9 IMPACT IDENTIFICATION AND ASSESSMENT

The significance of potential environmental and social impacts of the proposed seismic survey is assessed in this chapter. The criteria used to assess significance are detailed in Chapter 2 of this report. Prevention, mitigation and control measures are also provided in this chapter.

Offshore seismic survey is a well-established practice and the potential impacts of offshore seismic operations on marine animals are broadly known. This knowledge has resulted from a number of research studies conducted to assess the nature and magnitude of impacts related with offshore seismic survey. The identification of issues associated with the proposed seismic survey in the project area was based on:

- Issues raised during the Scoping Study Phase of the EIA process;
- A sound review and understanding of the affected environment;
- Review of the nature of the proposed activities and review of the results of published studies; and
- The professional judgment of the specialist team.

An important factor in considering the environmental impact is the scale of the proposed operation. At any given location, the seismic acquisition will be completed in a short period of time and the associated impacts will typically occur over a short period of time and will be largely limited to distances close to the seismic array. However, since seismic surveys generally cover large areas and the array passes along many kilometers of survey lines, even effects manifested at short distances from the array can accumulate to cause impacts over wider areas.

Any potential impacts due to seismic surveys should therefore be viewed with respect to the scale of the operation and the scale of biological events in time and space (eg baleen whale breeding season and sea turtle nesting/hatching season). For a seismic survey to have an appreciable effect on fish population, for example, it is important that biological events must overlap the temporal and spatial scale of survey activity.

The main environmental impacts of the seismic survey can be divided into the following overall categories:

- noise impacts from the seismic vessels and seismic airgun arrays on marine fauna;

- impacts resulting from discharges and emissions including impacts on air and sea water quality and impacts associated with solid waste disposal;
- impacts resulting from unplanned (accidental) oil/ chemical spills;
- impacts resulting from disruption of shipping and navigation from the transit of seismic and similar vessels during acquisition and the associated survey exclusion zones;
- impacts resulting from disruption of fishing activities (artisanal and industrial) by the transit of seismic and similar vessels during acquisition and the associated survey exclusion zones;
- impacts resulting from disruption of tourist related activities (mainly diving and fishing) by the transit of seismic vessels during acquisition and survey exclusion zones as well as seismic array emissions; and
- impacts resulting from negative perceptions regarding the development of the oil and gas sector in proximity to a key tourism destination and the associated negative socio-economic impacts.

Each of the above issues will be assessed in detail below.

9.1 SEISMIC NOISE IMPACTS ON MARINE FAUNA

9.1.1 Impacts on Plankton

Impact Description and Assessment

Studies of plankton are poorly documented in oceanic areas, including the proposed seismic survey area, and plankton communities are known to be highly variable in space and time due to water currents and variable levels of nutrients.

Seismic pulses have been demonstrated to cause lethal effects on plankton in the immediate vicinity of the air gun (within a distance of 10 m), although the impact experienced by the plankton population has been likened to the effect of turbulence generated by a large ship's propeller (REF) and therefore is not discernible from the myriad of vessels that transit the oceans each day. In addition, since the seismic source is constantly moving while the seismic vessel is underway, the impact of the seismic pulses is not localized in any one area and therefore is unlikely to cause significant impacts to plankton communities through repeated exposure to acoustic energy.

The potential impacts on plankton populations are therefore considered to be negligible and no mitigation measures are required.

Impact Summary

The impact on plankton (*Table 9.1*) would be a ***negative direct*** impact that occurs in the ***short term*** as it would only be associated with the duration of the seismic survey. The impact would be ***on-site*** with a ***negligible*** intensity resulting in a ***negligible*** magnitude. Sound levels reduce to non-pathological levels within a short distance of the source and the movement of the seismic vessel only occurs in a specific area within the concession areas.

Significant impacts on plankton are ***unlikely*** to occur and the pre-mitigation significance of the impact is deemed to be ***negligible*** due to the fact that only those plankton within the immediate vicinity of the active acoustic source would be affected, and the plankton community as a whole will recover quickly and no long term negligible effect are likely to be evident.

Mitigation

No mitigation measures are required.

Table 9.1 Impacts on Plankton

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short term	n/a
Extent	On-site	n/a
Intensity	Negligible	n/a
Magnitude	Negligible	n/a
Likelihood	Unlikely	n/a
Significance	**Negligible**	**n/a**

9.1.2 Impacts on Pelagic Invertebrates

Impact Description and Assessment

Pelagic invertebrates are those species that swim within the water column, and within the concession area includes a variety of cephalopods such as squid (eg *Loligo duvaucelli*) and octopus (various species), and other swimming molluscs (eg *Nautilus pompilus* and *Argonauta argo*). Despite the abundance and distribution of pelagic invertebrates such as cephalopods being largely unknown in the proposed survey areas, fishermen do target these species so they are presumed to be in sufficient numbers to support a fishery.

Sound pulses generated by seismic source may be lethal if invertebrates are in close proximity (<10 m) to the sound source. Giant squid suffered severe

internal injuries due to seismic air guns according to the studies of Guerra *et al*. 2004 (cited by Weilberg 2007). However, cephalopods are highly mobile pelagic invertebrates that are likely to move away from an approaching seismic vessel and the seismic source before being harmed.

No mitigation measures are recommended for pelagic invertebrates.

Impact Summary

The impact on pelagic invertebrates (*Table 9.2*) would be a ***negative direct impact*** occurring over a ***short term*** **period** associated with the duration of the seismic survey. The impact would be ***on-site*** in extent with a ***negligible*** intensity resulting in a ***negligible*** magnitude due to the mobile nature of the pelagic invertebrates and the movement of the seismic vessel through the survey area.

Given the mobile nature of the pelagic invertebrates and their ability to actively avoid the seismic source, impacts are ***unlikely*** to occur and the pre-mitigation significance of the impact is deemed to be ***negligible***.

Mitigation

Since pelagic invertebrates are likely to actively avoid the seismic source no mitigation is required. However, a soft start procedure would give the invertebrates time to move away from the seismic source before they suffered damage, especially in areas where they are known to be abundant.

Table 9.2 Impacts on Pelagic Invertebrates

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short term	n/a
Extent	On-site	n/a
Intensity	Negligible	n/a
Magnitude	Negligible	n/a
Likelihood	Unlikely	n/a
Significance	**Negligible**	n/a

9.1.3 Impacts on Benthic Invertebrates

Impact Description and Assessment

The benthic invertebrate community is the group of species that live on the seabed, or within the seabed sediments. Most benthic invertebrates are small in size and are either sessile (ie attached to the seabed) or are slow movers that

exhibit small range movements. Benthic communities also include coral reefs, rocky reefs and seagrass/ algal beds.

The benthic community within the majority of the proposed seismic survey area is unknown, and given that the depth of the water within the survey area exceeds 200 m in most areas, benthic organisms are unlikely to be exposed to levels of seismic energy that could be physically harmful. Coral reefs, rocky reefs and seagrass/algal areas tend to develop in shallow waters (less than 100 m water depth) and are therefore mainly found in areas well inshore of the survey area (minimum distance of 2.5 km from the coast). The survey will take place in waters greater than 50 m deep, and the likelihood of significant impacts to benthic organisms directly beneath the seismic array is considered negligible. No mitigation measures are recommended for benthic invertebrates.

Impact Summary

The impact on benthic invertebrates (*Table 9.3*) if they occurred would be a ***negative direct impact*** within the ***short term*** as it would only be associated with the passage of the seismic survey across an area of seabed. The impact would be ***on-site*** in extent and due to the depth of water across the majority of the proposed survey area, the intensity of impact would be ***negligible*** and of a ***negligible*** magnitude.

Impacts of the proposed seismic survey on benthic invertebrates are ***unlikely*** to occur and the pre-mitigation significance of the impact is deemed to be ***negligible***.

Mitigation

No mitigation measures are required.

Table 9.3 Impacts on Benthic Invertebrates

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short term	n/a
Extent	On-site	n/a
Intensity	Negligible	n/a
Magnitude	Negligible	n/a
Likelihood	Unlikely	n/a
Significance	**Negligible**	n/a

9.1.4 *Impacts on Fish*

Impact Description and Assessment

The fish fauna within the concession areas includes pelagic fish species (small species like sardines, and large species like tuna, billfish and dolphin fish), mesopelagic fish species that live within the deep waters (such as lantern fish), benthic deep water species such as the coelacanth, and reef and seagrass associated species.

Seismic sources are known to cause pathological injury in fish species at distances between 500 m and a few kilometres, with lethal impacts occurring within 500 m of the sound source (McCauley *et al.* 2003). Other sub-lethal effects may include impaired schooling and swimming abilities. Production of stress hormones have also been described in studies such as Weilgart (2008).

However, there is considerable evidence of avoidance of seismic survey areas by schooling pelagic fish for periods of up to five days after seismic shooting and changes in feeding behaviours associated with seismic noise (McCauley *et al.* 2003). Such changes in behaviour include startle responses of captive rockfish species at received levels of 200-205 dB re 1 µPa, downward compression of school formation during airgun firing of various species, and decline in abundance in the area of shooting measured through catch rate declines through longline and trawl operations. In contrast to the recorded changes in schooling behaviour and distribution of some fish species, some large pelagic fish show little avoidance behaviour and may actually investigate hydrophone streamers.

The importance of communication to the survival of local fish species is unknown, but it may be important in breeding behaviour of reef fish. Many different fish species are known to use swim bladders for the production of sound and this plays an important role in species identification and spawning behaviour. Given the large distribution range of most fish species (relative to seismic survey areas), the effects of seismic noise in masking communication sounds of fish and environmental sound stimuli are anticipated to be negligible.

On the basis of studies carried out elsewhere, the impact of seismic surveys on local fish behaviour is deemed to be moderate. Given the temporary nature of seismic surveys, the significance of such effects is therefore anticipated to be low in the long term.

Of particular interest is the African coelacanth (*Latimeria chalumnae*), a critically endangered species that has been reported from the region although not specifically from the survey area. Known as the "living fossil," this species lives in deep water and is a nocturnal hunter that shelters within caves throughout the day and forages at night on squid and fish species.

Coelacanths (or any other benthic species) inhabiting the seabed in deep waters are unlikely to be subjected to seismic energy greater than 180 dB re 1 µPa due to the depth of water that attenuates the seismic energy and due to the movement of the survey vessel across the survey area, an individual fish would be exposed to seismic energy for only a few brief pulses. Behavioural responses (eg alarm response) are possible, but would be expected to be brief in duration.

The proposed seismic survey is considered unlikely to produce any significant impacts on fish species, including coelocanths, present in the survey area.

Impact Summary

The impact on fish species other than the coelacanth (*Table 9.4*) would be a ***negative direct impact*** that could occur over the ***short term*** in association with the movement of the seismic vessel through the survey area. Fish populations may actively avoid the areas of greatest seismic energy for periods of hours to days but are likely to return to the areas once the seismic energy is no longer detectable.

Impacts to fish species would be ***on-site*** in extent and localized to the concession areas and restricted to survey lines and immediate surrounding areas. The intensity of the impacts would be ***low*** because of the generally low abundance of pelagic fish species in the open ocean and the ability of pelagic species to actively avoid the seismic source. Based on the above, the magnitude of the impact would be ***low***.

Given the fact that the potential impacts of the proposed seismic survey on fish in the seismic area would have a ***definite*** likelihood of occurrence and a ***low*** magnitude, the pre-mitigation significance of the impact is deemed to be ***minor***. With the implementation of the proposed mitigation measures, the impact magnitude will stay ***low***, and the residual impact significance will be ***minor***.

Table 9.4 ***Impacts on Fish (other than the Coelacanth)***

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short term	Short term
Extent	On-site	On-site
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Definite	Definite
Significance	Minor	Minor

The coelacanth is a critically endangered species and therefore the potential impact from the seismic survey (*Table 9.5*) is considered to be of ***medium*** intensity and ***medium*** magnitude. However, impacts to the coelacanth are considered to be ***unlikely*** (as for all fish species) due to the depth of water and the transitory nature of the seismic vessel. In addition, most known coelacanth habitat is outside the survey area. The pre-mitigation significance of the impact is therefore deemed to be ***minor***.

Table 9.5 ***Impacts on Coelacanth species***

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short term	Short term
Extent	On-site	On-site
Intensity	Medium	Low
Magnitude	Low	Low
Likelihood	Unlikely	Unlikely
Significance	Minor	Minor

Mitigation

The proposed mitigation measure to reduce possible impacts of seismic surveys on fish species is to use the soft start procedure (gradual increase of the acoustic transmission intensity) to allow the fish to move away from the energy source.

9.1.5 Impacts on Sharks and Rays

Impact Description and Assessment

Very few studies have been undertaken on the impact of seismic pulses on elasmobranchs (sharks and rays). Elasmobranchs sense pressure waves in the water using a specialised lateral line system of perception. Sharks and rays are typically attracted to sound sources because they usually indicate the presence of potential prey. As a result, sharks may be exposed to increased levels of sound energy that may affect their ability to sense prey.

Shark and ray species are known to exist throughout the proposed seismic survey area although exact numbers are not known. Even though species are likely to be widespread throughout the full range of water depths, the density of each species is likely to be low as most species are generally solitary. Benthic dwelling species are unlikely to be affected by the seismic survey as the energy of the seismic pulses will be significantly reduced after transmission through the full depth of water. Pelagic species are most at risk although many species (eg manta rays and whale sharks) are likely to actively avoid the seismic survey vessel.

Impact Summary

The impact of seismic surveys on elasmobranchs would be a ***negative direct impact*** that would occur during the ***short term*** as it would only be associated with the duration of the seismic survey. The impact would be ***on-site*** in extent as it would be localized to the concession areas and restricted to survey lines and immediate surrounding areas. The intensity of the impacts would be ***low*** due to the low density of species in the deep environments of the project area. Based on the above, the magnitude of the impact would be ***low***.

The potential impacts of the proposed seismic survey on elasmobranchs have a ***definite*** likelihood as sharks or rays are likely to be within close proximity to the survey vessel at some stage of the survey. However, with a ***low*** magnitude, the pre-mitigation significance of the impact is deemed to be ***minor***.

Mitigation

In order to mitigate the impacts of the seismic survey on elasmobranchs, the following mitigation measures should be implemented:

- Soft start procedure should be used to reduce the impacts on pelagic shark and ray species (eg whale sharks and manta rays) by providing them the opportunity to move away from the seismic source as the energy levels intensify; and
- For deep water sharks, no mitigation is required as the seismic energy will be significantly reduced by transmission through the water.

Table 9.6 Impacts on Sharks and Rays

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short term, however they may need a medium term for recovery	Short term, however they may need a medium term for recovery
Extent	On-site	On-site
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Definite	Definite
Significance	Minor	Minor

9.1.6 Impacts on Marine Mammals

Impact Description and Assessment

In general, because of their low reproductive and growth rates and their vulnerability to sources of seismic pulses, marine mammals are considered species of concern. Of critical concern is the dugong, which is the most endangered marine mammal species in the Western Indian Ocean. The status and distribution of the species is unknown and the sub-populations appear to be highly fragmented. In most areas, human disturbance has driven the dugongs away from their preferred habitats in shallow coastal bays. Exposure to seismic pulses is capable of causing further displacement of dugong and temporary impacts to their hearing although the habitat of the dugong is typically in shallow bays where seagrass grows and therefore is outside the area of seismic surveys.

The effects of seismic survey on whales and dolphins could include pathological injury to individuals, behavioural avoidance of the survey area and masking of communication and echolocation.

Pathological injury

Although there is no evidence of whales or dolphins being killed or injured by seismic emissions, pathological injury to cetaceans can result from exposure to high sound levels through a number of avenues, including trauma to both auditory and non-auditory tissues. Richardson *et al.* (1995) speculate (on the basis that prolonged exposure to noises of ~80 dB above the hearing threshold induces Permanent Threshold Shifts (PTS) in humans) that very prolonged exposure to noise levels of about 120 dB re 1µPa may induce PTS in beluga whales, although other marine mammals would require much higher levels than these. The "above threshold" criteria for inducing PTS in humans are based on continuous exposure for 8hr/day over 10 years, so that gradual PTS in marine mammals is highly unlikely to occur from seismic surveys.

However such permanent hearing damage does not always develop gradually, but may result from brief exposure to high sound levels.

McCauley (1994) suggested that damage to most marine mammal hearing could occur at around 220 dB re 1 µPa. Assuming spherical spreading, McCauley (1994) has suggested that pathological injury to baleen whale and dolphin hearing would occur within 32 m and 100 m from a large seismic array, respectively.

Lien *et al.* (1993) and Ketten *et al.* (1993) estimate damage to hearing of humpback whales caused by explosives in the north-western Atlantic Ocean. McCauley (1994) notes that airguns do not produce the near-instantaneous pressure increase produced by shock waves of explosives and that the information reported by Lien *et al.* (1993) and Ketten *et al.* (1993) are not applicable to non-explosive seismic sources. However, as noted by Evans and Nice (1996) such accounts suggest that humpback whales might tolerate sounds at levels which cause pathological trauma, as neither avoidance of the blast area, nor behavioural responses were noted.

Behavioural avoidance of seismic survey areas

Baleen whales (Humpback and Minke Whales)
Baleen whales are well adapted to hear low frequency sounds and therefore will be most receptive to the noise produced during the proposed seismic operation. Minke and humpback whales are common in the proposed survey area and usually occur between June to August during their northward migration up the east coast of Africa. Between August and October, whales migrate southward to the Antarctic Ocean, often with their newborn calves.

Responses of humpback whales to seismic surveys or airgun arrays have been reported by a number of authors (Malme *et al.*,1985; McCauley *et al.*,1996, 2000; Thompson *et al.*,1986). McCauley *et al.* (2000), on the basis of humpback whale movement, summarised the results of these studies into two findings:

- Displacements of migratory animals are localised and brief (initiated at a distance of about 4 to 5 km to a closest distance of about 3 km), and the little chance of physiological effects suggest seismic surveys to be a low risk for migratory whales; and
- Whales, which are not migrating but using the area as a calving or nursery ground, may be more seriously affected through disturbance of suckling or resting. McCauley *et al.* (2000) suggest potential avoidance ranges of 7-12 km by nursing animals (based on results of single airgun trials scaled to

3D array measurements), but note that these might differ under different sound propagation conditions.

Although not noted by McCauley *et al.* (1998, 2000), disturbance of mating behaviour (which could involve a high degree of acoustic selection) by seismic noise could be of consequence to breeding animals.

McCauley (2000) noted that in terms of management purposes, the impacts on migrating humpback whales and nursing humpback whales need to be assessed differently. While the risk of seismic surveys and activities to migrating whales appeared to be low, the risk to nursing whales or whales occupying a critical habitat would be far higher. However, in the vicinity of the proposed survey area nursing whales are more likely to occur in shallow waters close to the coast which are largely outside the seismic survey area.

Toothed whales

The available information on the responses of toothed whales, including dolphins, to seismic surveys is more limited than that for baleen whales. Richardson *et al.* (1995) noted that apart from the information for sperm whales (see Mate *et al.* (1994) below; they are unaware of any systematic data on the behavioural reactions of toothed whales to seismic surveys.

The minimum hearing thresholds measured for toothed whales are in the region of 39-55 dB with best frequencies of between 8 and 90 kHz. According to Richardson, measured audiograms of toothed whales suggest best hearing frequencies at around 100 kHz, which is well above that produced by offshore seismic surveys. This suggests that toothed whales and dolphins are less sensitive to seismic emission. Indeed, there have been reports of dolphins swimming near operating seismic vessels (Stronach, 1993 and Chamberlain, 1985 in Evans and Nice (1996); Duncan, 1985) which suggest that there is little effect of seismic surveys on these species.

Rankin and Evans (1998) compared the low frequency sounds from seismic exploration to the presence or absence of cetaceans in the Gulf of Mexico and found no relationship between the presence of noise and the distribution of toothed whales and dolphins based on the analysis of 228 hours of survey. Furthermore, distributions of sperm whales occurred in areas of high intensity seismic exploration and the authors concluded that repetitive signals from seismic exploration may not have a negative impact on distribution of toothed whales and dolphins in the Gulf of Mexico. Several other studies (Davis *et al.* 2000 and Madsen *et al.* 2002) reach similar conclusions.

Results of the Gulf of Mexico Sperm Whale Acoustic Monitoring Program (SWAMP) and Sperm Whale Seismic Study (SWSS) include:

- a sperm whale tagged and tracked in the Gulf of Mexico from July to December 2001, remained in the general vicinity (6.6 to 133 km) of a 3D seismic survey until the survey was completed in mid-November (Mate, 2003);
- a tagged sperm whale in the northern Gulf of Mexico appeared to move away from an operating seismic vessel, possibly in response to the initiation of seismic activity when pulses were received at the tag at roughly 137 dB re 1µPa (Johnson and Miller, 2002); and
- More recent data from the SWSS project includes two D-tag controlled exposure (of received levels of up to 148 dB re 1µPa) experiments on four sperm whales indicate no discernible changes in dive patterns or horizontal avoidance behaviors due to seismic noise exposure.

Masking of communication and echolocation (1)

Interference of seismic emissions with acoustic communication includes the following:

- the emissions may directly mask the communication signal (which implies the signal is of comparable frequency to the seismic emission);
- the hearing capability of the species involved may be reduced (temporarily or permanently) by exposure to high level noise; or
- the behaviour of the species may be altered to preclude communication.

Baleen whales appear to vocalize almost exclusively within the frequency range of the maximum energy of seismic survey noise (although humpback song is at slightly higher frequencies – see paragraph below), while toothed whales vocalize at frequencies higher than these.

Humpback whales vocalize; males sing complex songs while on the breeding grounds, and the behaviour is strongly correlated to breeding activity (Payne and McVay, 1971; Helweg *et al.*, 1992). Such humpback song ranges in frequency between 30 Hz to 8 kHz with peak levels at 144 to 174 dB re 1µPa at 1 m in the 120 Hz to 4 kHz bandwidth.

Calls may also be utilised by other whale species during breeding behaviour. Echolocation clicks and vocalisations produced by odontocete cetaceans are

(1) Echolocation, also called Biosonar, is the biological sonar used by several mammals such as bats, dolphins and whales to locate, range and find objects for navigation and foraging.

generally at frequencies well above those produced in seismic surveys (and it is probable that clicks are not masked by seismic survey noise (Goold and Fish, 1998). The largest impact of seismic noise on common dolphins would include masking of 10 m communication within 1 km of the sound.

Impact Summary

Pathological injury to cetacean hearing by high to very high amplitude seismic sounds (particularly those that might be infrasonic to certain dolphin and toothed whale species) is possible and mitigation measures are required in the form of soft starts and monitoring so that individuals are not subject to full pulse levels at close ranges.

Although it is assumed that such highly mobile creatures would avoid severe sound sources at levels well below those at which injury would occur, the case studies involving mid – frequency sonars suggest that both fatal trauma and behavioural avoidance (leading to fatal strandings) can result from high level acoustic impulses. As the frequency of the major output of seismic survey pulses lie well below the best hearing frequencies of many toothed whales and dolphins, these species may not react or avoid such seismic sounds, thereby possibly placing them at higher risk of trauma than if the sound was avoided.

Deep diving species may be more susceptible to acoustic disturbance (Watkins and Wartzok, 1985; Bowles *et al.*, 1994), particularly in the case of seismic surveys where acoustic impulses are focused at the seafloor, resulting in trapping of deep diving cetaceans within the survey pulse, as escape towards the surface (from depth) would result in exposure to higher sound level pulses.

Baleen whales appear to avoid impulsive sounds of received level of greater than 150 to 180 dB re 1 µPa, while subtle behavioural responses have been noted at levels of above 120 dB. Toothed whales and dolphins appear to have greater tolerance to seismic pulses.

The probability of localised avoidance of seismic noise by migrating baleen whales is high and the potential for impact from noise of a seismic survey noise on the behaviour of non–breeding or migratory baleen whales is deemed to be ***negative direct impact*** which, depending on levels of avoidance and species, is likely to be ***on-site*** in extent with a ***low to medium*** intensity and ***short-term duration***. The magnitude of behavioural avoidance of seismic area to whales would, therefore, be ***low*** with a ***likely*** occurrence resulting in a pre-mitigation impact of ***moderate*** significance.

There is less evidence of avoidance of seismic surveys by toothed whales (including dolphins) than for baleen whales (possibly because the majority of seismic survey sound energy lies at frequencies below best hearing of odontocetes). The impact of seismic survey noise from alteration of the behaviour of toothed whales is deemed to be a ***negative direct impact*** which, depending on levels of avoidance and species, is likely to be ***on-site*** in extent with a ***low to medium*** intensity and short-term duration. The magnitude of behavioural avoidance of seismic area to whales would therefore be ***low to medium*** and ***likely*** occurrence resulting in a pre-mitigation impact of ***moderate*** significance.

The effect of seismic survey noise masking the communication of baleen whale noise is extremely difficult to quantify. The degree of masking of a call for example will depend on a number of factors including the source level of the seismic noise, the distance of the receiver (listener) from the source, the source level of the call, the distance of the caller from the listener and the current ambient noise.

Although suspected to be a ***negative direct impact***, the impact of seismic surveys on the reproductive singing behaviour of humpback whales is unknown. Singing male humpback whales are expected within the survey area between July to November and it is recommended that seismic surveys are not carried out over these months.

Table 9.7 Pathological Noise Impacts on Baleen Whales

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	On site	On site
Intensity	Low to medium	Low
Magnitude	Low to medium	Low
Likelihood	Likely	Likely
Significance	**Moderate**	**Minor**

Table 9.8 Behavioural Noise Impacts on Baleen Whales

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	On site	On site
Intensity	Low to medium	Low
Magnitude	Low to medium	Low
Likelihood	Likely	Likely
Significance	**Moderate**	**Minor**

Table 9.9 Behavioural Noise Impacts on Toothed Whales (incl. Dolphins)

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	On site	On site
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	**Minor**	**Minor**

Table 9.10 Masking Noise Impacts on Baleen Whales

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	Regional	Regional
Intensity	Unknown, Possible masking of breeding vocalisations; Probable masking of nonspecific's / environment (High if breeding impacted)	Unknown, Possible masking of breeding vocalisations; Probable masking of nonspecific's / environment (High if breeding impacted)
Magnitude	Unknown – probably medium to high	Unknown – probably medium to high
Likelihood	Likely	Likely
Significance	**Unknown – moderate to high**	**Unknown – moderate to high**

Table 9.11 Masking Noise Impact on Toothed Whales (incl. Dolphins)

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	Regional	Regional
Intensity	Unknown, Possible masking of breeding vocalisations; Probable masking of nonspecific's / environment (High if breeding impacted)	Unknown, Possible masking of breeding vocalisations; Probable masking of nonspecific's / environment (High if breeding impacted)
Magnitude	Unknown – probably medium to high	Unknown – probably medium to high
Likelihood	Likely	Likely
Significance	**Unknown – low**	**Unknown – low**

Mitigation

In order to mitigate the impacts of seismic surveys on marine mammals, the following mitigation measures should be implemented:

- Use minimum seismic levels (intensity, acoustic pressure) that are sufficient to obtain the necessary results from the acquisition survey;
- Monitor the presence of marine mammals by using Marine Mammal Observers (MMOs) on board the seismic vessel, who will perform a visual/acoustic observation prior to the commencement of seismic activities;
- Delay the start of the seismic acquisition whenever a whale or dolphin is present within the exclusion zone of 500 m around the seismic vessel, and wait until they leave the area;
- Use the soft start procedure (gradual increase of the acoustic transmission intensity) to allow the animals to move away from the acquisition source/vessel. This procedure should be implemented over at least 20 minutes time period;
- Only commence with soft start procedures once the 500 m exclusion zone around the seismic vessel has been monitored to verify the absence of marine mammals through visual observation and/ or the use of acoustic monitors;
- Use Passive Acoustic Monitors (PAMs) on board the vessel during night seismic acquisitions or seismic activities under foggy conditions. PAMs will allow for the detection of the marine mammals vocalizations in the vicinity of the seismic vessel. Also ensure that the MMOs have sufficient training for the interpretation of PAM data and PAM operations;
- Avoid carrying out seismic activities during the humpback whales migration season (July to November), particularly during birth and

nursing periods when whales with calves use the marine waters in close proximity to the coast;

- Increase the exclusion zone to 1 km in areas with steep bathymetric gradients to reduce the acoustic impact on whales that might use those areas as places of refuge/rest, migration corridors or places for birth and breeding;
- Always begin new seismic lines with the soft start procedure, and shut down acoustic source at the completion of each seismic line as the vessel turns to line-up with the next seismic line to avoid impacting the adjacent areas (especially to the west, where shallow water habitats occur).
- If for any reason the acoustic transmission is interrupted and not re-initiated within a time period of 5 minutes, a soft start procedure will be followed once the exclusion zone has been verified as being clear of marine mammals for a period of at least 20 minutes. If mammals are present within a range of 500 m, procedures of observation, listening, delay and soft start should be applied.

9.1.7 Impacts on Sea Turtles

Impact Description

The effects of seismic noise on turtle species could include:

- pathological injury and mortality; or
- behavioural avoidance of seismic survey areas.

Impact Assessment

Behavioural responses to seismic sounds have been reported for sea turtles in caged response trials as discussed below.

- Captive loggerhead turtles (in a 300 x 45 m enclosure) have been shown to avoid operating airguns (two 13 cm^3 "poppers" and one of 165 cm^3 volume, at 2 m depth) by 30 m in an experimental situation (O'Hara, 1990), although received sound pressure levels from the airguns were not measured. Based on sound levels of similar volume airguns, McCauley *et al*. (2000) suggest the received level could have been in the order of 175-176 dB re 1 µPa rms.

- Moein *et al*. (1994, in McCauley *et al*. 2000) investigated avoidance behaviour, physiological response and electroencephalogram measurements of hearing capability of 11 caged (18 m x 61 m x 3.6 m) loggerhead turtles to airgun sounds. Airguns were fired at 175, 177 and

179 dB (no units are provided) at 5-6 second intervals. No information as to the operational pressure, deployment depth or received levels of the airguns are given, although McCauley *et al*. (2000) suggested (based on avoidance distances quoted and cage measurements) that received levels ranged between 172 and 176 dB re 1 µPa rms. The first trial at 24 m elicited avoidance, while further trials several days later did not elicit statistically significant avoidance, possibly as a result of a reduction in hearing. Moein *et al*. 1994, (in McCauley *et al*. 2000) suggested that this was due to habituation or a temporary shift in hearing threshold. While physiological stress was recorded, McCauley *et al*. (2000) note that no control was applied in that stress resulting from handling of turtles during trials was not accounted for.

- McCauley *et al.* (2000) carried out two trials to investigate behavioural responses of caged green and loggerhead turtles to an approaching airgun. Trials were carried out 2 days apart using a 20 cui single airgun. Above levels of 166 dB re 1 µPa rms the turtles significantly increased their swimming activity compared to periods without operating airguns. Above 175 dB re 1 µPa rms turtle behaviour became more erratic which the authors suggest may have reflected an agitated behavioural state. The authors caution that the low water temperatures during trials may have lessened the metabolic rate and therefore response level during trials.

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. However, juvenile turtles may be less able to avoid seismic sounds in the open ocean, and consequently may be more susceptible to impacts. An important consideration is therefore the nesting and hatching seasons for various turtle species found in the proposed survey area.

Impact Summary

Given information from other large marine vertebrates, the pathological / injury impact on turtles is assumed to be a ***negative direct impact***. The impact would be ***short term***, ***on-site*** in extent, ***medium*** intensity to non - breeding turtles, and of ***medium*** magnitude. However this intensity increases to ***high*** within the nesting season, where turtle breeding stimuli could override avoidance response.

Based on the above, the pathological pre-mitigation impacts of seismic surveys on turtles would be ***likely*** to occur and be of ***moderate*** significance in the nesting season. The impact of seismic surveys on non–breeding turtle

behaviour is also a ***negative direct*** impact with ***short term*** duration, ***on-site*** extent and a ***medium*** intensity.

The effect of seismic noise in masking environmental cues is unknown and speculative. Given the general extent of turtle migrations (compared to the relatively smaller areas of seismic survey) the impact of masking of environmental cues by seismic noise (and therefore on turtle migrations) is deemed to be of ***low*** significance.

While it is recognised that the nesting season over the period October to March is sensitive, it is strongly recommended that seismic surveys are not planned in nearshore waters during the hatching season between January and April. Seasonal and spatial mitigation combined with soft starts will reduce the potential impact to ***low*** significance.

Mitigation

In order to mitigate the impacts, the following mitigation measures should be implemented:

- Use minimum seismic levels (intensity, acoustic pressure) that are sufficient to obtain the necessary results of the acquisition;
- Delay the start of the seismic acquisition whenever a turtle is present within the exclusion zone of 500 m around the seismic vessel, and wait until the animals leave the area;
- Use the soft start procedure (gradual increase of the acoustic transmission intensity) to allow the animals to move away from the acquisition source/vessel. This procedure should be implemented over at least 20 minutes time period;
- Only commence with soft start procedures once the 500 m exclusion zone around the seismic vessel has been monitored to verify the absence of marine turtles through visual observation;
- Monitor the presence of marine turtles by using Marine Mammal Observers (MMOs) on board the seismic vessel, who will perform a visual/acoustic observation prior to the commencement of seismic activities;
- Always begin new seismic lines with the soft start procedure, and shut down acoustic source at the completion of each seismic line as the vessel turns to line-up with the next seismic line to avoid impacting the adjacent areas (especially to the west, where shallow water habitats occur).
- If for any reason the acoustic transmission is interrupted and not re-initiated within a time period of 5 minutes, a soft start procedure will be followed once the exclusion zone has been verified as being clear of

marine turtles for a period of at least 20 minutes. If turtles are present within a range of 500 m, procedures of observation, delay and soft start should be applied.

Table 9.12 Pathological Noise Impacts on Turtles

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	On-site	On-site
Intensity	Assumed medium due to slow swimming to high during nesting seasons (overriding nesting stimulus); endangered species	Assumed medium due to slow swimming to high during nesting seasons (overriding nesting stimulus); endangered species
Magnitude	Medium	Medium to low
Likelihood	Likely	Likely
Significance	**Moderate to major**	**Minor**

Table 9.13 Behavioural Noise Impacts on Turtles

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	On-site	On-site
Intensity	High – due to short term avoidance of breeding habitat to endangered species (if avoidance occurs).	High – due to short term avoidance of breeding habitat to endangered species (if avoidance occurs).
Magnitude	High	Medium to low
Likelihood	Likely	Likely
Significance	**Major**	**Minor**

9.1.8 Impacts on Seabirds

Impact description

Seismic noise is unlikely to impact seabirds as they spend most of their time in the air while at sea, with only short dives into the surface waters to catch prey.

Impact Assessment

Seabirds spend only short periods of time in the water while feeding and are able to actively avoid areas where the acoustic noise is greatest (ie near the acoustic source). Some seabird species tend to follow vessels as they are attracted to the turbulence behind the vessel where prey are brought near the surface, or scrap food is thrown overboard. Seabirds are able to actively avoid stressful areas and are unlikely to be directly affected by the seismic noise.

Impacts to prey species (eg pelagic fish) may also affect feeding success of seabirds feeding in the vicinity of the seismic vessel. However, given the feeding ranges of most seabird species and the distribution of prey such impacts are unlikely and deemed *negligible*.

Impact Summary

The impact of seismic emissions on seabirds is deemed to be of *negligible* significance.

Table 9.14 Pathological Noise Impacts on Seabirds

	Without Mitigation	Residual Impact (with mitigation)
Duration	n/a	n/a
Extent	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	**Negligible**	**Negligible**

Table 9.15 Behavioural Noise Impacts on Seabirds

	Without Mitigation	Residual Impact (with mitigation)
Duration	n/a	n/a
Extent	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	**Negligible**	**Negligible**

Mitigation

No mitigation is required.

9.2 SEISMIC NOISE IMPACTS ON FISHERIES AND TOURISM

9.2.1 Impact on Artisanal and Industrial Fisheries

Impact Description and Assessment

The seismic survey could potentially result in a temporary drop in catch levels of fish and other types of catch normally caught by artisanal and semi-industrial fisheries as a result of the movement of fish schools away from the areas undergoing seismic surveys.

The operation of seismic airguns is known to affect the catch rate of trawl, longline and other fishing operations over short periods of time (days) after the seismic exploration. The change in distribution of fish induced by seismic operations can lead to temporary decrease in catch rates within, and close to, the area of operation. At the same time, it can cause an increase in catch rates in areas where fish have moved.

Information is not consistent about the distances from the seismic sound source from which fish may flee and thus the radius of the affected area. Fishing is a key economic activity undertaken within the concession area, mainly by artisanal fishermen, but also by commercial (industrial) and recreational fishermen and any changes in fish catch will impact these fishers. The impacts on the various kinds of fishers are discussed below.

Artisanal Fishermen

Artisanal fishing is the key community activity likely to be impacted by the seismic surveys. Artisanal line and net fishing from boats (mostly 3 – 5 km offshore) and collection of marine products (eg crabs and shells) along the shore are carried out for subsistence purposes and are the most important sources of income of people living along the coast within the project area. Most fishing is carried out close to shore in and around the reefs that are outside the seismic survey footprint due to insufficient water depths for the seismic vessel. Fishing centres along the coast are located within the Mecúfi, Chiúre and Memba districts, with various small fishing camps in between the fishing centres. The occupation and use of these centres and camps varies with the reports of fish density at different times of the year.

The artisanal fishers that will be potentially impacted by the seismic noise are the producers who catch the fish and the processors who smoke/ dry the fish. Those engaged in supporting industries such as boat-building and net making are less likely to be impacted. Although divers constitute an important sector of small-scale fishing (eg for lobsters, calamari and octopus), they tend to operate from the shore in shallower waters, or from canoes close to offshore reefs and are less likely to be directly affected by the seismic survey. The collection of sea products (eg shells and crabs) is an activity mostly carried out by women, in the intertidal zone and is unlikely to be impacted by the proposed seismic survey.

Illegal fishing operators (reportedly approximately 20 - 30 operating between Pemba and Angoche) use bigger boats to carry up to 40 fishers into offshore areas (further than 21 km from the coast) where they distribute themselves into smaller boats to net fish. These operators have fixed places for fishing,

but can move to different places over four to six months and operate mainly between January and April.

A decrease in catches in coastal areas would affect artisanal fishermen that usually use fishing grounds in the Mecúfi, Chiúre and Memba districts and around Pemba. This could result in a significant impact due to the vulnerable socio-economic status of these communities and the limited opportunity to move to alternative locations. A decrease in catches by artisanal fishermen would not only result in a loss of income and reduction of food security for fisher families but would also affect other activities directly dependent on fisheries. The 3D seismic activities are expected to will result in a higher impact on artisanal fishermen because of the increased density of the lines that need to be acquired, although the footprint of 3D surveys is smaller than the 2D surveys. The impact as a result of a potential decrease in fish catches is expected to be less significant and limited to the short-term (days) during the 2D seismic exploration activities.

The significance of this impact will be dependent on the duration (number of days where the fish catch is substantially reduced) and magnitude (percentage reduction in fish catch) of the impact. The uncertainty discussed above in relation with the impacts on fish is reflected in the assessment of impact on fish in *Section 9.1.3*.

Industrial Fisheries

There is some industrial fishing from larger vessels primarily for shrimp and deepwater fish species, located further from the coast in the north. These shrimp and fish species are mainly exported, rather than sold on the domestic market. Although there is no detailed information on the numbers of industrial fishing vessels that use the waters in the concession area, or detailed data related to their catches, it is anticipated that the impact on this sector will be less significant than on the artisanal fishing sector. Line fishing will be more impacted than prawn and other crustacean fishing, due to the behavioral effects on fish versus that of crustaceans. Catches directly after the seismic survey may be lower in these areas in the short term, with the actual duration of effects only becoming known during and after surveying.

Given that the impact is relatively localised and the industrial fishers can move their vessels further from the seismic acquisition area, if necessary, the impacts are expected to be lower on industrial fishers.

Impact Summary

The impact of seismic noise on artisanal fishers will be vary from ***on-site*** (territorial reef fish) to ***local*** (highly mobile fish) and be of ***short-term*** duration. The intensity of the impact is ***high*** due to the vulnerable socio-economic conditions of the communities who depend of fisheries as a key source of livelihoods. The pre-mitigation magnitude is therefore ***medium***, resulting in a pre-mitigation impact of ***moderate*** significance.

The impact of seismic noise on industrial fisheries in the project area will be ***local***, ***short-term*** and with a ***low*** intensity due to the mobility of the fishing vessels to move to areas unaffected by seismic noise. The magnitude is therefore ***low*** and the impact is likely to occur resulting in the impact on industrial fishers being deemed to be of ***minor*** significance.

It should be noted that a lack of research on the effect of seismic survey on fisheries, specifically in tropical shallow waters, results in uncertainty in the prediction of the magnitude and duration of the impact on fisheries in the medium to long term. This assessment of significance is therefore conservative.

Table 9.16 Seismic Noise Impacts on Artisanal Fisheries

	Without Mitigation	**Residual Impact (with mitigation)**
Duration	Short-term	Short-term
Extent	On site (territorial reef fish) to local (highly mobile fish)	On site (territorial reef fish) to local (highly mobile fish)
Intensity	High	Moderate
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	**Moderate**	**Minor**

Table 9.17 Seismic Noise Impacts on Industrial Fisheries

	Without Mitigation	**Residual Impact (with mitigation)**
Duration	Short-term	Short-term
Extent	Local	Local
Intensity	Low due to mobility of fishing vessels	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	**Minor**	**Negligible**

Mitigation

In order to mitigate the impacts of seismic noise on fisheries, the following mitigation measures should be implemented:

- Minimise the seismic footprint where possible and limit survey activity in nearshore areas frequented by fishers;

- Submit a Notice to Mariners to inform the fishers of seismic activities;

- Employ a Fisheries Liaison Officer (FLO)/ Environmental and Communication Site Officer (ECSO) to coordinate dissemination of information associated with the seismic survey, and to liaise with fishing committees and fishing organisations leading up to the seismic survey, throughout the survey, and after the survey is completed;

- Coordination and communication with fishers – it is important to establish a communication structure to liaise with the artisanal and industrial fishing industries. Daily notification should be sent via SMS (where cell phone service is available) or radio stations, to inform fishers of the planned seismic events as well as the location of the seismic vessel on any particular day, and plans for the following few days. If fishers are aware of where the seismic vessel will be operating they may be able to avoid those areas and reduce their losses;

- Establish a complaint procedure – A complaint procedure through which valid complaints regarding the seismic impacts to fisheries (eg lost income, lost equipment) could be discussed between the FLO/Environmental and Communication Site Officer (ECSO) and the Government fisheries department; and

- Employ locals to crew chase boats (or employ local boats as chase boats) to ensure effective communication between fishers and the seismic survey personnel. At least one of the crew members on each chase boat should be fluent in local languages, and have knowledge of local fishing practices. This could avoid misunderstandings, and minimise the potential for conflict between the chase boat crew and fishers while at sea.

9.2.2 *Impacts on Recreational and Sport Fishing*

Impact Description

The seismic survey would potentially result in a temporary drop in catch rates of game fish due to fish avoidance of the sound emissions during or after seismic surveying.

Impact Assessment

Recreational and sport fishing occurs within the project area and is carried out by tourists, especially by those based in Pemba, Nacala Port area and Memba from resorts in the north and through specialised recreational fishing operators in the south. These amateur fishers organize recreational competitions according to specific international regulations at various times during the year.

No information is available of the exact species of fish caught by the recreational fishers, but it is expected that recreational fishing activities target billfish species as well as demersal rocky dwellers and pelagic species. The most sought after billfish species are likely to include marlin, sailfish, wahoo, skipjack tuna, yellowfin tuna, trevally and Spanish mackerel. The rocky bottom fish species targeted by some sport fishing clubs are also species targeted by industrial and artisanal line fishing. The seismic surveys could result in these species avoiding the seismic area, resulting in a decrease in catch for recreational fishing, possibly resulting in a reduced fishing experience for sports/recreational fishermen, with associated negative impacts on tourism.

Impact Summary

The potential impact of a drop in catch levels for recreational fishing will be a short-term and of ***negligible*** to ***medium*** intensity depending on whether the survey occurs outside or inside the peak tourist season. The effects of the impact will be felt ***locally*** (for mobile pelagic species) or ***on-site*** (for territorial reef fish). The impact intensity is therefore of ***low*** to ***medium*** intensity, ***low*** to ***medium*** magnitude but is likely to occur. The pre-mitigation significance of the impact is deemed to be ***minor*** (out of tourist season) to ***moderate*** (during fishing competitions).

Mitigation

In order to reduce the significance of the impact of seismic noise on recreational and sport-fishing, the following mitigation measures should be implemented:

- Avoidance of the peak tourist seasons of December/January, the Easter break and June/August, where possible;
- Minimise the seismic footprint where possible and limit survey activity in nearshore areas frequented by recreational fishers;

- Submit a Notice to Mariners to inform recreational fishers and sport-fishing operators of intended seismic activity;

- Employ a Fisheries Liaison Officer (FLO)/ Environmental and Communication Site Officer (ECSO) to coordinate dissemination of information associated with the seismic survey, and to liaise with tourist operators engaged in fishing activities leading up to the seismic survey, throughout the survey, and after the survey is completed;

- Coordination and communication with fishers – it is important to establish a communication structure to liaise with the recreational fishing industry. Daily notifications should be sent via SMS (where cell phone service is available) or radio stations, to inform fishers of the planned events as well as the location of the seismic vessel on any particular day, and for several days in advance. If tourist operators are aware of areas where the seismic vessel will be operating they may be able to fish in alternative areas to maintain the tourist experience;

- Establish a complaints procedure whereby tourist operators can register a complaint with the FLO/ ECSO, and the FLO/ ECSO can discuss claims for compensation with the relevant Government department;

- Employ locals to crew chase boats (or employ local boats as chase boats) to ensure effective communication between fishers and the seismic survey personnel. At least one of the crew members on each chase boat should be fluent in local languages, and have knowledge of local fishing practices. This could avoid misunderstandings, and minimise the potential for conflict between the chase boat crew and recreational fishers within the survey area;

- Assist in promoting Pemba as a destination – promote Pemba as a destination by contributing to marketing campaigns through which the area is marketed and promoted; and

- Media fact sheet – a media fact sheet should be prepared which can be used to assist the tourist operators to brief members of staff as to how to convey information relating to the seismic survey.

Table 9.18 Seismic Noise Impact on Recreational and Sport Fishing

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term

	Without Mitigation	Residual Impact (with mitigation)
Extent	On-site (territorial reef fish) to local (highly mobile fish)	On-site (territorial reef fish) to local (highly mobile fish)
Intensity	Low (out of tourist season) Medium (during fishing competitions)	Low
Magnitude	Low – Medium	Low
Likelihood	Likely	Likely
Significance	Minor (out of tourism season) to Moderate (during fishing competitions)	Minor

9.2.3 *Impact on Diving and Underwater Related Recreational Activities*

Impact Description

As with marine mammals, it is expected that seismic surveys and resultant exposure to high levels of underwater sound will result in injury to humans. There are three types of injury/ damage, namely, shifts of hearing threshold, tissue damage as a result of the near instantaneous increase in pressure, which forms shock waves of explosive pulses and acoustically induced decompression sickness (at over 210 dB). As pressure rises are not rapid in non-explosive seismic sources, tissue damage from such sources is likely to be negligible.

It is further noted that over and above pathological injury, a reduced diving experience may result from exposure to increased background noise resulting from the survey or absence of marine species.

Impact Assessment

Recreational diving occurs mainly within the tourist areas of the project area. The area within Membas Bay is attractive for diving and snorkelling because of the sections of vertical drop-offs, swim-throughs and shallow caves in some of the most extensive coral shallows along the northern coast. Snorkelers are typically attracted to shallow areas of 10 to 15 m where the diversity of coral and coral dependent species is greatest.

Much of the limited information available on the impact of underwater noise on humans is from military sources. The U.S. Navy has conducted two studies of relevance (see www/surtass-lfa-eis.com):

- The Applied Research laboratory of the University of Texas carried out 437 tests on 87 divers over the period 1993 to 1995. Divers were subject to a nine 100 second 50 percent duty cycle 160 dB pulses of varying frequency

above 160 Hz. The study did not induce any long term effects on major organ systems and concluded that sound pressure levels of below 160 dB would "not be expected" to cause physiological damage to a diver.

- Studies conducted by the U.S. Office of Naval Research (ONR) and the U.S. Naval Submarine Medical Research Laboratory (NSMRL) in conjunction with a consortium of university and military laboratories developed guidance for safe exposure limits for recreational and commercial divers to low frequency sound, particularly SURTASS Low Frequency Active Sonar (LFAS). The studies concluded that the maximum intensity used during tests (received level of 157 dB) did not produce physiological evidence of damage in human subjects. A two percent "very severe" aversion reaction was recorded in divers at a level of 148 dB. The NSMRL therefore determined (by scaling back the intensity by 3 dB (a 50 percent reduction in signal strength) that a received level of 145 dB would provide a suitable margin of safety for divers. Consequently, in June 1999, NSMRL set interim guidance for the operation of low frequency underwater sound sources in the presence of recreational divers at 145 dB. This guidance has been endorsed by both the Navy's Bureau of Medicine and Surgery and the Naval Sea System Command (British Ministry of Defence, 2004).

Richardson *et al.* (1995) also noted a number of vertigo and discomfort effects to human divers from underwater sounds.

The underwater seismic array emissions are expected to be in the order of 220 - 250 dB re 1µPa at 1 m from the source and much reduced at increasing distances from the source. Richardson *et al.* (1995) noted that in water depths of 25 to 50 m, seismic airgun arrays are often audible for distances of 50-75 km and that detection ranges can exceed 100 km with efficient propagation or in deep water. Application of such attenuation rates suggest that seismic sounds could be heard by divers for considerable distances from source. In shallow water (20 to 110m deep) basic cylindrical spreading modeling suggests that the limit for humans would be met at around 56 km from the source. However, this does not include the effect of bottom attenuation, which could affect the result by a factor of five.

The majority of dive tourists travel considerable distances to the area and are likely to travel elsewhere if a reduced diving experience is perceived. The overall diving experience may be impacted by:

- the reduced opportunities to dive certain areas; and

- a reduced diving experience due to hearing a background of seismic sounds.

International regulations generally require that divers do not operate in areas undergoing seismic surveys. Advanced warnings should be provided to ensure that they are able to vacate the areas in a timely manner.

The proposed seismic surveys could have significant impacts on the dive tourism industry operating within the seismic survey area.

Impact Summary

The negative impact of the seismic activities and associated noise on recreational divers and other related underwater activities will be ***temporary***, ***local*** and with ***low*** intensity outside of the tourist season, and ***high*** intensity during the tourist season. The magnitude of the impact is therefore ***low – medium***. The impact will definitely occur and the pre-mitigation impact is judged to be of ***minor – moderate*** significance.

Mitigation

The following mitigation measures are recommended to reduce the significance of the impact of the project activities on divers and underwater recreational activities:

- Avoid undertaking seismic surveys during peak tourist seasons of December/ January, Easter (March/ April) and June/ August, if possible;

- Develop an effective communication plan including identification of communication channels to transmit information (ie notification of the location and timing of seismic survey activities) to key diving operators;

- development of a detailed compensation plan to ensure that all impacted stakeholders are compensated should there be loss of business as a result of lost diving opportunities or the enforcement of exclusion times, and provide compensation where appropriate.

Table 9.19 Seismic Noise Impact on Diving and Underwater Related Recreational Activities

	Without Mitigation	**Residual Impact (with mitigation)**
Duration	Temporary	Temporary
Extent	Local	Local

	Without Mitigation	Residual Impact (with mitigation)
Intensity	Low (outside tourist season) - High (during tourist season)	Low (outside tourist season) – Moderate (during tourist season)
Magnitude	Low - Medium	
Likelihood	Definite	
Significance	Minor (outside tourist season) – Moderate (during tourist season)	Minor

9.3 IMPACTS DUE TO SEISMIC VESSEL MOVEMENTS AND THE EXCLUSION ZONE

Various forms of exclusion will need to be enforced during the seismic surveys. This is required to prevent disturbances to the seismic acquisition, which needs to occur in a continuous manner exactly along the proposed seismic lines. Any disturbance of the seismic acquisition programme could result in delays while the streamers are untangled and the vessel is turned back onto the seismic acquisition path and may incur additional costs. The seismic vessels and their streamers could also interfere with the movement of other vessels and result in entanglement.

The seismic programme is proposed for deep water areas (between approximately 200 and 2500 m deep) with the coastal boundary of the proposed seismic survey area within approximately 10 km of the shoreline. During turning, however, the vessel may approach as close as 2 km to the shore but the seismic source will be shut down during the turning manoeuvre.

Exclusion zones will be required for the duration of the seismic surveys and will be enforced through the use of chase boats that will move ahead of the seismic vessel to warn vessels out of the way. The size of the exclusion zone will depend on the specific seismic survey vessel being used but typically prohibits the approach of any vessel to within at least 500 m of the survey vessel and the streamers.

9.3.1 *Impact on Artisanal and Industrial Fisheries due to Exclusion Zones*

Impact Description

The exclusion zone required by the seismic vessels would limit the access of fishermen to fishing areas, resulting in a reduction in catch for artisanal fishermen and a disruption of industrial fishing activities. However, this impact will only occur at the time of the seismic survey vessel crossing through the fishing areas. The fishers will be able to resume fishing once the seismic survey vessel (and streamers) has passed.

Impact Assessment

Artisanal Fishermen

The 2D seismic survey will have a limited impact on artisanal fishermen as exclusion times for certain areas in the water may range from 2 to 3 days (depending on the survey plan), resulting in a short-term impact. The exclusion zone will have a negative impact on line and net fishermen who may be prevented from fishing during the survey period.

Several key artisanal fishing grounds in the Mecúfi, Chiúre and Memba districts and to the south of Pemba are located within the concession area; exclusion from these areas will result in an impact of medium intensity as the duration of exclusion is likely to be only be for a few days.

The seismic operations may also result in loss and/ or damage to any fishing gear deployed within the fishing grounds in the proposed seismic survey area. Such equipment will need to be collected by the chase boats prior to the arrival of the seismic survey vessel.

Industrial Fishing

Industrial fishing occurs in offshore from larger vessels, targeting shallow water shrimp as well as deepwater fish species located further from the coast. Although the exact location of the industrial fishing areas is unknown, they are likely to overlap with the exclusion zones associated with the seismic surveys, resulting in an impact of their operations. However, the impact will only occur while the seismic survey vessel (and streamers) is passing through the area, and the fishers can resume activities once the seismic vessel has passed.

Impact Summary

The impact of the exclusion zones for the seismic survey on artisanal fishermen will be ***temporary*** (for the duration of the seismic surveys in the area), restricted to the exclusion zone and of ***medium*** intensity due to the high reliance on fishing as a key livelihood. The magnitude of the impact is ***medium***, and will definitely occur, such that the pre-mitigation impact will be of ***moderate*** significance. With the implementation of mitigation measures as suggested below, the significance of the impact will remain ***moderate*** due to the high vulnerability of the communities and their particular dependence on this source of livelihood.

The impact of the exclusion zone on industrial fisheries will be ***temporary***, restricted to on-site. The intensity of the impact will be low resulting in an

impact of ***low*** magnitude, the impact will definitely occur resulting in an impact of ***minor*** significance.

Mitigation

In order to reduce the significance of the potential impact of the exclusion zone on artisanal and industrial fishing, the following measures are recommended:

- Employ a Fisheries Liaison Officer (FLO)/ Environmental and Communication Site Officer (ECSO) to coordinate dissemination of information associated with the seismic survey, and to liaise with fishing committees leading up to the seismic survey, throughout the survey, and after the survey is completed;

- Coordination and communication with fishers – it is important to establish a communication structure to liaise with the recreational fishing industry. Daily notifications should be sent via SMS (where cell phone service is available) or radio stations, to inform fishers of the planned events as well as the location of the seismic vessel on any particular day, and for several days in advance. If fishers are aware of areas where the seismic vessel will be operating they may be able to fish in alternative areas to maintain catch rates;

- Establish a complaints procedure – A complaints procedure through which valid complaints regarding the seismic impacts to fisheries (eg lost income, lost equipment) could be raised via fishing committees and discussed between the FLO/ ECSO and the Government fisheries department; and

- Employ locals to crew chase boats (or employ local boats as chase boats) to ensure effective communication between fishers and the seismic survey personnel. At least one of the crew members on each chase boat should be fluent in local languages, and have knowledge of local fishing practices. This could avoid misunderstandings, and minimise the potential for conflict between the chase boat crew and fishers while at sea.

Table 9.20 Impacts on Artisanal Fisheries due to Exclusion Zone

	Without Mitigation	**Residual Impact (with mitigation)**
Duration	Temporary	Temporary
Extent	On-site	On-site
Intensity	Medium	Medium
Magnitude	Medium	Medium

	Without Mitigation	Residual Impact (with mitigation)
Likelihood	Definite	Definite
Significance	**Moderate**	**Moderate**

Table 9.21 Impacts on Industrial Fisheries due to Exclusion Zone

	Without Mitigation	Residual Impact (with mitigation)
Duration	Temporary	Temporary
Extent	On-site	On-site
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Definite	Definite
Significance	**Minor**	**Negligible**

Note: Illegal fishers will not be compensated.

9.3.2 Impacts on Shipping and Cruise Liners due to Exclusion Zones

The presence of the seismic survey vessel (and streamers) is likely to interfere with the movement of other marine vessels through the survey area. Approximately 1,000 ships (approximately 83 per month) travel along the Mozambican coast between 37 and 64 km offshore. The exclusion zones required for the seismic acquisition activities will overlap with the marine shipping paths of approximately seven of these internationally-registered merchant vessels which pass through Areas 3 and 6 to and from Nacala Port every week. Future traffic is expected to be supplemented with three ships periodically bringing supplies to Anadarko's offshore gas prospect. No ships are known to pass through the concession area north of the Port of Nacala. The long distance ocean-going vessels, the few island-hoppers and the single coastal petroleum ship that visits Pemba each quarter, tend to travel closer to the shore, and generally do not pass through Areas 3 and 6.

In addition, a number of ocean-going cruise liners occasionally pass through the concession area. The maritime and port authorities will be made aware of plans for cruise ships passing through the area closer to the planned dates of the trips.

Impact Summary

The impact on shipping due to the presence of the seismic survey vessel and imposition of the exclusion zone is ***short-term***, but with ***national extent*** due to the disturbance of international shipping routes, and realignment of the vessel routes within Mozambican waters. The intensity will be ***low***. This will result in an impact of ***low*** magnitude with a definite likelihood resulting in an impact of ***minor*** significance.

Mitigation

The recommended mitigation measures are the following:

- Coordination and communication with ships – establish a communication structure to liaise with the shipping industry, using established forms of communication such as Notice to Mariners. Daily notifications should be sent via SMS (where cell phone service is available) or radio stations, to inform ships of the planned events as well as the location of the seismic vessel on any particular day;

- Issue a Notice to Mariners to inform shipping operators of intended seismic operations;

- Maritime radio communication between commercial ships and the seismic survey vessel should be used to inform the position and trajectory of the survey at any given time, especially when other vessels are known to be operating in the area; and

- Chase boats should be used to patrol in front of the seismic vessel warning all vessels out of the path of the seismic vessel.

Table 9.22 Impacts on Shipping due to Exclusion Zones

	Without Mitigation	**Residual Impact (with mitigation)**
Duration	Short-term	Short-term
Extent	National	National
Intensity	Low	Negligible
Magnitude	Low	Low
Likelihood	Definite	Definite
Significance	**Minor**	**Minor**

9.4 IMPACTS DUE TO AIR EMISSIONS

9.4.1 Impacts on Air Quality

Impact Description and Assessment

Emission of nitrogen and sulphur-based gaseous compounds (NOx and SOx) to the atmosphere will occur during operation of the seismic survey vessel (including mobilisation to Mozambique). The extent of impact to air quality will depend on the quality of fuel used (eg low sulphur fuels) and the efficiency of the vessel's engines (ie level of maintenance).

This short-term impact on air quality is anticipated to be minimal and no greater than that from another vessel of similar size, although the activity of the vessel is concentrated within a defined survey area for a period of two months.

Impact Summary

The impact on air quality is ***short-term***, but with ***on-site extent*** due to the presence of the seismic vessel in the area. The intensity will be ***negligible***. This will result in an impact of ***negligible*** magnitude with a definite likelihood resulting in an impact of ***minor*** significance.

Mitigation

No mitigation measures are required, although the preferential use of low sulphur fuels and proper maintenance of engines will assist in the reduction of air emissions.

Table 9.23 Impacts on Air Quality

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	On-site	On-site
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Definite	Definite
Significance	**Minor**	**Minor**

9.5 IMPACTS DUE TO WASTE GENERATION

9.5.1 *Impact due to generation and disposal of liquid and solid waste during seismic survey*

Impact Description and Assessment

Waste generated during the daily operation of the seismic vessel will include sewage, food scraps, solid waste (eg cardboard and wood packaging) and hazardous waste (eg waste lubricants, oily rags). The operator of the seismic vessel will need to comply with international guidelines for the management of waste, especially the *International Convention for the Prevention of Pollution from Ships, 1973* (MARPOL 73/78) which provides guidelines for a variety of waste types.

Sewage

MARPOL Annex IV *Regulations for the Prevention of Pollution by Sewage from Ships* states that the discharge of sewage into the sea is prohibited except when the ship is operating an approved sewage treatment plant and is discharging comminuted and disinfected sewage using an approved system at a distance of more than 3 nautical miles (nm) from the nearest land; or is discharging sewage which is not comminuted or disinfected at a distance of more than 12 nm from the nearest land (*Regulation 11*).

If sewage generated on board the seismic survey vessel is handled in accordance with the MARPOL guidelines, sewage impacts will be negligible.

Galley Wastes

Galley waste comprises biodegradable food waste (garbage), which can pose an organic and bacterial load on the sea, and can attract large numbers of seabirds (gulls) and other scavenging marine life which may in turn impact on the natural balance of marine productivity in the area, and/or interfere with seismic operations.

Under Annex V of the MARPOL Convention, garbage includes all kinds of food, domestic and operational waste, excluding fresh fish, generated during the normal operation of the vessel and liable to be disposed of continuously or periodically. Disposal of plastics anywhere into the sea is totally prohibited, and severe restrictions apply to discharges of other garbage from ships into coastal waters. Annex V also obliges Governments to ensure the provision of facilities at ports and terminals for the reception of garbage.

MARPOL Regulation 9 (adopted in 1995) requires that all ships of 400 gross registered tonnes (GRT) and above, every ship certified to carry 15 persons or more, and every fixed or floating platform engaged in exploration and exploitation of the seabed must provide a Garbage Record Book, to record all disposal and incineration operations.

Disposal into the sea of food wastes may be permitted when they have been passed through a comminuter or grinder. Comminuted or ground food waste shall be capable of passing through a screen with openings no larger than 25 mm. If biodegradable food waste is handled in accordance with these MARPOL guidelines, the significance of any impact is anticipated to be negligible.

Solid and Hazardous Waste

Potential impacts arising as a result of solid and hazardous waste generation include:

- Physical damage to marine organisms or fouling of the sea as a result of inappropriate waste management and disposal methods;

- Toxic effects on marine organisms in the event of an accidental release of solid or hazardous wastes into the marine environment; and

- Onshore soil and groundwater contamination associated with onshore disposal of waste once the survey has been completed.

The solid and hazardous wastes generated onboard the survey vessel will be managed and disposed of in accordance with MARPOL. Solid waste will be compacted and held in appropriate storage areas on board for disposal on shore by a reputable contractor. All hazardous wastes generated on the vessel (ie used oil, cable fluid and lithium batteries) will be stored, labelled, handled and disposed in accordance with appropriate Mozambique or International guidelines.

If solid and hazardous waste is handled in accordance with Mozambique or MARPOL guidelines, the significance of any impact is anticipated to be negligible.

Impact Summary

The impact of on marine environment due to disposal of liquid and solid waste during seismic survey will be a ***negative direct impact***. The impact will be ***regional*** in extent for solid wastes as they will be disposed of onshore, and for liquid wastes such (sewage) the impact will be ***local*** since treated sewage will be disposed into the marine environment during the survey.

The impact will be of a ***medium*** intensity depending on the quantities of waste disposed. The impact is ***likely*** to occur with a ***long term*** impact and based on a ***medium*** to high magnitude, this impact will be of a ***moderate to high*** significance.

Mitigation

In order to mitigate the impacts of waste generation, the following mitigation measures should be implemented:

- Follow MARPOL guidelines for the handling and disposal of all wastes generated at sea;

- Galley waste will be treated (macerated to a specific size) prior to disposal overboard, and shall only be disposed overboard when in offshore areas. Sewage will be treated in an approved sanitation unit to achieve no floating solids or discolouration. Galley waste and sewage will be disposed of according to the *International Convention for the Prevention of Pollution from Ships, 1973* (MARPOL 73/78);

- Holding tanks should be provided on the vessel for all waste oils and appropriate containers to be provided for other fluids. Bilge water and deck drainage will be treated to 15 ppm oil concentration before discharge. Fluid wastes will be disposed at licensed disposal facilities on shore when the vessel is demobilised at port;

- A Garbage Record Book shall be provided to record all disposal and incineration operation. The date, time, position of ship, description of the garbage and the estimated garbage and the estimated amount incinerated or discharged must be logged and signed.

- Inventories of waste generation should be maintained and updated; and

- All hazardous wastes must be disposed of at licensed waste contractors onshore.

Table 9.24 Impacts on marine environment due to disposal of liquid and solid waste during seismic survey

	Without Mitigation	**Residual Impact (with mitigation)**
Duration	Long term	Long term
Extent	Regional / local	Regional / local
Intensity	Will depend on the quantity of waste – probably medium to high	Will depend on the quantity of waste – probably medium
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	Moderate to high	Minor

9.6 IMPACTS DUE TO OIL/ CHEMICAL SPILLS

Impact Description and Assessment

Accidental events, such as hydrocarbon spills resulting from damaged fluid-filled streamers or the collision/ grounding of vessels, have the potential to result in adverse impacts on the marine environment. The likelihood of such

events happening is generally low but the potential impacts need to be considered.

PCMRB has expressed a desire to use solid streamers for the seismic survey although the decision will ultimately depend on the selected survey contractor. If solid streamers are used, the risk of accidental release of streamer fluid is greatly reduced. As a precaution, the impact assessment has been based on the use of kerosene filled streamers.

Light hydrocarbon products (eg kerosene) are non-persistent oils and tend to evaporate and dissipate rapidly and naturally leaving little residue in the marine environment, particularly under tropical conditions (*ITOPF, 2008*). Streamers are usually divided into sections and damage to one section does not result in the loss of fluid from the entire streamer. Therefore, considering the relatively small volume of kerosene that may be released and the volatile nature of kerosene, impacts to the marine environment from a damaged streamer are considered to be minor and transitory.

In contrast, a large release of bunker or diesel fuel as a result of vessel collision or grounding has a greater potential to impact the environment. The actual impacts will largely depend on the quantity and type of hydrocarbons released, the location of the accident and prevailing weather/ oceanographic conditions at the time of release

Diesel fuel is considered non-persistent oil and spreads rapidly upon release into the sea to form a thin surface sheen. Modelling suggests that typical marine diesel oil could evaporate by as much as 30 – 60% in 5 days (*NOAA, 2004*). Nevertheless, diesel oil is toxic to marine life when fresh and can therefore affect free swimming biota, particularly those species inhabiting the surface layers such as sea birds. Bunker fuel is much heavier and more persistent in the marine environment and therefore has the potential to impact larger areas of the environment if not properly contained.

Whilst the consequences (ie scale of impact) resulting from these accidental events may be severe (ie rupture of fuel tanks and loss of containment), the likelihood of their occurrence is typically small.

Oil and chemical spills have the potential to cause **moderate** impacts to coastal and offshore marine life and habitats, as well as public health; however, given the offshore location of the survey area impacts associated with potential accidental events (if they occur) are unlikely to reach coastal areas where the most vulnerable marine habitats (eg coral reefs, mangroves, etc) and tourist operations are located. Spills at sea also have the potential to cause **moderate**

impacts to local (pelagic) marine life such as whales, turtles and fish, and seabirds.

Impact Summary

The impact of oil/ chemical spills (*Table 9.32*) could vary between ***temporary*** and ***long-term***, although fuel spills in the open seas are likely to evaporate and dissipate rapidly. Impacts would be ***on-site*** at the location of the spill but could spread to a ***regional extent*** due to weather conditions. The intensity will be ***low*** to ***medium*** but ***unlikely*** to occur. This will result in an impact of ***medium*** magnitude resulting in an impact of ***minor*** significance.

Table 9.25 Impacts of Oil/ Chemical Spills

	Without Mitigation	**Residual Impact (with mitigation)**
Duration	Short-term to Long-term	Short-term to Long-term
Extent	On-site to Regional	On-site to Regional
Intensity	Low to Medium	Low to Medium
Magnitude	Medium	Medium
Likelihood	Unlikely	Unlikely
Significance	**Minor**	**Minor**

Mitigation

Prevention of accidental events (such as spills and leaks of oil/ chemicals) must be considered highest priority but if an event does occur then a planned response needs to be implemented as soon as possible. The following criteria should be considered to minimise the chance of accidental events and/ or to allow an appropriate response to occur within the required timeframe:

- Ensure that an emergency response and contingency plan is in place to cope with accidental events (eg Shipboard Oil Pollution Emergency Response Plan);
- If possible use solid streamers that require only small amounts of non-hazardous fluid for flotation;
- If fluid filled streamers are used, use low molecular weight (volatile) fluid that will evaporate and dissipate quickly under tropical conditions;
- Fluid filled streamers should be filled by trained personnel in a dedicated (and bunded) area using pumping and filling equipment that is maintained regularly;

- Streamers should be equipped with positioning devices to ensure easy recovery in the event they are accidentally detached from the seismic survey vessel;

- All equipment lost overboard shall be recovered if at all possible;

- Survey activities shall be suspended in bad weather conditions or due to other reasons that increase the risk of collision, grounding or equipment loss;

- Adequate spill response equipment (eg absorbent booms) will be stocked and maintained on the vessel in a Spill Response Kit;

- Vessel crew is to be trained in the use of clean-up equipment through routine spill clean-up exercises;

- All accidental spills onboard the vessel should be cordoned off, cleaned up as soon as possible and prevented from flowing overboard to minimise contamination potential; and

- All accidental releases/ spills of harmful substances, regardless of quantity shall be immediately reported to PCMRB in accordance with PCMRB procedures.

Establishment of comprehensive spill prevention/ response plans and the on board presence of appropriate quantities of spill response equipment (and trained personnel) will assist in minimising the impact (and likelihood) of accidental spills. In addition, due to the offshore location of the survey area and the relatively rapid degradation of hydrocarbon spills in the marine environment, residual impacts are expected to be of negligible. Mitigation measures applied to reducing the impact to fishing boats and shipping operations (eg exclusion zones and efficient watchkeeping practices) provide additional measures for reducing the likelihood of accidental collision (and therefore spills) from the seismic survey vessel.

9.7 IMPACTS ON TOURISM AND TOURISM ACTIVITIES

9.7.1 *Impact on Recreational Fishing due to Exclusion Zones*

Impact Description

An exclusion zone around the seismic vessel will need to be enforced for the duration of the seismic survey resulting in the disruption of recreational and sport fishing in areas that overlap with the survey. These activities occur mainly in high tourist periods associated with school holidays in various parts of the world, which are typically December/ January, April/ May, and July/ August.

Impact Assessment

Recreational and sport fishing is carried out mainly by tourists, especially in Pemba, Nacala Port and Memba areas from resorts and through specialised recreational fishing operators. Recreational fishing competitions are also organised at various times during the year.

The exclusion zone will prevent the recreational and sport fishing from fishing in areas near to the seismic survey vessel. This impact is likely to be within an area at least 500 m from the seismic vessel but of short duration since the seismic vessel will be continuously moving and the recreational vessels will be able to move to others areas to continue with recreational fishing activities. The intensity of the impact will, however, be dependant on the timing of the seismic survey and is likely to be of *medium* to *high* intensity if it corresponds to the peak tourist and sport fishing seasons. If the seismic survey activities coincide with a fishing competition at a particular location, the intensity of the impact may be higher.

Impact Summary

The impact of the exclusion zone on sport and recreational fishing will be a ***short-term*** impact occurring ***on-site***, close to the seismic lines. The impact intensity will be ***medium*** outside of the peak tourist season and ***high*** within the tourist season such that the impact magnitude is correspondingly ***low to medium***. The impact will definitely occur and the pre-mitigation significance will be ***minor*** (outside of the tourist season) – ***moderate*** (within tourist season, including fishing competitions). The implementation of the recommended mitigation measures reduces the impact intensity to ***medium***, the magnitude to ***low***, and the residual significance to ***minor***.

Mitigation

The following mitigation measures are suggested to reduce the significance of the impacts on recreational fishing due to the exclusion zone:

- Avoidance of the peak tourist seasons of December/January, the Easter break and June/August, where possible;

- Minimise the seismic footprint where possible and limit survey activity in nearshore areas frequented by recreational fishers;

- Employ a Fisheries Liaison Officer (FLO)/ Environmental and Communication Site Officer (ECSO) to coordinate dissemination of information associated with the seismic survey, and to liaise with tourist operators engaged in fishing activities leading up to the seismic survey, throughout the survey, and after the survey is completed;

- Coordination and communication with fishers – it is important to establish a communication structure to liaise with the recreational fishing industry. Daily notifications should be sent via SMS (where cell phone service is available) or radio stations, to inform fishers of the planned events as well as the location of the seismic vessel on any particular day, and for several days in advance. If tourist operators are aware of areas where the seismic vessel will be operating they may be able to fish in alternative areas to maintain the tourist experience;

- Establish a complaints procedure whereby tourist operators can register a complaint with the FLO/ ECSO, and the FLO/ ECSO can discuss claims for compensation with the relevant Government department;

- Employ locals to crew chase boats (or employ local boats as chase boats) to ensure effective communication between fishers and the seismic survey personnel. At least one of the crew members on each chase boat should be fluent in local languages, and have knowledge of local fishing practices. This could avoid misunderstandings, and minimise the potential for conflict between the chase boat crew and fishers while at sea; and

- Media fact sheet – a media fact sheet should be prepared which can be used to assist the operators to brief members of staff as to how to convey information relating to the seismic survey, where this is necessary.

Table 9.26 Impacts on Recreational Fishing due to Exclusion Zone

	Without Mitigation	Residual Impact (with mitigation)
Duration	Short-term	Short-term
Extent	On-site	On-site
Intensity	Medium (out of tourist season) - High (within tourist season)	Medium
Magnitude	Low - Medium	Low
Likelihood	Definite	Definite
Significance	**Minor (out of tourist season)– Moderate (in tourist season)**	**Minor**

9.7.2 *Impacts on Whale and Dolphin Sightseeing Activities*

Impact Description

An exclusion zone around the seismic vessel will need to be enforced for the duration of the seismic survey resulting in disruption of whale and dolphin sightseeing activities if they overlap with the survey area. Any behavioural avoidance of the seismic vessel by whales and dolphins will have an additional impact on the sightseeing activities.

Impact Assessment

Pemba, Nacala Port and Memba are the primary tourist areas where specialised whale and dolphin sightseeing operators are most prevalent. For example, Nuarro Luxury Eco Lodge located on the Baixo Pinda Peninsula arranges seasonal whale and dolphin watching from shore and boat in the whale watch season from June to November.

Whales and dolphins may temporarily move away from the seismic vessel during the survey and if the seismic vessel is in the area where tourist operations are being undertaken there may be fewer sightings of whales and dolphins. The impact on tourism is considered of low intensity and short duration in that it will only be in the immediate vicinity of the survey vessel and only during the whale watching season (June to November). The overall significance of this potential impact is considered to be low. Significance could be reduced further to negligible significance if there is good communication with operators to inform them of the seismic schedule.

Impact Summary

The impact on whale and dolphin sightseeing tourism activities as a result of the enforcement of exclusion zones and potential behavioural avoidance by

whales and dolphins will be ***temporary***, ***local***, and with ***medium*** intensity due to the importance of whale and dolphin sightseeing tourism activities for the area. The magnitude of the impact will be ***medium***, the impact is ***likely*** to occur (if the seismic survey occurs during the peak season) and result is considered to be an impact of ***moderate*** significance.

Mitigation

The following mitigation measures are suggested for reducing the significance of the potential impact of the exclusion zone on whale and dolphin sightseeing activities:

- Undertaking of seismic surveys so as to avoid peak whale season (July to November);

- Minimise the seismic footprint where possible and limit survey activity in nearshore areas frequented by tourist whale watchers;

- Coordination and communication with tourist operators – it is important to establish a communication structure to liaise with the tourism industry. Daily notifications should be sent via SMS (where cell phone service is available) or radio stations, to inform operators of the planned events as well as the location of the seismic vessel on any particular day, and for several days in advance. If tourist operators are aware of areas where the seismic vessel will be operating they may be able to find alternative areas to maintain the tourist experience;

- Establish a complaints procedure whereby tourist operators can register a complaint with PCMRB, and the PCMRB can discuss claims for compensation with the relevant Government department;

- Employ locals to crew chase boats (or employ local boats as chase boats) to ensure effective communication between fishers and the seismic survey personnel. At least one of the crew members on each chase boat should be fluent in local languages, and have knowledge of local fishing practices. This could avoid misunderstandings, and minimise the potential for conflict between the chase boat crew and fishers while at sea; and

- Media fact sheet – a media fact sheet should be prepared which can be used to assist the operators to brief members of staff as to how to convey information relating to the seismic survey, where this is necessary.

Table 9.27 Impacts on Cetacean Sightseeing Activities due to Exclusion Zone

	Without Mitigation	Residual Impact (with mitigation)
Duration	Temporary	Temporary
Extent	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	**Moderate**	**Minor**

9.7.3 Cumulative Impacts on the Tourism Industry

Impact Description

The presence of seismic survey vessels, enforcement of exclusion zones and underwater noise affecting dive experiences and sport fishing would likely result in changes in perceptions of the concession area as a pristine natural tourist destination. The perceived incompatibility of the oil and gas industry with the tourism industry based on a pristine natural environment could result in negative impacts on the tourism sector.

Impact Assessment

The concession area is part of one of the most important tourism regions of Mozambique and the Pemba-Quirimbas Zone is classified as a short-term Priority Area for Tourism Investment by the Strategic Plan for Tourism Development in Mozambique (2004-2013).

The Region has a relatively unspoilt natural beauty, an attractive historical character and a rich marine life which make it a region with potential for tourism activities. Tourism is an opportunity being developed along the coastal beaches. Most of the infrastructure is in Pemba Bay although tourism complexes are also scattered along the rest of the coast adjacent to Area 3.

The negative impact on the tourism industry would result from changing attitudes and perception and enjoyment of the area by tourists. This would relate to disappointment that the area is no longer a pristine environment, assumptions and distress regarding negative impacts on the environment and its conservation, as well as underwater noise of seismic survey activities. In addition, the limitations placed on tourists by having to avoid the exclusion zones, as well as the prohibition of activities in the sea during certain periods may affect tourist attitudes and desire to visit the area. This could result in a decreased number of tourists which would ultimately impact on tour

operators, local employment and the suppliers of goods and services to tour operators.

A reduction in investor confidence in the tourism industry in the area is likely to occur as a result of reduced tourist numbers. Attitude changes among investors will vary between the different sensitive locations whereby investors will be more interested in maintaining the pristine value of the natural resources and leveraging these for attracting high-value tourism clients. In response, investors in other areas of Mozambique are considering alternative strategies to deal with lower-end tourism opportunities if hydrocarbons are commercially produced close to them. These alternatives will only be viable if higher bed numbers are possible in this remote and inaccessible area where logistical costs factor highly in the commercial viability of the facilities.

Impact Summary

The cumulative impact related to visual and noise impacts on tourism will be ***long-term*** and ***regional***. The intensity of the impact will be ***low***, resulting in a ***medium*** impact magnitude. The impact will ***definitely o***ccur and will be of ***moderate*** significance.

The cumulative impact of the seismic survey activities on the tourism sector is ***long-term*** and ***regional*** due to the potential for decreased numbers of tourists as a result of negative perceptions of the area as a tourism destination. The intensity of the impact is ***medium***, with a ***medium*** magnitude and is ***definite***. The pre-mitigation significance is ***moderate***.

The potential cumulative impacts on investor confidence are ***long-term***, ***permanent***, with a ***high*** intensity. The magnitude is ***high***, and the impact is ***likely*** to occur resulting in an impact of ***major*** significance.

Mitigation

In order to mitigate the potential cumulative visual and noise impact on tourism and reduce its significance, the following measures are suggested:

- Avoidance of peak tourism seasons and associated fishing competition times, which generally occur during high tourist periods namely December/ January, April/ May, and July/ August;

- Minimise the seismic footprint where possible and limit survey activity in nearshore areas frequented by tourist whale watchers;

- Coordination and communication with tourist operators – it is important to establish a communication structure to liaise with the tourism industry. Daily notifications should be sent via SMS (where cell phone service is available) or radio stations, to inform operators of the planned events as well as the location of the seismic vessel on any particular day, and for several days in advance. If tourist operators are aware of areas where the seismic vessel will be operating they may be able to find alternative areas to maintain the tourist experience;

- Establish a grievance procedure whereby tourist operators can register a grievance with PCMRB, and PCMRB can discuss claims for compensation with the relevant Government department;

- Media fact sheet – a media fact sheet should be prepared which can be used to assist the operators to brief members of staff as to how to convey information relating to the seismic survey, where this is necessary; and

- Assist in promoting Pemba as a destination – promote Pemba as a tourist destination by contributing to marketing campaigns through which the area is marketed and promoted.

Table 9.28 Cumulative Visual and Noise Impacts on Tourism

	Without Mitigation	Residual Impact (with mitigation)
Duration	Long-term	Long-term
Extent	Regional	Regional
Intensity	Low	Low
Magnitude	Moderate	Low
Likelihood	Definite	Definite
Significance	**Moderate**	**Minor**

Table 9.29 Cumulative impacts on the Tourism Sector – Decrease in Tourist Numbers

	Without Mitigation	Residual Impact (with mitigation)
Duration	Long-term	Long-term
Extent	Regional	Regional
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Definite	Definite
Significance	**Moderate**	**Minor**

Table 9.30 Cumulative impacts on the Tourism Sector – Decrease in Investor Confidence

	Without Mitigation	Residual Impact (with mitigation)
Duration	Long-term	Long-term
Extent	Regional	Regional

	Without Mitigation	Residual Impact (with mitigation)
Intensity	High if investor pulls out permanently	Medium
Magnitude	High	Medium
Likelihood	Likely	Likely
Significance	**Major**	**Moderate**

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