see Table 8-21).

Identification of Mitigation Measures

Many of the affected fisheries operate year-round and timing of the seismic survey to avoid certain periods of peak fishing activity is therefore not considered to be advantages to any of the sectors, except for the tuna pole

sector, which shows increased catches over the period November to December over the Cape Canyon in the south-eastern part of the proposed survey area.

In addition to the mitigation related to seismic noise impacts on commercial fisheries presented in Section 8.4.1.2, the following is recommended:

No.	Mitigation measure	Classification
1	Commence surveying in the North and work southwards in order to avoid surveying in the vicinity of the Cape Canyon during December.	Avoid
2	Manage the lighting on the project vessels to ensure that it is sufficiently illuminated to be visible to fishing vessels and compatible with safe operations.	Abate on site
3	Notify any fishing vessels at a radar range of 12 nautical miles from the seismic vessel via radio regarding the safety requirements around the seismic vessel.	Abate on site
4	Ensure project vessels fly standard flags and lights to indicate that they are engaged in towing surveys and are restricted in manoeuvrability.	Avoid

Residual Impact Assessment

With the implementation of the project controls and mitigation measures, the residual impact on the tuna pole sector will reduce to **LOW** significance. The impact on the demersal trawl and demersal longline sectors will remain of **MEDIUM** overall significance, while the impact on the mid-water trawl and large pelagic longline sectors remain of LOW significance and the impact of the small pelagic purse-seine and traditional line fish sectors of **NEGLIGIBLE** significance (see Table 8-21).

Table 8-21: Impact of temporary exclusion from fishing grounds for fishing sectors off the West Coast

Project Phase:	**Operational**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**HIGH:** demersal longline, large pelagic longline, tuna pole **MEDIUM:** demersal trawl, midwater trawl, research surveys (demersal trawl) **LOW:** small pelagic purse-seine, traditional line fish, research surveys (acoustic)	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**MEDIUM:** demersal trawl, demersal longline, tuna pole **LOW:** demersal longline, large pelagic longline **VERY LOW:** small pelagic purse-seine, traditional line fish	**MEDIUM:** demersal trawl, demersal longline **LOW:** demersal longline, large pelagic longline, tuna pole **VERY LOW:** small pelagic purse-seine, traditional line fish
Intensity	HIGH: demersal trawl, demersal longline, tuna pole MEDIUM: mid-water trawl, large pelagic longline LOW: small pelagic purse-seine, traditional line fish	HIGH: demersal trawl, demersal longline MEDIUM: mid-water trawl, large pelagic longline, tuna pole LOW: small pelagic purse-seine, traditional line fish
Extent	LOCAL: traditional line fish REGIONAL: all other sectors	REGIONAL to LOCAL
Duration	SHORT TERM	SHORT TERM

Significance	**MEDIUM:** demersal trawl, demersal longline, tuna pole	**MEDIUM:** demersal trawl, demersal longline
	LOW: mid-water trawl, large pelagic longline	**LOW:** mid-water trawl, large pelagic longline, tuna pole
	NEGLIGIBLE: small pelagic purse-seine, traditional line fish	**NEGLIGILBE:** small pelagic purse-seine, traditional line fish
Probability	**UNLIKELY** (small pelagic purse-seine, traditional line fish) **POSSIBLE** (midwater trawl, tuna pole) **HIGHLY LIKELY** (demersal trawl, demersal longline, large pelagic longline)	**UNLIKELY to HIGHLY LIKELY**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**VERY LOW**
Cumulative potential	**POSSIBLE TO LIKELY**	**POSSIBLE TO LIKELY**

8.5.1.2 Disruption to Commercial Shipping Routes

Source of Impact

The project activities that may interfere with marine traffic are:

Project phase	Activity
Mobilisation	N/A
Operation	Operation of survey vessels and seismic array
Demobilisation	N/A

A survey vessel is considered to be an “offshore installation” and a “vessel restricted in its ability to manoeuvre”, and as such it (including the seismic array) is protected by, as a minimum, a 500 m safety zone. Typical safe operational limits for 2D surveys are illustrated in Figure 6-11. Unauthorised vessels may not enter the exclusion zone.

Potential Impact Description

The implementation of the safe operational zone around the survey vessel and seismic array will effectively exclude vessels from portions of the survey area at any one time. Thus, their presence presents a potential risk of interference with shipping routes. The exclusion of other vessels from the safety zone may require these vessels to adjust their course slightly (detour) to avoid survey vessel and line being shot (**direct negative** impact).

Project Controls

The project controls are as described in Section 8.5.1.1.

Sensitivity of Receptors

There are various international shipping routes along the South African coastline. Most international shipping traffic is located on the outer edge of the continental shelf. Due to the large extent of the proposed survey area, it overlaps with the main traffic routes that pass along the West Coast (see Figure 7-55). Thus, marine traffic can be expected to pass through the proposed survey area. The sensitivity of the receptor is considered to be **high**.

Impact Magnitude (or Consequence)

As noted above, the survey area is located along a main vessel traffic route and some traffic can be expect in the survey area. Since the survey vessel with its seismic array is limited in its manoeuvrability, the proposed area of exclusion is larger than the stipulated 500 m around the survey vessel and seismic array. The typical safe operational limits for 2D surveys includes an exclusion distance of approximately 7 km ahead, 4 km to either side and 11 km astern of the survey vessel (i.e. a shifting exclusion area of up to144 km^2).

If the normal laws of the sea are followed the impact associated with survey vessel is considered to be of **medium intensity**, **regional** (although localised at any one time) and **short-term** (five months) in duration. The **magnitude** is thus considered to be **low** (see Table 8-22).

Impact Significance

Based on the **medium sensitivity** of receptors and the **low magnitude**, the potential impact on commercial shipping is of **low significance** (see Table 8-22).

Identification of Mitigation Measures

Recommendations to mitigate the potential impact on commercial shipping routes are similar to that recommended for the fishing industry (see Section 8.4.1.2 and Section 8.5.1.1).

Residual Impact Assessment

The potential impacts cannot be eliminated due to the nature of the activity and associated safe operational zone. With the implementation of the mitigation measures, the intensity of the impact will reduce to low. The residual impacts will reduce to **very low magnitude** , but because of the expected high traffic volumes, remains of **LOW significance** (see Table 8-22).

There is the possible chance of an increase in vessel activity in the Orange Basin should further speculative or proprietary surveys be planned for the 2021/2022 summer survey window period in parallel to Spectrum's planned survey. The operation of multiple exploration activities could result in a cumulative impact on commercial shipping.

Table 8-22: Impacts on commercial shipping due to safety zone around survey vessel and seismic array

Project Phase:	**Operational**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**HIGH**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**LOW**	**VERY LOW**
Intensity	MEDIUM	LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**LOW**	**LOW**
Probability	**HIGHLY LIKELY**	**LIKELY**
Confidence	**MEDIUM**	**MEDIUM**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**

Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**POSSIBLE**	**POSSIBLE**

8.6 INTERACTION WITH THE LOCAL ECONOMY

8.6.1 Employment and Business Opportunities

8.6.1.1 Economic Benefits for Local Service Providers and Suppliers

Source of Impact

The project activities that are likely to result in economic benefits for local service providers or suppliers are:

Project phase	Activity
Mobilisation	N/A
Operation	• Operation of survey vessels • Provision of services (e.g. catering and refuelling) • Berthing during crew changes
Demobilisation	N/A

The seismic activities will result in limited economic benefits with respect to the use of local service providers or suppliers. The demand for such local services will largely limited to crew accommodation, meals, basic goods, and refuelling, provided at Cape Town (**direct** Impact). In addition, the total workforce required for the exploration activities is expected to be 60 to 80 persons in total. Although the majority of these positions will be filled by international specialists employed by the seismic survey contractor(s), there will be indirect employment via the contracting of local service providers and suppliers.

Potential Impact Description

The proposed project will result in a temporary spending injection that will benefit the local economy (**direct positive** impact). All expenditures will lead to increased economic activity that will result in direct and indirect positive impacts on employment and income.

Project Controls

Requirements to maximise the use of local workforce and local supply when realistically possible will be provided by Spectrum to the seismic contractor.

Sensitivity of Receptors

The receptor is considered to be Cape Town the preferred supply base for the proposed survey operations.

Cape Town is a major metropolitan area that supports large and diversified economic sectors that can support, and potentially benefit from the survey activities. The sensitivity of Cape Town is therefore considered to be **very low**.

Impact Magnitude (or Consequence)

The proposed survey will require minimal support from local service providers and suppliers in terms of crew accommodation, meals, basic goods, and refuelling, provided at Cape Town. It is likely that any benefits will not

be noticeable given its well-established industrial sector and large resident population. Thus, the **intensity** of the impact is considered to be **low**. Based on the **short-term** nature of the survey (five months) and that the impact is largely restricted to Cape Town (**local**), the impact is considered to be of **very low (positive) magnitude** (see Table 8-23).

Impact Significance

Based on the **very low sensitivity** of the receptor and the **very low (positive) magnitude**, the potential impact (or benefit) to the local economy of Cape Town is of **negligible positive significance** (see Table 8-23).

Identification of Mitigation Measures

The following mitigation measures are recommended to maximise business benefits and manage potential over-expectation:

No.	Mitigation measure	Classification
1	Apply fair, transparent and reasonable preferential contracting of local companies to maximise benefits in Cape Town.	Enhancement
2	Include as a condition of contracting that any non-local service providers will apply reasonable preferential sub-contracting of companies located in Cape Town or other towns off the West Coast.	Enhancement
3	Ensure that all service providers/contractors actively manage community expectations related to local procurement, local content, and local employment opportunities.	Enhancement
4	Establish and maintain a functional grievance mechanism that allows stakeholders to submit specific grievances related to operations, by ensuring they are informed about the process and that resources are mobilized to manage the resolution of all grievances, in accordance with the Grievance Management procedure.	Abate on site

Residual Impact Assessment

The implementation of the enhancement and mitigation measures will not change the intensity, extent or duration of the impact. Thus, the residual impact will remain of **very low (positive) magnitude** and **NEGLIGIBLE POSITIVE significance** (see Table 8-23).

Table 8-23: Economic benefits for local service providers and suppliers due to employment and business opportunities

Project Phase:	**Operational**	
Type of Impact	**Direct**	
Nature of Impact	**Positive**	
Sensitivity of Receptor	**LOW**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	LOW	LOW
Extent	LOCAL	LOCAL
Duration	SHORT TERM	SHORT TERM
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**
Probability	**HIGHLY LIKELY**	**HIGHLY LIKELY**

Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**-**	**-**
Mitigation Potential	**-**	**LOW**
Cumulative potential	**POSSIBLE**	**POSSIBLE**

8.7 UNPLANNED EVENTS

8.7.1 Collisions with Project Vessels and Equipment

Source of Impact

The movement of vessels can result in collisions and faunal strikes, as indicated below:

Project phase	Activity
Mobilisation	Ship strikes during transit of vessels to survey area
Operation	• Ship strikes during operation • Strikes and entanglement of marine fauna during seismic acquisition
Demobilisation	Ship strikes during transit to port or next destination

These activities are described further below:

- Passage of the seismic and support vessels to and from the survey area; and
- Towing of seismic equipment.

8.7.1.1 Health and Safety Impacts to Coastal/Near-shore Tourism and Recreation

Potential Impact Description

The movement of the vessels between the survey area and the supply port may result in limited interaction with coastal/nearshore tourism, fishing and other marine recreational activities during their approach to the port. Such interaction may result in vessel strikes or collisions, resulting in damage to vessels and death / injuries to humans (**direct negative** impact).

Spills from collisions are dealt with in Section 8.7.2.

Project Controls

The seismic contractor will ensure that the proposed seismic survey is undertaken in a manner consistent with good international industry practice and BAT, as well as respecting navigation rules and the relevant national and international legislation (see Table 2-2 and Table 2-3). The primary objective for avoiding the impacts of vessel collisions is to prevent any such incidents from taking place.

To be prepared for a collision event, the project will implement an emergency response system to mitigate the consequences. As standard practice, an Emergency Response Plan (ERP) / Evacuation Plan will be prepared and put in place. A Medical Evacuation Plan (Medevac Plan) will form part of the ERP.

Sensitivity of Receptors

The Port of Cape Town supports some small-scale artisanal fisheries, recreational fisheries and recreational boating. Artisanal fishing for household subsistence is largely limited to surf and rock fishing and is very limited in scale. Recreational fishing is also associated with surf and rock fishing with Cape Town having facilities for small boat launches.

The Port of Cape Town also supports relatively extensive commercial vessel traffic (refer to Section 8.5.1.2 regarding impact on commercial shipping), and recreational and pleasure vessels should already have ample experience of operating around commercial vessels. The sensitivity of recreational and pleasure vessels is, therefore, considered to be **very low**.

Impact Magnitude (or Consequence)

As the seismic activities will be undertaken approximately 40 km from the coastline, interaction between the project vessels and coastal/near-shore tourism, recreational and pleasure vessels will be negligible (only possible interaction with vessels to and from port). The proposed project will also result in a negligible increase in the number of commercial vessels entering the port of Cape Town. Certified recreational and pleasure craft have and continue to operate around the port and alongside existing commercial vessels.

Assuming compliance with port control and laws of the sea, the impact is deemed to be of **low intensity**. Considering the **regional** extent and **short-term duration** (five months), the **magnitude** is **very low** (see Table 8-24).

Impact Significance

Based on the **very low sensitivity** of receptors and the **very low magnitude**, the potential impact on coastal recreation and fishing vessels is considered to be of **negligible significance** without mitigation (see Table 8-24).

Identification of Mitigation Measures

The following mitigation measures are recommended:

No.	Mitigation measure	Classification
1	Request, in writing, the South African Navy (SAN) Hydrographer to broadcast a navigational warning via Navigational Telex (Navtext) for the duration of the activity.	Avoid
2	Enforce the 500 m safety/exclusion zone around the survey vessel and seismic array.	Avoid
3	Ensure at a minimum, one FLO person (speaking English and Afrikaans) is on board the escort vessel to facilitate communication in the local language with the fishing vessels that are in the area.	Abate on site
4	Escort vessel with appropriate radar and communications will be used during the seismic operation to warn vessels that are in danger of breaching the safety/exclusion zone. Any vessels at a radar range of 12 nm from the survey vessel will be notified via radio regarding the safety requirements.	Abate on site
5	Manage the lighting on the project vessels to ensure that it is sufficiently illuminated to be visible to fishing vessels and compatible with safe operations.	Abate on site
6	Ensure project vessels fly standard flags and lights to indicate that they are engaged in towing surveys and are restricted in manoeuvrability.	Abate on site
7	Establish and maintain a functional grievance mechanism that allows stakeholders to submit specific grievances related to operations, by ensuring they are informed about the process and	Abate on site

No.	Mitigation measure	Classification
	that resources are mobilized to manage the resolution of all grievances, in accordance with the Grievance Management procedure.	

Residual Impact Assessment

With the implementation of the mitigation measures, the intensity of the residual impact reduces from low to very low, but the **magnitude** remains **very low** and **significance NEGLIGIBLE** (see Table 8-24).

Should additional exploration activities be initiated by existing Exploration Right or Reconnaissance Permit holders in the Orange Basin during the 2021/2022 survey window period, there is a potential for increasing the collision risk.

Table 8-24: Health and safety impacts to coastal/near-shore tourism and recreation due to a vessel collision

Project Phase:	Mobilisation, Operation and Decommissioning	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**VERY LOW**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	LOW	VERY LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**
Probability	**POSSIBLE**	**UNLIKELY**
Confidence	**MEDIUM**	**MEDIUM**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**POSSIBLE**	**POSSIBLE**

8.7.1.2 Impacts on Marine Fauna

Potential Impact Description

The potential effects of vessel presence and towed equipment on marine fauna (and especially turtles and cetaceans) include physiological injury or mortality (**direct negative** impact).

Project Controls

The seismic contractor will ensure that the proposed survey is undertaken in a manner consistent with good international industry practice and BAT.

The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished. No vessel may approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m.

Sensitivity of Receptors

The leatherback and loggerhead turtles that occur in offshore waters around southern Africa, and likely to be encountered in the proposed survey area are considered regionally 'Critically Endangered' and 'Endangered', respectively. The breeding areas for Leatherback turtles occur over 1 000 km to the north of the survey area in Gabon and on the northeast coast of South Africa and turtles encountered in the survey area are thus likely to be migrating vagrants. Although leatherback turtles have not been reported by MMOs during previous seismic operations in the Orange Basin, loggerhead turtles have been recorded during summer surveys off the West Coast (unpublished SLR MMO database). Due to their extensive distributions and feeding ranges, the number of turtles encountered in the survey area is expected to be low. Consequently, the sensitivity of turtles is considered to be **medium**.

Thirty-three species or sub species/populations of cetaceans (whales and dolphins) are known or likely to occur off the West Coast. The majority of migratory cetaceans in South African waters are baleen whales (mysticetes), while toothed whales (odontocetes) may be resident or migratory. Of the 35 species, the Blue Whale is listed as 'Critically Endangered', the Fin and Sei whales are 'Endangered' and the sperm, Bryde's (offshore) and humpback (B2 population) whales are considered 'Vulnerable' (South African Red Data list Categories). Although the proposed survey area is relatively far removed from the coast, it overlaps with Child's Bank and is located approximately 25 km from Tripp Seamount, where a greater number of individuals can be expected. The sensitivity of cetaceans to strikes is thus considered to be **high**.

Overall, considering the precautionary principle, the sensitivity of marine fauna to collision is considered to be **high**.

Impact Magnitude (or Consequence)

Collisions between turtles or cetaceans and vessels are not limited to seismic ships, and given the slow speed (about 4 - 6 kts) of the vessel while towing the seismic array, ship strikes and entanglement whilst surveying are unlikely, but may occur during the transit of vessels to or from the survey area.

The physical presence of the survey vessel and increased vessel traffic between the survey area and supply ports could increase the likelihood of animal-vessel collisions. Ship strikes have been documented from many regions and for numerous species of whales, with large baleen whales being particularly susceptible to collision. Any increase in vessel traffic through areas used as calving grounds or through which these species migrate will increase the risk of collision between a whale and a vessel.

The large amount of equipment towed astern of survey vessels also increases the potential for collision with or entrapment in seismic equipment and towed surface floats. Entanglement of cetaceans in gear is possible in situations where tension is lost on the towed array. Basking turtles are particularly slow to react to approaching objects and may not be able to move rapidly away from approaching airguns. Turtles are also thought to be attracted to the seismic cables to forage on barnacles and other organisms growing along these cables (https://www.ketosecology.co.uk/ PDF/KE2009_Turtle_guards.pdf). Thus, ensuring all equipment that has been used in other regions is thoroughly cleaned prior to deployment will mitigate the risk of collisions to some extent. Almost all reported turtle entrapments are associated with the subsurface structures ('undercarriage') of the tail buoys attached to the end of each seismic cable. Entrapment occurs either as a result of 'startle diving' in front of towed equipment or following foraging on barnacles and other organisms growing along seismic cables and surfacing to breathe immediately in front of the tail buoy. Once stuck inside or in front of a tail buoy, the water

pressure generated by the towing speed, forces the animal against/inside the buoy with little chance of escape due to the angle of its body in relation to the forward movement of the buoy.

The potential for collision between adult turtles / cetaceans and the seismic vessel, or entanglement in the towed seismic equipment and surface floats, is highly dependent on the abundance and behaviour of turtles and cetaceans in the survey area at the time of the survey and vessel speed. However, due to the extensive turtle distributions and feeding ranges, and the extended distance from their nesting sites, the numbers of individuals encountered during the proposed survey are likely to be low. Similarly, cetacean numbers encountered during the survey are likely to be low. Thus, the impacts on turtles and cetaceans are considered to be of **low intensity** for the populations as a whole. Furthermore, as the duration of the impact would be limited to the **short-term** (five months) and be restricted to the survey area (**regional**), the potential for collision and entanglement is, therefore, considered to be of **very low magnitude** (see Table 8-25).

Impact Significance

Based on the **high sensitivity** of receptors and the **very low magnitude**, the potential impact on the marine fauna is considered to be of **low significance** without mitigation (see Table 8-25).

Identification of Mitigation Measures

In addition to MMOs keeping watch for turtles and cetaceans, the following measures will be implemented:

No.	Mitigation measure	Classification
1	Ensure that 'turtle-friendly' tail buoys are used by the survey contractor or that existing tail buoys are fitted with either exclusion or deflector 'turtle guards'.	Abate on site
2	Ensure vessel transit speed between the survey area and supply port is a maximum of 12 knots (22 km/hr), except within 25 km of the coast where it is reduced further to 10 knots (18 km/hr) as well as when sensitive marine fauna is present in the vicinity.	Avoid / reduce at source
3	Ensure all equipment (e.g. arrays, streamers, tail buoys, etc.) that has been used in other regions is thoroughly cleaned prior to deployment.	Avoid / reduce at source
4	Retrieve or regain tension on towed gear as rapidly as possible after loss of tension.	Avoid
5	Contact the South African Whale Disentanglement Network (SAWDN) to provide specialist assistance in releasing entangled animals, should a cetacean become entangled in towed gear.	Abate

Residual Impact Assessment

With the implementation of the mitigation measures, which would reduce the intensity of the impact to very low, the residual impact will remain of **very low magnitude** and of **LOW significance** (see Table 8-25).

Table 8-25: Impacts on marine fauna from vessel strikes and entanglement

Project Phase:	**Mobilisation, Operation and Decommissioning**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**HIGH**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**

Intensity	LOW	VERY LOW
Extent	REGIONAL	REGIONAL
Duration	SHORT TERM	SHORT TERM
Significance	**LOW**	**LOW**
Probability	**POSSIBLE**	**UNLIKELY**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.7.2 Accidental Release of Oil at Sea

Source of Impact

The project activities likely to result in an accidental release of diesel / oil are listed below are:

Project phase	Activity
Mobilisation	Vessel accident
Operation	• Bunkering of fuel (in port) • Vessel accident and survey equipment damage
Demobilisation	Vessel accident

These activities (or events) are described further below:

- Small instantaneous spills of marine diesel at the surface of the sea can potentially occur during bunkering and such spills are usually of a low volume. Very low volumes of hydraulic fluid can be involved in the case of streamer damage.
- Larger volume spills of marine diesel will occur in the event of a vessel collision or vessel accident.

8.7.2.1 Impacts on Marine Ecology/Environment

Potential Impact Description

Diesel, hydraulic fluid and/or oil spilled in the marine environment will have an immediate detrimental effect on water quality, with the toxic effects potentially resulting in mortality (e.g. suffocation and poisoning) of marine fauna or affecting faunal health (e.g. respiratory damage) (**direct negative** impact). Sub-lethal and long-term effects can include disruption of physiological and behavioural mechanisms, reduced tolerance to stress and incorporation of carcinogens into the food chain. If the spill reaches the coast, it can result in the smothering of sensitive coastal habitats.

Project Controls

To be prepared in the event of a spill incident, the project will implement an emergency response system to mitigate the consequences of the spill.

Regulation 37 of MARPOL Annex I will be applied, which requires that all ships of 400 gross tonnage and above carry an approved Shipboard Oil Pollution Emergency Plan (SOPEP). The purpose of a SOPEP is to assist personnel

in dealing with unexpected discharge of oil onboard, to set in motion the necessary actions to stop or minimise the discharge to the sea and to mitigate its effects on the marine environment. Thus, project vessels will be equipped with appropriate spill containment and clean-up equipment, e.g. dispersants and absorbent materials. All relevant vessel crews will be trained in spill clean-up equipment use and routine spill clean-up exercises.

As standard practice, the Emergency Response Plan (ERP) will include crisis contacts and protocols.

Sensitivity of Receptors

Accidental spills and loss of marine diesel during bunkering (in port) or in the event of a vessel accident could take place in the survey area and along the route taken by the survey and support vessels between the survey area and supply port at Cape Town. The survey area is located in the marine environment, more than 40 km offshore, far removed from coastal MPAs and any sensitive coastal receptors (e.g. key faunal breeding/feeding areas, bird or seal colonies and nursery areas for commercial fish stocks); however, discharges could still directly affect migratory pelagic species transiting through the survey area. Diesel spills or accidents *en route* to the onshore supply base in Cape Town could result in fuel loss closer to shore, thereby potentially having an environmental effect on the sensitive coastal environment.

The taxa most vulnerable to hydrocarbon spills are coastal and pelagic seabirds. Some of the species potentially occurring in the survey area, are considered regionally or globally 'Critically Endangered' (e.g. Tristan albatross, Cape gannet), 'Endangered' (e.g. black-browed and yellow-nosed albatross, African Penguin, bank and Cape cormorant) or 'Vulnerable' (e.g. Hartlaub's gull, swift tern). As Child's Bank and Tripp Seamount, which are important features that attract an abundance of marine life and are productive fishing grounds, are located within and approximately 25 km north of the survey area, respectively, the sensitivity of faunal receptors to hydrocarbon spills is considered to be **high**.

Impact Magnitude (or Consequence)

Oil or diesel spilled in the marine environment will have an immediate detrimental effect on water quality. Being highly toxic, marine diesel released during an operational spill will negatively affect any marine fauna in which it comes into contact. In the offshore environment, the taxa most vulnerable to spills are coastal and pelagic seabirds.

When considering the consequences of the effects of small (2 000 – 20 000 litres) diesel fuel spills into the marine environment, it must be noted that diesel is a light oil that, when spilled on water, spreads very quickly to a thin film and evaporates or naturally disperses within a few days or less, even in cold water. Diesel oil can be physically mixed into the water column by wave action, where it adheres to fine-grained suspended sediments, which can subsequently settle out on the seafloor. As it is not very sticky or viscous, diesel tends to penetrate porous sediments quickly, but also to be washed off quickly by waves and tidal flushing. In the case of a coastal spill, shoreline clean-up is thus usually not needed. Diesel oil is degraded by naturally occurring microbes within one to two months. Nonetheless, in terms of toxicity to marine organisms, diesel is considered to be one of the most acutely toxic oil types. Many of the compounds in petroleum products are known to smother organisms, lower fertility and cause disease. Intertidal invertebrates and seaweed that come in direct contact with a diesel spill may be killed. Fish kills, however, have never been reported for small spills in open water as the diesel dilutes rapidly. Due to differential uptake and elimination rates, filter-feeders (particularly mussels) can bio-accumulate hydrocarbon contaminants. Crabs and shellfish can be tainted from small diesel spills in shallow, nearshore areas.

In the unlikely event of a small operational spill or vessel collision, the intensity of the impact would depend on whether the spill occurred in offshore waters where encounters with pelagic seabirds, turtles and marine mammals would be low due to their extensive distribution ranges, or whether the spill occurred closer to the shore where encounters with sensitive receptors will be higher. Based on the results of an oil spill modelling exercise undertaken in the Orange Basin (PRDW 2013), a diesel slick in the proposed survey area would be blown in a north-westerly direction due to the dominant winds and currents off the West Coast. The diesel would most likely remain at the surface for less than 36 hours with no probability of reaching sensitive coastal habitats.

In offshore environments, impacts associated with a spill would be of **low intensity**, **regional** (depending on the nature of the spill) over the **short-term** (less than five days). The impact **magnitude** for a marine diesel spill in the survey area (**offshore** environment) is, therefore, considered **very low**.

However, in the case of a spill *en route* to the survey area, the spill may extend into coastal MPAs and reach the shore affecting intertidal and shallow subtidal benthos and sensitive coastal bird species, in which case the **intensity** would be considered **high**, but still remaining local over the **short-term**. The **magnitude** for a **nearshore** spill is **medium**.

Impact Significance

Based on the **high sensitivity** of receptors and the **very low (offshore)** and **medium magnitude (nearshore)**, the potential impact on the marine fauna is considered to range from **low significance (offshore)** to **medium significance (nearshore)** without mitigation (see Table 8-26).

Identification of Mitigation Measures

In addition to the best industry practices and project controls, the following measures will be implemented to manage and reduce the impacts associated with small operational spills:

No.	Mitigation measure	Classification
Oil spills		
1	Ensure personnel are adequately trained in both accident prevention and immediate response, and resources are available on each vessel.	Avoid / reduce at source
2	Obtain permission from DFFE to use low toxicity dispersants. Use cautiously.	Abate on and off site
3	Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station.	Restore
Bunkering at sea (not planned)		
4	Ensure offshore bunkering is not undertake in the following circumstances: • Wind force and sea state conditions of ≥6 on the Beaufort Wind Scale; • During any workboat or mobilisation boat operations; • During helicopter operations; • During the transfer of in-sea equipment; and • At night or times of low visibility.	Avoid / Reduce at source
Equipment		
5	Ensure that solid streamers rather than fluid-filled streamers are used. Alternatively, low toxicity fluid-filled streamers could be used.	Avoid / Reduce at source

Residual Impact Assessment

With the implementation of the mitigation measures, which would reduce the intensity of a nearshore impact to low, the residual impact will be of **very low magnitude** and of **LOW significance** for both offshore and nearshore spills (see Table 8-26).

Table 8-26: Impacts on marine ecology/environment from the accidental release of oil

Project Phase:	**Mobilisation, Operation and Decommissioning**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**HIGH**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**MEDIUM**	**VERY LOW**
Intensity	HIGH	LOW
Extent	REGIONAL	LOCAL
Duration	SHORT TERM	SHORT TERM
Significance	**MEDIUM**	**LOW**
Probability	**UNLIKELY**	**UNLIKELY**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW (offshore) TO MEDIUM (nearshore)**	**LOW**
Mitigation Potential	**-**	**MEDIUM**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.7.2.2 Impacts on Commercial Fishing

Potential Impact Description

An oil spill can also result in several **indirect negative** impacts on fishing. These include:

- Exclusion of fisheries from polluted areas and displacement of targeted species from normal feeding / fishing areas, both of which could potentially result in a loss of catch and / or increased fishing effort;
- Mortality of animals (including eggs and larvae) leading to reduced recruitment and loss of stock (e.g. mariculture); and
- Gear damage due to oil contamination.

Oil contamination could potentially have the greatest impact on commercial fisheries for rock lobster and sessile filter feeders (e.g. mussels) and grazers (e.g. abalone). Mortality is expected to be high on filter feeders and, to a lesser extent, grazers. These species have low mobility and no means to escape contamination and ultimately mortality. Thus, mariculture facilities off the West Coast (e.g. at Saldanha Bay and St Helena Bay) could be impacted if a spill extended into the inshore areas. For a large oil spill, fishing / mariculture activities and revenues could be affected over a wide area until such time as the oil has either been dispersed or broken down naturally.

Project Controls

Project controls are as described in Section 8.7.2.1.

Sensitivity of Receptors

Due to dominant wind and currents off the West Coast, a diesel slick resulting from an accidental spill would be blown in a north-westerly direction, remaining at the surface for less than 36 hours (PRDW 2013). The sensitivity of the various fishing sectors that operate in the proposed survey area is thus considered to be **medium**.

Both Saldanha Bay and St Helena Bay support nearshore mariculture activities. These activities are, however, far removed from the proposed survey area operational activities (e.g. bunkering in port) and sensitivity for mariculture is thus also considered to be **medium**.

Impact Magnitude (or Consequence)

The survey area coincides with fishing grounds used by the demersal and mid-water trawl, demersal longline, large pelagic longline, tuna pole sectors, and to a lesser extent, the small pelagic purse-seine and traditional line fish sectors. Thus, any spill within the proposed survey area (or area of operation), could impact these sectors. The dominant wind and current direction will ensure that any spill in the survey area is dispersed in a north-westerly direction away from the coast and more actively fished inshore areas of the proposed survey area. Thus, any spill offshore, which will disperse rapidly (days), is unlikely to have an impact on more sensitive features in the inshore areas of the proposed survey area.

The potential impact on the offshore fishing sectors is considered to be **localised** for small instantaneous spills and regional for larger volume spills and of **low intensity** for both spill scales in the **short term**. Thus, for both cases, the impact **magnitude** is considered to be **very low**.

The effects of an oil spill would, however, potentially have the greatest impact on sessile filter feeding (e.g. mussels and oysters) and grazing species (e.g. abalone) resulting in mortality through physical clogging and or direct absorption. Although unlikely, an accidental spill (during a vessel accident) close to the coast from vessels travelling to and from the survey location could potentially impact mariculture activities in the St Helena Bay and Saldanha Bay areas and small-scale shellfish harvester sectors along the coast. In such an unlikely event, the intensity would be considered **high**, but of **local** extent and **short term** duration for both spill scales due to the dominant winds and currents moving spills offshore away from the coast. Thus, for both cases, the impact **magnitude** is expected to be **low** (see Table 8-27).

Impact Significance

Based on the **medium sensitivity** of receptors and the **very low to low magnitude**, the potential impact on commercial fishing is of **very low** significance without mitigation while the impact on nearshore mariculture and the small-scale sectors would be of **low** significance (see Table 8-27).

Identification of Mitigation Measures

Recommendations to mitigate the potential impact on commercial fishing are the same to that recommended for marine fauna (see Section 8.7.2.1).

Residual Impact Assessment

With the implementation of the mitigation measures, the residual impact will remain of **VERY LOW** and **LOW significance** (see Table 8-27).

Table 8-27: Impacts on Commercial Fishing from the accidental release of oil

Project Phase:	**Mobilisation, Operation and Decommissioning**	
Type of Impact	**Indirect**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**MEDIUM**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW (offshore)** **LOW (nearshore)**	**VERY LOW**
Intensity	LOW (offshore) HIGH (nearshore)	LOW
Extent	LOCAL (nearshore) REGIONAL (offshore)	LOCAL (nearshore) REGIONAL (offshore)
Duration	SHORT TERM	SHORT TERM
Significance	**VERY LOW (offshore)**	**VERY LOW**
	LOW	**LOW**
Probability	**UNLIKELY (mariculture) to POSSIBLE (fishing sectors)**	**UNLIKELY**
Confidence	**MEDIUM**	**MEDIUM**
Reversibility	**FULLY REVERSIBLE**	**FULLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**LOW**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.7.3 Loss of Equipment at Sea

Source of Impact

The project activities are provided below:

Project phase	Activity
Mobilisation	N/A
Operation	Accidental loss of equipment to the water column or seabed
Demobilisation	N/A

These activities (or event) are described further below:

- Accidental loss of paravanes, streamers, arrays, tail buoys or sound source during seismic acquisition; and
- Accidental loss of equipment during vessel transfer with crane (i.e. waste containers, equipment, consumable package, etc.).

During seismic acquisition, the survey vessel tows a substantial amount of equipment with the streamer being towed by lead-in cables. The streamer is fitted with a dilt float at the head of the streamer, numerous streamer

mounts (birds and fins) to control streamer depth and lateral positioning, and a tail buoy to mark the end of the streamer. Streamers are neutrally buoyant at the required depth (5-10 m), but have buoyancy bags embedded within them that inflate at a depth of 40 m. If streamers are accidentally lost, they would float in the water column for some time before sinking. Dilt floats and tail buoys would ultimately be dragged down under the weight of the streamer.

Airguns are suspended under floats by a network of ropes, cables and chains, with each float configuration towed by an umbilical. Should both the float and umbilical fail, the airguns would sink to the seabed.

8.7.3.1 Impacts on Marine Ecology/Environment

Potential Impact Description

The potential impacts associated with lost equipment include (**direct negative** impact):

- Potential disturbance and damage to seabed habitats and crushing of epifauna and infauna within the equipment footprint; and
- Potential physiological injury or mortality to pelagic and neritic marine fauna due to collision or entanglement in equipment drifting on the surface or in the water column.

Project Controls

The seismic contractor will ensure that the proposed survey is undertaken in a manner consistent with good international industry practice and BAT.

Sensitivity of Receptors

The proposed survey area is located more than 40 km offshore at its closest point, far removed from any sensitive coastal receptors and where the pelagic and benthic ecosystem threat status is largely considered of 'Least Concern' and the deepwater habitat types are comparatively uniform and cover large areas. The benthic fauna in deeper areas of the proposed survey area (beyond 450 m) are very poorly known and there are no species of commercial value occurring in the deeper offshore areas. Sensitive deep-water coral communities would be expected at topographic features such as Tripp Seamount (to the north of the proposed survey area) and Child's Bank. The sensitivity of benthic fauna in the proposed survey area is considered to be **low**.

Although there are pelagic species listed as 'Critically Endangered', 'Endangered' and 'Vulnerable' possibility occurring in the area, entanglement with a lost streamer is highly unlikely. Thus, the sensitivity of pelagic fauna to lost equipment is considered to be **medium**.

Overall, considering the precautionary principle, the sensitivity of marine fauna for crush, collision and entanglement with lost equipment is considered to be **medium**.

Impact Magnitude (or Consequence)

The accidental loss of equipment onto the seafloor would provide a localised area of hard substrate in an area of otherwise mostly unconsolidated sediments. The benthic fauna attracted to such hard substrata in otherwise unconsolidated sediments of the outer shelf and continental slope would likely be different from those of the surrounding unconsolidated sediments. In the unlikely event of equipment loss onto the seafloor associated impacts would be of **low intensity** and be highly localised and limited to the **site** over the **short-term** (any lost

object, depending on its size, will likely sink into the sediments and be buried over time). The impact **magnitude** for equipment lost to the seabed is therefore considered **very low** (see Table 8-28).

The loss of streamers and floats would result in entanglement and collision hazards in the water column before the object sinks under its own weight. In the unlikely event of lost equipment floating in the water column , associated impacts would similarly be of **low intensity** and be highly localised and limited to the **site** (although would potentially float around regionally) over the **short-term**. The impact **magnitude** for equipment lost to the water column is, therefore, considered **very low** (see Table 8-28).

Impact Significance

Based on the **medium sensitivity** of receptors and the **very low magnitude**, the potential impact on the marine fauna is considered to be of **very low** significance without mitigation (see Table 8-28).

Identification of Mitigation Measures

The following measures will be implemented to manage accidental loss of equipment:

No.	Mitigation measure	Classification
1	Ensure that loads are lifted using the correct lifting procedure and within the maximum lifting capacity of the crane system.	Avoid
2	Minimise the lifting path between vessels.	Avoid
3	Undertake frequent checks to ensure items and equipment are stored and secured safely on board each vessel and maintain a good inventory of equipment onboard in order to know what is lost.	Avoid
4	Retrieve lost objects / equipment, where practicable, after assessing the safety and metocean conditions. Establish a hazards database listing the type of gear left on the seabed and/or in the licence area with the dates of abandonment/loss and locations, and where applicable, the dates of retrieval. Notify the SAN Hydrographer of any hazards left on the seabed or floating in the water column, and request that a Notice to Mariners with this information be sent.	Repair / restore

Residual Impact Assessment

With the implementation of the mitigation measures, which would reduce the intensity of the impact to very low, the residual impact will remain of **very low magnitude** and of **VERY LOW significance** (see Table 8-28).

Table 8-28: Impacts on Marine Ecology/Environment from loss of equipment at sea

Project Phase:	**Operation**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**MEDIUM**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	LOW	VERY LOW
Extent	SITE	SITE
Duration	SHORT TERM	SHORT TERM
Significance	**VERY LOW**	**VERY LOW**

Probability	**UNLIKELY**	**UNLIKELY**
Confidence	**HIGH**	**HIGH**
Reversibility	**FULLY TO PARTIALLY REVERSIBLE**	**FULLY TO PARTIALLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**LOW**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.7.3.2 Impacts on Commercial Fishing

Potential Impact Description

The potential impacts associated with lost equipment include (**direct negative** impact):

- Potential snagging of demersal gear with regards to equipment that sinks to the seabed; and
- Potential entanglement hazards with regards to lost equipment drifting on the surface or in the water column.

Project Controls

The seismic contractor will ensure that the proposed survey is undertaken in a manner consistent with good international industry practice and BAT.

Sensitivity of Receptors

Considering lost equipment on the seafloor, the demersal trawl sector gear may be snagged or damaged, while floating equipment (e.g. lost streamer) may become entangled with fishing gear (e.g. pelagic longlines) The sensitivity of receptors is thus considered to be **medium**.

Impact Magnitude (or Consequence)

The loss of equipment would result in entanglement and collision hazards in the water column for fishing gear in the survey area before the object sinks under its own weight, particularly for pelagic long-line gear (which can be up to 100 km long). The accidental loss of equipment onto the seafloor would provide a localised area of hard substrate in an area of otherwise unconsolidated sediments. Since the survey area overlaps with demersal fishing grounds along the shelf break, snagging of demersal gear in inshore areas of the block due to equipment that sinks to the seabed is considered possible.

In the unlikely event of a lost streamer or other equipment, the impact could be of **low intensity**, limited to the **site** (although would potentially float around regionally) over the **short-term**. The impact **magnitude** for equipment lost to the water column and seafloor is, therefore, considered **very low** for the fishing sectors active in the proposed survey area (see Table 8-29).

Impact Significance

Based on the **medium sensitivity** of the active fishing sectors and the **very low magnitude**, the potential impact on commercial fishing is of **very low significance** without mitigation (see Table 8-29).

Identification of Mitigation Measures

Recommendations to mitigate the potential impact on commercial fishing are the same to that recommended for marine fauna (see Section 8.7.3.2). In addition, the following is recommended:

No.	Mitigation measure	Classification
1	Ensure at a minimum, one FLO person (speaking English and Afrikaans) is on board each escort vessel to facilitate communication in the local language with the fishing vessels that are in the area.	Abate on site
2	Notify PASA, the South African Maritime Safety Association (SAMSA) and the SAN Hydrographer of any hazards left on the seabed or floating in the water column, and request that they send out a Notice to Mariners with this information.	Avoid
3	Establish a functional grievance mechanism that allows stakeholders to register specific grievances related to operations, by ensuring they are informed about the process and that resources are mobilised to manage the resolution of all grievances, in accordance with the Grievance Management procedure.	Abate

Residual Impact Assessment

The implementation of the mitigation measures will reduce the intensity of the impact to very low. The residual impact will, however, remain of **very low magnitude** and of **VERY LOW significance** (see Table 8-29).

Table 8-29: Impacts on Commercial Fishing from loss of equipment at sea

Project Phase:	**Operation**	
Type of Impact	**Direct**	
Nature of Impact	**Negative**	
Sensitivity of Receptor	**MEDIUM**	
	Pre-Mitigation Impact	**Residual Impact**
Magnitude (Consequence)	**VERY LOW**	**VERY LOW**
Intensity	LOW	VERY LOW
Extent	SITE	SITE
Duration	SHORT TERM	SHORT TERM
Significance	**VERY LOW**	**VERY LOW**
Probability	**POSSIBLE**	**POSSIBLE**
Confidence	**MEDIUM**	**MEDIUM**
Reversibility	**FULLY TO PARTIALLY REVERSIBLE**	**FULLY TO PARTIALLY REVERSIBLE**
Loss of Resources	**LOW**	**LOW**
Mitigation Potential	**-**	**LOW**
Cumulative potential	**UNLIKELY**	**UNLIKELY**

8.8 CUMULATIVE IMPACT

8.8.1 Bio-Physical

The assessments of impacts of seismic sounds provided in the scientific literature usually consider short-term responses at the level of individual animals only, as scientific understanding of how such short-term effects relate to adverse residual effects at the population level are limited. Data on behavioural reactions to seismic noise acquired over the short-term could, however, easily be misinterpreted as being less significant than the cumulative effects over the long-term, i.e. what is initially interpreted as an impact not having a detrimental effect and thus being of low significance, may turn out to result in a long-term decline in the population, particularly when combined with other stressors (e.g. temperature, competition for food, shipping noise). Confounding effects are, however, difficult to separate from those due to seismic surveys.

Similarly, potential cumulative impacts on individuals and populations as a result of other seismic surveys or other exploration activities (e.g. other speculative or proprietary surveys that might be planned in the Orange Basin during the same survey window period) undertaken either previously, concurrently or subsequently are difficult to assess. A significant adverse residual environmental effect is considered one that affects marine biota by causing a decline in abundance or change in distribution of a population(s) over more than one generation within an area and where natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent. Some of the historic seismic survey data acquired in the South African offshore over the past two decades is illustrated in Figure 8-2. Despite the density of seismic survey coverage over the past 17 years, the Southern right whale population is reported to be increasing by 6.5% per year (Brandaõ *et al.* 2018), and the humpback whale population by at least 5% per annum (IWC, 2012) over a time when seismic surveying frequency has increased, suggesting that, for these species at least, there is no evidence of long-term negative change to population size as a direct result of seismic survey activities.

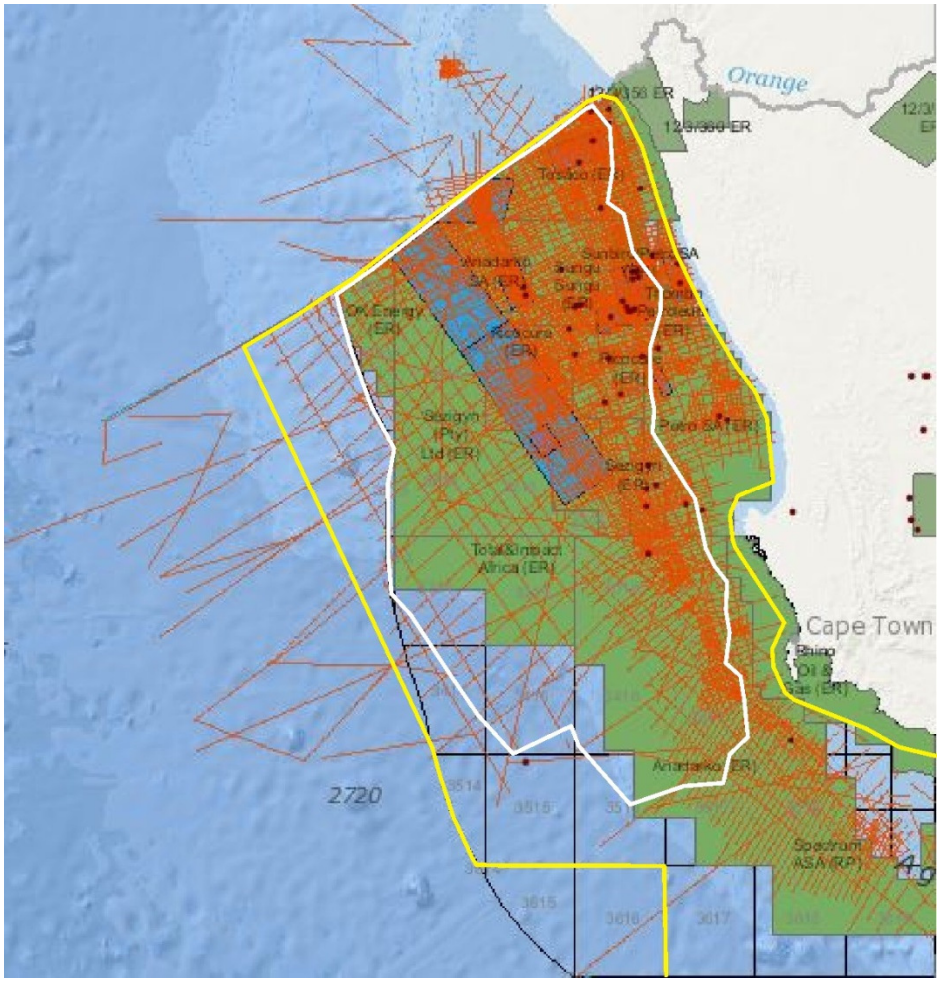

Figure 8-2: The Reconnaissance Permit area (yellow) and proposed 2D survey area (white) in relation to historic 2D (orange lines) and 3D (blue and purple polygons) seismic surveys conducted off the West Coast between 2001 and 2018 (Source: PASA)

Reactions to sound by marine fauna depend on a multitude of factors including species, state of maturity, experience, current activity, reproductive state, time of day. If a marine animal does react briefly to an underwater sound by changing its behaviour or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the population as a whole (NRC, 2005). However, if a sound source displaces a species from an important feeding or breeding area for a prolonged period, impacts at the population level could be significant. The increasing numbers of Southern right and humpback whales around the southern African coast, and their lingering on West Coast feeding grounds long into the summer, suggest that those surveys conducted over the past decades have not negatively influenced the distribution patterns of these two migratory species at least. Information on the population trends of resident species of baleen and toothed whales is unfortunately lacking, and the potential effects of seismic surveys on such populations remains unknown.

Consequently, suitable precautionary mitigation measures must be implemented during seismic data acquisition to ensure the least possible disturbance of marine fauna in an environment where the cumulative impact of increased background anthropogenic noise levels has been recognised as an ongoing and widespread issue of concern. Should other speculative or proprietary seismic survey campaigns be undertaken concurrently with Spectrum's proposed survey in the Orange Basin, cumulative impacts may be likely and there would need to be alignment in planning of such concurrent operations in order to avoid cumulative impacts.

8.8.2 Socio-Economic

Seismic activities have been predicted to possibly affect the migration patterns of tuna leading to substantially reduced catches of tuna along specifically the West Coast of Southern Africa. In the Benguela region, it has been suggested that the seasonal movement of Longfin Tuna northwards from the west coast of South Africa into southern Namibia may be disrupted by the noise associated with an increasing number of seismic surveys. While the potential exists to disrupt the movement of Longfin Tuna and so impact on catch rates for the pelagic long-line and tuna pole sector, this disruption, if it occurs, would be localised spatially and temporarily and would be compounded by environmental variability. In Australia, no direct cause and effect in changes in movement or availability of Bluefin Tuna could be attributed to seismic surveys (Evans *et al.,* 2018), with observed changes being attributed to inter-annual variability. Due to the dearth of information on the impacts of seismic noise on truly pelagic species links between changes in migration patterns and subsequent catches thus remains speculative.

There is the possible chance of an increase in disturbance and disruption to fisheries active in the area (namely demersal and mid-water trawl, demersal and large pelagic long-line, tuna pole, small pelagic purse-seine and traditional line fish) should additional exploration activities related to other speculative or proprietary seismic surveys commence within the same survey window period off the West Coast.

There is also the possibility of cumulative benefits being accrued to local services providers and suppliers if multiple exploration activities become active either in parallel or in close sequence to each other. The need for ongoing support from local service providers and suppliers over multiple projects may see possible cumulative benefits over a longer period of time, but may also raise strong expectations.

8.9 NO-GO ALTERNATIVE

The No-Go alternative represents the option not to proceed with the proposed speculative seismic surveys, which leaves the project area of influence in its current state, except for variation by natural causes and other human activities (e.g. fishing, commercial shipping, etc.), as well as that caused due to possible future exploration and well drilling for which an environmental authorisation has previously been issued. The No-go alternative would result in avoidance of the impacts predicted to occur from the proposed seismic survey activities (refer to Table 8-30). The result would be the prevention of a range of impacts assessed from negligible to medium significance in the short-term.

South African Government policy supports exploration for indigenous hydrocarbon resources and currently promotes the use of hydrocarbons as part of the energy mix up to 2030. The ‘do nothing’ or ‘no-go’ option would limit seismic data acquisition from the West Coast. The opportunity to acquire more detail on the seabed topography for future use in cable laying projects and potential offshore renewable energy projects (wind) would also be lost.

While exploration does not automatically lead to production, it is an essential stage in the industries’ development cycle, which might lead to the production of oil and gas resources. The scope and nature of the future production activities that might result off the West Coast are as yet unknown, but could include a development of economic proportions significant to the South Africa economy. Such development would have numerous risks and benefits, which would need to be identified, appraised and managed through dedicated processes mandated by the applicable regulatory framework and investor requirements. The investment decisions and regulatory approvals to implement (or abandon) a production development would result from

those processes. It is relevant that the activities and processes of exploration and production are distinct and considered separately in the South African regulatory framework. As a result, this assessment does not include consideration of the risks or benefits of any aspect of possible production that might arise as a future consequence of the exploration. Similarly, reasonable consideration of the No-Go alternative is limited to the exploration viewpoint.

In addition to promoting oil and gas exploration and use of hydrocarbons in the energy mix, South African Government policy also supports a reduction in GHG emissions and a transition to a lower carbon economy. Not undertaking the proposed exploration activities would prevent relatively minor GHG emissions from occurring. Exploration, as contemplated, has no direct effect on whether South African consumers use more or less oil or gas, nor on which types of fossil fuels contribute to the countries' energy mix. By extension, the undertaking of exploration has no direct influence on GHG emissions that would arise from the consumption of fossil fuels. These aspects are influenced by South Africa's energy and climate change related policy, the financial costs of the various energy sources and consumer choices in this regard. Thus, undertaking the proposed seismic surveys versus the No-Go alternative is unlikely to have any direct influence on South Africa's reliance on hydrocarbons, nor on GHG emissions from the consumption of oil or gas.

8.10 IMPACT ASSESSMENT AND MITIGATION SUMMARY

A summary of the assessment of the potential environmental and social impacts and proposed mitigation associated with the proposed seismic survey is provided in Table 8-30.

Table 8-30: Summary of the significance of the impacts associated with the proposed 2D seismic survey in the Orange Basin

Note: (1) Neg = Negligible; VL = Very Low; L = Low; M = Medium; H = High; VH = Very High; +ve = Positive
(2) * indicates that no mitigation is possible and/or considered necessary, thus significance rating remains.
(3) ** indicates that although the significance rating of the impact remains the same, the intensity of the impact decreases due to the proposed mitigation.

No.	Activities	Aspects	Impacts on Main Receptors	Pre-Mitigation Significance	Key Mitigation / Project Controls	Residual Significance
1	**OPERATION OF VESSELS (SURVEY AND SUPPORT)**					
1.1	***Emissions to Atmosphere***					
1.1.1	Emissions from the operation of the project vessels	Increase of air pollutants	Local reduction in air quality	**NEG**	Compliance with MARPOL 73/78 Annex VI	**NEG****
1.1.2			Contribution to global greenhouse gas emissions	**NEG**		**NEG**
1.2	***Routine Operational Discharges to Sea***					
1.2.1	Liquid and solid discharges to sea	Local reduction in water quality	Impact marine ecology/environment	**VL**	Compliance with MARPOL 73/78 Annexes I, IV and V	**VL**
1.2.2	Discharge of ballast water and vessel / equipment transfer	Potential introduction of alien invasive species	Impact on marine biodiversity	**VL**	Compliance with IMO 2004 Ballast Water Management Convention	**NEG**
1.3	***Underwater noise from project vessels transit***					
1.3.1	Vessel operation	Increased underwater noise levels	Impact on marine fauna	**VL**	None	**VL***
1.4	***Lighting from vessels***					
1.4.1	Vessel operation (at night)	Increased ambient lighting	Impact on marine fauna	**VL**	Optimise lighting	**VL****

No.	Activities	Aspects	Impacts on Main Receptors	Pre-Mitigation Significance	Key Mitigation / Project Controls	Residual Significance
2	**SEISMIC ACQUISITION**					
2.1	***Underwater Noise from Airguns***					
2.1.1	Seismic acquisition / firing of the airguns	Increased underwater ambient noise levels	Impact on cetaceans	**M**	• Avoid key migration period • Undertake survey from North to South • Pre-shoot watch (MMO & PAM) • "Soft-start" procedures • MMO observation during surveying (daylight) • PAM during surveying (24/7) • Shut-downs	**L**
2.1.2						
2.1.3			Impact on seals	**L**	• Pre-shoot watch (MMO) • "Soft-start" procedures • MMO observation during surveying (daylight) • Shut-downs	**VL**
2.1.4			Impact on turtles	**M**	• Pre-shoot watch (MMO) • "Soft-start" procedures • MMO observation during surveying (daylight) • Shut-downs	**L**
2.1.5			Impact on penguins and feeding aggregations of diving seabirds	**L**	• Pre-shoot watch (MMO) • "Soft-start" procedures • MMO observation during surveying (daylight) • Shut-downs	**VL**
2.1.6			Impact on fish	**M**	• Pre-shoot watch (MMO) • "Soft-start" procedures • MMO observation during surveying (daylight) • Shut-downs	**L**

No.	Activities	Aspects	Impacts on Main Receptors	Pre-Mitigation Significance	Key Mitigation / Project Controls	Residual Significance
2.1.7	Seismic acquisition / firing of the airguns	Increased underwater ambient noise levels	Impact on invertebrates	**NEG**	• "Soft-start" procedures • Shut-downs	**NEG****
2.1.8			Impact on plankton	**M**	Avoid key spawning period	**VL**
2.1.9			Impact on demersal trawl, demersal longline	**M**	• Avoid key tuna pole fishing period by undertaking survey from North to South • Stakeholder notification • Navigational warning • Fisheries Liaison Officer (FLO) • Grievance mechanism	**M**
2.1.10			Impact on tuna pole	**M**		**L**
2.1.11			Impact on mid-water trawl, large pelagic longline	**L**		**L**
2.1.12			Impact on small pelagic purse-seine, traditional line fish	**NEG**		**NEG**
2.2	***Temporary Safety Zone around Survey Vessel and Array***					
2.2.1	Operation of seismic vessel	Temporary safety zone around survey vessel and array	Impact on demersal trawl, demersal longline	**M**	• Avoid key tuna pole fishing period by undertaking survey from North to South • Stakeholder / vessel notification • Navigational warning • Vessel lighting • Grievance mechanism	**M****
2.2.2			Impact on tuna pole	**M**		**L**
2.2.3			Impact on mid-water trawl, large pelagic longline	**L**		**L****
2.2.4			Impact on small pelagic purse-seine, traditional line fish	**NEG**		**NEG****
2.2.5			Disruption to commercial shipping	**L**		**L****
3	**INTERACTION WITH THE LOCAL ECONOMY**					
3.1	***Employment and Business Opportunities***					
3.1.1	Provision of services	Local employment and local business opportunities	Economic benefits for local service providers and suppliers	**NEG +ve**	• Contracting of local companies • Manage community expectations • Grievance mechanism	**NEG +ve**
4	**UNPLANNED EVENTS**					
4.1	***Collisions with project vessels and equipment***					
4.1.1	Ship strikes and entanglement	Obstruction on sea surface, seafloor or in water column	Health and safety impacts to coastal recreation and fishing	**VL**	• Emergency Response Plan • Stakeholder information • Navigation warning • Implement a grievance mechanism	**VL****

No.	Activities	Aspects	Impacts on Main Receptors	Pre-Mitigation Significance	Key Mitigation / Project Controls	Residual Significance
4.1.2			Impacts on marine fauna	**L**	• 'Turtle-friendly' tail buoys • Reduced transit speed • Ensure all equipment used is thoroughly cleaned	**L****
4.2	***Accidental Release of Oil at Sea***					
4.2.1	Vessel or equipment damaged and bunkering of fuel	Release of fuel into the sea and localised reduction in water quality	Impacts on marine ecology/environment	**M**	• Bunkering procedure • Shipboard Oil Pollution Emergency Plan – MARPOL Annex I • Emergency Response Plan and notification • Spill training and clean-up equipment	**L**
4.2.2			Impacts on offshore commercial fishing	**VL**		**VL****
4.2.3			Impact on nearshore mariculture	**L**		**L****
4.3	***Loss of Equipment at Sea***					
4.3.1	Accidental loss of equipment	Obstruction on seafloor or in water column	Impacts on marine ecology/environment	**VL**	• Maintenance and lifting procedures • Retrieve of lost objects / equipment, where practicable • Notify PASA, SAMSA and the SAN Hydrographer	**VL****
4.3.2			Impacts on commercial fishing	**VL**		**VL****