6.0 EFFECTS ASSESSMENT OF PROJECT ACTIVITIES

6.1 MARINE AND MIGRATORY BIRDS

Marine bird populations that occur include surface feeders (Greater Shearwater, Storm Petrel, Gulls, Kittiwake), pursuit divers (alcids), and plunge divers (Gannet) (Brown 1986, CWS). Concentrations of birds are likely to occur in association with food sources, which include shrimp, krill, fish larvae, squid, herring, mackerel, ship waste, and detritus. Marine and migratory birds are protected by legislation (*Migratory Birds Convention Act* 1994) and the *SARA* and thus, are a regulatory concern.

6.1.2 Boundaries

With respect to temporal boundaries, the potential interactions of concern are those related to the seismic activities that could occur in July to November for surveys during a three year (2011 to 2013) time period.

The ecological spatial boundary for marine bird species includes the offshore foraging habitats.

6.1.3 Potential Issues

There are no data suggesting that seismic surveys have adverse impacts on birds. Potential impact mechanisms are noise impacts from seismic surveys and disturbance from vessels. Noise produced from these geophysical surveys might only impacts Alcidae (auks) offshore bird species that spend considerable amount of time underwater, swimming, or plunge diving for food. Noise from the surveys could adversely affect surface-feeding and diving seabirds near the air source arrays. A possible mechanism for indirect effects is alteration of prey concentration and displacement from foraging areas. However persistent, widespread alterations in abundance of fishes are not expected.

Regulators have expressed concern on effects from attraction of birds to vessel lighting and to vessels through the discard of organic waste.

Coastal and marine birds could be affected by a spill due to an accident involving the survey vessel.

6.1.4 Significance Criteria

A significant adverse effect on coastal and marine and migratory birds is one likely to cause:

- A death or life-threatening injury of one or more individual of a listed species; and/or
- Death or life-threatening injury or non-listed species in sufficient numbers to affect the population adversely; and/or
- Long-term or permanent displacement of any species from preferred feeding, breeding or nursery habitats;
- Destruction or adverse effects of critical habitat for any listed species

An adverse, but not significant effect on marine birds and migratory is one that is likely to cause:

- Death or life-threatening injury of individuals in small numbers that would not adversely affect the population; and/or
- Short-term displacement of any species form preferred feeding, breeding, nursery grounds or migratory routes
-

6.1.5 Effects Assessment and Mitigation

6.1.5.1 Vessel Presence

Seismic survey vessel traffic will be limited to routes to the Study Area and the Study Areas itself. The closest IBA is Quaker Hat Island located 40 km southeast of Cape Harrison and 10 km northeast of the northern head of Hamilton Inlet. This IBA is an isolated small island, devoid of trees, with rocky shores, and situated 10 km of from the mainland shoreline. This IBA is located approximately 35 km from the Study Area boundary.

Avifauna species that occupy the Study Area will likely not be disturbed by vessel activity due to its transitory nature and in keeping with marine traffic experienced in the region. The area of interest for seismic surveys is offshore and, therefore, is not expected to adversely affect coastal breeding colonies.

Organic wastes attract gull species which may in turn lead to increased predation on a number of smaller bird species. The discard of inorganic wastes, such as plastics, can result in harmful effects through ingestion or entanglement. The vessels will have a waste management plan and they will adhere to that document.

Birds are attracted to vessel lighting at night, and birds such as storm-petrels, may fly into vessel lights and other equipment. There is one extreme case of bird attraction where lights on a fishing vessel attracted 1.5 tonnes (6,000 birds) of crested auklets. The presence of the seismic vessel is a negligible addition of night lighting compared to fishing vessels and commercial traffic which transit through in the Study Area year round. Collisions of migrating seabirds (*e.g.,* shearwaters, dovekies, murres and Leach’s storm-petrel) is more of an issue with erect structures such as lighthouses, broadcast and communication towers, illuminated office buildings, and offshore platform and light-induced fisheries (Gauthreaux and Belser 2006, Montevecchi 2006).

Lighting is required for night time vessel activities; therefore, navigation, deck lights and interior lights must be left on for safety and legislated by international convention. The 'range' of lights, that is, the distance from which they can be seen, varies. As an example, the masthead light of a big oceangoing vessel may have a range of about 10 km. However, an effort will be made to minimize high-intensity work lights in the evening. Lighting may be turned off in inclement weather (low cloud cover, overcast skies, fog and drizzle conditions), if not required. Under foggy conditions, coastal lighting is more of an influence as birds fly closer to land (Chaffey 2003, Weir 1976, Blomqvist and Peterz 1984). Routine checks for stranded birds will be recorded and reported and a release program of birds affected by light will be implemented.

MKI's procedure for handling stranded birds is based on those outlined in the Leach's Storm Petrel Mitigation Program developed by Williams and Chardine (1999) (Appendix D). An Environmental Observer will be assigned on the vessel during seismic surveys and responsible for this activity. All marine observations will be recorded and information will be given to appropriate organizations such as CWS to provide valuable information on the distribution of marine birds off Labrador. MKI will obtain a valid Live Seabird Handling permit from CWS.

The literature indicates there is no measurable effect on marine birds. No mitigation specific to seabirds is required under the Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment. However, as some seabirds are attracted to vessels opportunistically, seismic operations will not be delayed until they depart the area before ramping up. Such practice would hamper the entire program considering the attraction birds have for vessels.

6.1.5.2 Noise Emissions

Many species of marine birds utilize habitats within the Study Area; however, little information on the effects of seismic exploration surveys on these species exists in the scientific literature. Davis *et al*. (1998) suggested the lack of data regarding seabirds and seismic-related surveys reflects the minimal evidence that any effects occur.

Research on disturbance due to seismic exploration surveys has revealed negligible results. Lacroix *et al*. (2003) studied moulting Long-tailed Ducks (*Clangula hyemalis*) in the Beaufort Sea and found no adverse effects of seismic activity on movement or diving behaviour, although detecting subtle disturbance effects was limited. Stemp (1985) found no evidence of seismic effects on marine bird mortality or distributional effects in Davis Strait, and Parsons (in Stemp 1985) reported shearwaters did not respond to seismic sources when in close proximity (30 m) to high frequency sounds. Additionally, Turnpenny and Nedwell (1994) found no ill effects of air source seismic surveys on guillemots, fulmars, and kittiwakes. Research in the Irish Sea also indicated no evidence seabirds were attracted or repelled by seismic activity (Evans *et al*. 1993).

Nonetheless, issues and concerns related to potential interactions between marine avifauna and seismic exploration surveys include:

- direct and indirect disturbances due to seismic noise;
- disturbance of vessel traffic noise and lighting; and
- oiling of birds due to vessel discharge or accidental equipment failure.

There have been few studies on the effects of air source-based seismic surveys on birds. However, there are no data showing that impacts exist. Offshore observers record seabird sightings relative to the vessel, yet they have not reported any mortalities or injuries associated with the surveys. Shearwaters have been observed within 30 m of seismic array with their heads underwater and demonstrating no response (Stemp 1985). Because seismic pulses are directed downward and highly attenuated at the surface, near surface feeding and diving marine birds would not likely be exposed to sound levels that would result in significant adverse effects on hearing or be life threatening. Above the water, the sound is reduced to a muffled shot that should have little or no effect on birds that have their heads above water or are in flight. It is possible birds on the water at close range would be startled by the sound, however, the presence of the vessel and associated gear dragging in the water should have already warned the bird of unnatural visual and auditory stimuli. The only seabirds that may be affected at greater depths is the Alcidae family (Common Murre, Thick-billed Murre, Razorbill, Dovekie, Black Guillemot, Atlantic Puffin). These species dive from a resting position on the water in search of small fish and invertebrates and are capable of reaching great depths (20 to 60 m) and spending considerable time (25 to 40 seconds) underwater (Gaston and Jones 1998). The effects of underwater sound on Alcidae are not well known, but sound is probably not important to Alcidae in securing food.

Temporary threshold shift (TTS) can last from minutes or hours to days. The magnitude of TTS depends on the duration and level of noise exposure (Davis *et al.* 1998). No studies have tested the level of sound necessary to cause TTS to marine birds, although TTS can occur in birds exposed to sound in air (Saunders and Dooling 1974). Seismic sounds are not continuous and the effects of intermittent pulse are not known. Corwin and Cotanche (1988) have shown that the auditory system of birds is able to recover from exposure to sounds.

Stemp (1985) found no evidence that a seismic program in the Davis Strait area had resulted in distributional effects on marine birds. Evans *et al*. (1993) noted that there was no evidence to suggest that seabirds were either attracted to or repelled by seismic testing in the Irish Sea. Turnpenny and Nedwell (1994) refer to data in which trained observers reported no behavioural effects on guillemot, fulmar, and kittiwake species that were monitored during air source seismic surveys. Thus behavioural changes will likely not be evident for the bird species at risk – Ivory Gulls or Harlequin Ducks - in the Study Area.

6.1.5.3 Vessel Discharge and Accidental Events

Accidental surface releases of hydrocarbons can expose birds to oil by breathing contaminated air, through skin contact, through eating contaminated prey items (Davies and Bell 1984), or by ingesting contaminants while preening contaminated plumage (Stout 1993). Exposure to hydrocarbons may result in a loss of waterproofing, thermoregulatory capability (hypothermia), and buoyancy (drowning) due to the matting of feathers (Wiese 1999; MMS 2004). Oil ingestion, even in small amounts, may result in lethal and sub-lethal effects, including starvation due to increased energy needs to compensate for heat loss (MMS 2004). Potential impacts are expected to be limited as there will be no streamer fluid for this program. If a spill occurred and marine birds were impacted, the Williams and Chardine protocol (entitled "The Leach's Storm Petrel: General Information and Handling Instruction") or protocols recommended by the C-NLOPB for handling oiled or standard birds would be followed. No significant adverse effects are likely to occur as a result of an accidental event associated with this Project.

The impacts of oil on birds have been well documented (*e.g.,* Hartung 1995); however, no oil from seismic vessel discharge is expected to occur and thus, should not have any severe adverse effects of avifauna. Coastal and marine birds could also be affected by a spill from any vessel (fishing, commercial and DFO research) at sea. The single seismic vessel does not increase the risk to coastal and seabird populations. Discharge from vessels will be standard for any marine vessel and MKI's contracted vessel will follow the Offshore Waste Treatment Guidelines (OWTG) (NEB *et al*. 2002). Potential oil spillage may occur from ballast and bilge water discharge, however, if oil is suspected to be in the water, it will be tested and if necessary, treated using an oil/water separator to ensure that oil concentrations in the discharge do not exceed 15 mg/L as required by the MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships 1972, and the Protocol of 1978 related thereto), International Maritime Organization and OWTG. There will be limited amounts of marine fuel and lube oil onboard that could potentially be spilled into the ocean. The potential for an oil pollution incident is low for this Project.

6.1.6 Cumulative Effects

The cumulative effects of anthropogenic disturbance such as commercial fishing and marine traffic, along with natural process such as weather and food availability, have potential to change predator and prey abundances inside and outside the Study Area, thus causing adverse negative effects of avifauna. However, the minimal increase in vessel traffic from this Project will be minor compared with existing vessel traffic in the area and should not significantly increase disruption to avifauna. There is significant international shipping through the Study Area. The majority of the local commercial shipping is along the coast between remote communities, where the critical habitat of seabirds occurs.

Routine discharges from marine vessels containing petroleum hydrocarbons could cumulatively influence avifauna. Survey vessels used for this Project will comply with discharge regulations established by OWTG and thus should not significantly add to short-term or long-term effects of oil spillage on marine avifauna.

Overall, there are no cumulative adverse effects of this seismic exploration Project expected to occur on the distribution, abundance, breeding status and general well-being of marine avifauna inside and outside the Study Area.

6.1.7 Monitoring and Follow-up

An Environmental Observer will be onboard to record marine bird (and marine mammals) sightings during the program. The protocol will follow CWS's Standardized Protocols For Pelagic Seabirds Surveys From Moving and Stationary Platforms for the Hydrocarbon Industry: Interim Protocol – June 2006 (Appendix E). MIK will ensure that CWS is provided field data collection with respect to marine birds. Marine bird data reports will be provided following this survey and any other subsequent seismic surveys.

6.1.8 Summary

Table 6.1 provides a summary of the potential for interaction, impact analysis, mitigations and cumulative and residual effects for marine and migratory birds.

Table 6.1: Summary of Environmental Assessment for Marine and Migratory Birds

Interactions and Issues

- Direct physical effects associated with seismic noise (*e.g.,* auditory damage)
- Indirect effect through decline in prey availability
- Disturbance from vessel noise and lights
- Accidental surface spills causing oiling of birds

Impact Analysis

There are no documented adverse effects directly on seabirds as reported by offshore observers. Effects associated with vessel presence and lights will be similar to what marine bird are exposed to now with the considerable commercial and fishing vessel traffic. Ivory Gulls occur with the Study Area, their interaction will be the same as other gulls behaviour around vessels. Environmental effects including cumulative effects on marine and migratory birds is considered non-significant.

Mitigation

- A dedicated observer will be on board the seismic vessel to record marine birds and incidents of collisions, oiling and strandings.
- Vessel compliant with audit prior to survey.
- Compliance with OWTG (NEB *et al.* 2002) and MARPOL for all discharges.
- Avoidance of bird colonies by vessel

Project Activity	**Magnitude**	**Geographic**	**Frequency**	**Duration**	**Reversibility**	**Ecological/Socio-Cultural and Economic Content**
Vessel Presence/Lights	1	3	3	4	R	1
2-D programme	0	1	2	3	R	1
Accidental Spill	1	3	1	1	R	1

Significance of Effect

- Not adversely significant

Confidence

- High level of confidence based on previous seismic surveys, monitoring observations and research.

Magnitude	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility**
0=neglible	**1= 10s of metres**	**1=days**	**1= isolated**	**R=reversible**
1=low	**2= <500 m**	**2=two weeks**	**2= intermittent**	**I=Irreversible**
2=medium	**3= 1-10 km**	**3=30 days**	**3 = continuous**	
3=high	**4= 10-50 km**	**4= 60 days**		
	5= >50 km			

Ecological/Socio-cultural and Economic Context

1- Relatively pristine area or area not adversely affected by human activity

2- Evidence of existing adverse effects

6.2 MARINE FINFISH AND SHELLFISH

Marine fish are an important component of the marine ecosystem and play a significant role in the stability of commercial fisheries. Environmental effects on the marine fish community may affect commercial fisheries and other ecosystem components that rely on several species of marine fish as a food source or conversely, be affected by predation. This analysis considers Project interactions with commercial pelagic, demersal finfish and shellfish, including egg, larval, juvenile and adult life stages. Fish spawning is of critical importance as survivability of fish at early life stages may be a major limiting factor on adult populations.

6.2.1 Boundaries

The spatial boundaries of interaction between marine finfish and shellfish and the Project are primarily related to the predicted zone of influence of noise attenuation from the seismic array. In the vertical orientation, the sound level will exceed background to the seafloor in the Study Areas because the seismic energy is directed at the seafloor. In the horizontal plane, the sound levels will exceed typical background levels (90 to 120 db re 1 µPa) at 35 to 50 km from the source. Ecological boundaries vary depending on the distribution, spawning and migration patterns of the adult fish, and the presence of fish eggs and larvae.

With respect to temporal boundaries, the potential interactions of concern are those related to the seismic activities that could occur in July to November in 2011 until 2013. Although exact timing of potential surveys post-2011 is not known at this time, fishing interests will be considered in the planning of future surveys.

With regard to administrative boundaries, NAFO and DFO manages the fisheries resources in the area and DFO is primarily responsible for scientific surveys within the area. The Study Area are included in six NAFO Unit Areas, 2H, 2J, 2G, 3K, 0B and 1F.

The technical boundaries and the information available for this study rely on existing information with regard to marine finfish/shellfish distribution, migration and spawning areas. There is a lack of precise spatial information on spawning grounds, particularly as related to non-commercial species. Other uncertainties surround some demersal fish species, which continue to decline despite moratoriums and controls on fishing effort.

6.2.2 Potential Issues

Potential interactions between the Project and marine finfish and shellfish relate primarily to direct physical injury and detrimental behavioural effects as a result of noise from seismic activities. Physical injury may include failure to reach the next development stage, hearing injury and death to:

- fish eggs and larvae;
- juvenile and adult finfish; and
- invertebrates.

Behavioural effects may include:

- avoidance behaviour;
- increased swimming speeds;

- disruption of migration patterns; and
- disruption of reproductive behaviour and success.

Acoustic behaviour and uses of sound by fish are less documented than the physiology of sound detection by fishes. The effects of intense and potential harmful sound on fish hearing and behaviour are poorly understood. Such noise may disturb fish and may produce temporary or permanent hearing impairment in some individuals, but is unlikely to cause death or life-threatening injury.

6.2.3 Significance Criteria

A significant adverse environmental effect is one that is likely to cause one or more of the following:

- mortality or life-threatening injury to individuals of a species at risk;
- the abundance of one or more non-listed species is reduced to a level from which recovery of the population is uncertain;
- long-term or permanent displacement of any species from spawning habitat; or
- destruction or adverse changes to critical or essential fish habitats.

To be considered statistically significant, Project-related mortality would exceed the range of natural mortality by two standard deviations.

A non-significant adverse environmental effect is one that is likely to cause on or more of the following:

- mortality or life-threatening injury of individuals (other than listed species) in small numbers that would not adversely affect the population or the ecological functioning of the fish community; and or
- short term displacement of individuals from preferred feeding, spawning, nursery grounds or migratory routes (including critical habitat for listed species and essential fish habitat)

6.2.4 Effects Assessment and Mitigation

6.2.4.1 Vessel Presence

The presence of the various seismic vessels used for the 2-D survey is not expected to be any different than the daily and frequent marine traffic in the area. Vessels are not expected to invoke an adverse effect upon marine fish and shellfish.

6.2.4.2 Noise Emission

Most studies on the biological effects of seismic sound energy have concentrated on marine mammals and fish, groups which have sensitive hearing organs and which, in many cases, incorporate sound as part of social behaviour. Therefore, this section will discuss effects on fish hearing; physical and anatomical effects; auditory masking and behavioural effects as they may affect spawning fish; and eggs and larvae.

6.2.5 Finfish Hearing

There are some data available on the hearing sensitivities of finfish (see Popper and Carlson 1998; Popper *et al*. 2003 for reviews). For example, cod, salmon, America plaice and herring have hearing sensitivities between 80 and 200 Hz, with a sensitivity threshold at 80 to 100 dB re to 1µPa (Mitson 1995). Fish sounds are normally generated in the range of 50 to 3,000 Hz. Fish use sound for communication, navigation, and sensing of prey and predators. Sound transmission is thought to play an important role in cod and haddock mating (Engen and Folstad 1999, Hawkins and Amorin 2000). Seismic signals are typically in the range of 10 to 200 Hz (Turnpenny and Nedwell 1994) and will therefore overlap slightly with signals produced by fish. However, detecting a signal does not mean the fish will have any measurable reaction to the noise. The hearing ability of fish varies considerably by species, as will the effects of seismic exploration. Variability in effect may also vary within a species because seismic signals have a more pronounced effect on larger fish than of smaller fish of the same species (Engås *et al*. 1996).

The frequency of seismic pulses does fall within this range, but responses to these sounds vary according to species. Gadoids have been shown to leave the area during seismic surveys (Skalski *et al*. 1992, Løkkeborg and Soldal 1993, Engås *et al*. 1996, Slotte *et al*. 2004, Parry and Gason 2006), and species such as cod, rockfish and whiting (*Merlangius merlangus*) have been reported to change depth in response to seismic pulses (Pearson *et al*. 1992; Wardle *et al*. 2001). In contrast, Wardle *et al*. (2001) report that neither finfish nor invertebrates showed signs of moving away from a reef on the west coast of Scotland after four days of seismic airgun firing. Several studies have shown that exposure to noise such as that produced by seismic airguns can result in temporary hearing loss and physical damage to the ear (Enger 1981; Hastings *et al*. 1996; Amoser and Ladich 2003; McCauley *et al*. 2003; Popper *et al*. 2005). There are, however, substantial differences in the effects of airguns on the hearing thresholds of different species. Popper *et al*. (2005) showed that fish with poorer hearing, such as pike (*Esox lucius*), showed little hearing loss in response to seismic airgun activity, while fish with good hearing, such as lake chub (*Couesius plumbeus*), showed the most hearing loss. Periods of hearing loss may affect survival due to the compromised ability to hear biologically relevant sounds. Mortality of fish, fish eggs, and larvae has been observed only within a few metres of airguns (Dalen and Knutsen 1987; Parry and Gason 2006).

While the effects of airguns on fish have been studied for several species, there is much diversity in the structure of the auditory systems of different species (Popper and Carlson 1998; Popper *et al*. 2003). It is necessary to examine the effects of airguns on all types of hearing specializations. In addition, most studies to date have concentrated on short-term effects. Studies on long-term survival and sublethal effects are needed (Payne 2004).

6.2.6 Shellfish Sound Sensory

Invertebrates, on the other hand, have been little studied in terms of bioacoustics and there is a paucity of information relating to the effects on them of seismic sound waves. Crustaceans appear to be most sensitive to low frequency sounds, less than 1,000 Hz (Budelmann 1992; Popper *et al*. 2001). Some crustacean species generate low frequency sounds which presumably serve a communicatory function, for example, the spiny lobsters (*Palinuridae*) and the snapping shrimps (*Alpheidae*). Because invertebrates lack air-filled cavities, it is almost certain that they would respond to the particle motion component of sound rather than to sound pressure, and as a consequence their sensitivity to sound is likely to be inferior to that of fish. Crustaceans have a variety of hair-like sense organs that are potentially capable of responding to mechanical stimuli, including sound, but similar structures have not been identified in bivalve and gastropod molluscs. These mollusc groups are therefore unlikely to change their behaviour in response to seismic sound waves, although they could show physiological reactions and anatomical damage. The highly mobile predatory cephalopod molluscs (squid, octopus) are thought to be insensitive to sound.

The subject of acoustic detection in decapod crustaceans has been previously investigated over the past few decades to estimate invertebrate response to sound and vibration (Popper *et al*. 2001). A number of physiological studies of statocysts of marine crabs suggest that some of these species are potentially capable of sound detection (Popper *et al*. 2001). Decopods have surface hair-like cells that serve as chemoreceptors and mechanoreceptors to detect water flow and vibrational stimuli and they respond to frequencies up to 100 Hz with a single spike per cycle. Chorodontal organs, associated with flexible body appendages, signal joint position, movement and stress and they respond to low-frequency waterborne vibrations. Statocysts are located on the basal segment of each antennule in crabs and other body areas in other crustaceans are involved in maintaining equilibrium. They are unlikely to respond to acoustic stimulation. Norway lobster (*Nephrops norvegicus*) showed postural responses to sound frequencies of 20 to 180 Hz in the lab (Goodall *et al*. 1990). In the field the response was due to particle displacement and not pressure. Responses were analogous to fish lateral line which response to water motions produced within a fish-length of the detecting animal (Popper *et al*. 2001).

6.2.7 Auditory Masking

The potential effect that seismic activities may have on masking communications by fishes is not well documented. There have been no published reports on the effects of hearing impairment or excessive masking on the acoustic communication behaviour of any fish species. There is overlap in the frequency of seismic signals and the sounds emitted by fish, so there is potential for sound reception and production in fish to be reduced (Myrberg 1980). Acoustic communication is important during cod spawning. Sound recordings at the major spawning ground off the Lofoten Islands, Norway revealed a hushed hubbub of sound, at approximately 40 to 500 Hz during the spawning period. Recent experiments on goldfish indicate that fish are capable of “auditory scene analysis”, meaning that a sound stream of interest can be “heard out” and analyzed for its informational content independently of simultaneous, potentially interfering sounds (Fay 1998, in MMS 2004). These studies were carried out using repetitive impulses or clicks as signals and as potentially interfering sounds. These results suggest that the presence of intermittent, audible air sleeve source points would not necessarily impair fishes in receiving and appropriately interpreting other biologically relevant sounds from the environment (MMS 2004).

Studies have shown that exposure to intense sound can affect the auditory thresholds of fish resulting in TTS under certain conditions (i.e. Amoser and Ladich 2003; Smith *et al*. 2004). However, these studies focused on captive fish that were exposed to loud (158 dB re 1 µPa) noise for periods of 10 minutes for 12 or 24 hours. TTS may seldom (or never) occur in the wild unless fish are prevented from fleeing the irritant (LGL Limited 2005). Threshold shifts affect the fish's ability to hear its natural full range of sound.

The 2-D seismic surveys are unlikely to result in population level effects on fish hearing.

6.2.8 Behavioural Effects

Seismic activity can have a greater spatial effect on the behaviour of fish than on the physiology of fish. Some studies indicate that such behavioural changes are very temporary while others imply that marine animals might not resume pre-seismic behaviours or distributions for several days (Engås *et al*. 1996, Løkkeborg 1991, Skalski *et al*. 1992). Most available literature (Blaxter *et al*. 1981, Dalen and Raknes 1985, Pearson *et al*. 1992, McCauley *et al*. 2000a, 2000b, Davis *et al*. 1998) seems to indicate that the effects of noise on fish are brief and if the effects are short-lived and outside a critical period, they are expected not to translate into biological or physical effects. It appears that behavioural effects on finfish as a result of seismic shooting should result in negligible effects on individuals and populations in most cases. These behaviours include startle responses to predators, courtship and mate choice, maintenance of schooling and aggregation, aggressive competition for mates and other resources, and overhearing or intercepting potential predators, prey, and competitors. The potential for interactions during particularly sensitive periods, such as spawning or migration, are a concern.

There are well documented observations of fish and invertebrates exhibiting behaviours that appeared to be in response to exposure to seismic activity like a startle response, a change in swimming direction and speed, or a change in vertical distribution (Hassel *et al*. 2003, Wardle *et al*. 2001, McCauley *et al*. 2000a, 2000b, Pearson *et al*. 1992, Schwarz and Greer 1984, Blaxter *et al*. 1981) although the significance of these behaviours is unclear. The effects of nearby air sleeve operations on fish as determined from several studies, are summarized in Table 6.2.

Table 6.2: Summary of Behavioural Effects of Fish and Invertebrates from Nearby Air Sleeve Operations

Reference	Level (dB re 1 µPa $_{(rms)}$)	Species	Effects
McCauley *et al.* (2000a,b)	156-161	various fishes	Common ‘alarm’ behaviour of forming ‘huddle’ on cage bottom centre, noticeable increase in alarm behaviours begins at lower level
Pearson *et al.* (1992)	[a]149	rockfish (*Sebastes* spp.)	Subtle behavioural changes commence
Pearson *et al.* (1992)	[a]168	rockfish	Alarm response significant
McCauley *et al.* (2000a,b)	>171	fish ear model	Rapid increase in hearing stimulus begins
McCauley *et al.* (2000a,b)	182-195	fish (*P. sexlineatus*)	Persistent C-turn startle
Pearson *et al.* (1992)	100-205	selected rockfish species	C-turn startle response elicited
Wardle *et al.* (2001)	[b]183-207	various wild finfish	C-turn startle responses
McCauley *et al.* (2000a,b)	146-195	various finfish	No significant physiological stress increase
McCauley *et al.* (2000a,b)	174	Squid *(Sepioteuthis australis)*	Startle (ink sac fire) and avoidance to startup nearby
McCauley *et al.* (2000a,b)	156-161	Squid	Noticeable increase in alarm behaviours
McCauley *et al.* (2000a,b)	166	Squid	Significant alteration in swimming speed patterns, possible use of sound shadow near water surface

Source: adapted from McCauley *et al.* 2000a; 2000b.

[a] - converted from mean peak to rms using -12 dB correction from 7,712 records from Bolt 600B air-sleeve.

[b] - correction of -12dB applied (peak to rms).

Fish startle by sudden changes in noise levels, but seem to acclimate to “ambient noise”. Noise generated by seismic activity may cause some species to avoid the zone of influence around the seismic vessel. Studies note that many species of fish dive to avoid intense sound (Protasov 1966, Schwartz and Greer 1984, Knudsen *et al*. 1992). Blaxter *et al*. (1981) found that schooling herring changed direction with a sudden noise level of 144 dB re 1 µPa and when ramping up occurred, they reacted to a noise level around 5 dB higher. Turnpenny and Nedwell (1994) investigated information from power station trials and found that air source signals ranging from 160 to 186 dB re 1 µPa resulted in avoidance behaviour. In one trial, Lokkeborg and Soldal (1993) estimated that avoidance behaviour in fish occurs between 160 and 171 dB re 1 µPa. McCauley *et al*. (2000) conducted trials with captive fish and found that increases in swimming behaviour occurred when seismic sound levels reached 156 dB re 1 µPa.

The expected distance for fish to react to a typical peak source level of 250 to 255 dB re 1 μPa is from 3 to 10 km (Engås *et al*. 1996). A reaction may simply mean a change in swimming direction. The spatial range of response in fish will vary greatly with changes in the physical environment in which the sounds are emitted. In one environment, fish distribution has been shown to change in an area of 40 x 40 nautical miles and 250 to 280 m deep for more than five days after recording ended, with fish larger than 60 cm being affected to a greater extent than smaller fish (Engås *et al*. 1996). Payne *et al*. (2008) in their review on seismic effects on fish that "Regarding cod, Engås *et al*. (1996) provided strong evidence for effects but the results have been critiqued by Gausland (2003) who noted that the catch rates were not statistically different than normal variation in catch rates. For the purpose of this review, we had two senior scientists with expertise in cod science review the original work and the critique. They agreed that the study of Engås *et al*. (1996) was of note but Gausland's critique was also of merit. Granting the difficulty in carrying out such studies, the scientists noted the lack of a control(s) for the study of Engås *et al*. (1996). Concern was also expressed that a number of replicates would generally be required for statistical validity. Confounding factors between control and test groups in any such experiments could also include such factors as locale, fish size, school size, nature of prey on which fish might be feeding at the time (*e.g.,* capelin which are sensitive to sound and may move away from the area versus shrimp which are indicated not to be sensitive to sound), whether the fish were "migrating", and whether other ship traffic might be traversing the area at the time.

DNV Energy (2007 in Hurley 2009) state that scare effects have been demonstrated in a radius of more than 30 km from the sound source. McCauley *et al*. (2000 a, b) describes a more intense "generic" fish alarm startle response of seeking shelter in tight schools and moving near the bottom. The level that will induce this response varies with fish species and the physical environment at the time but was observed at 156 to 168 dB re 1 μPa.

The Science Review Working Group (CNSOPB 2002), which evaluated two proposed seismic surveys near Cape Breton, agreed that although the duration of behavioural effects of seismic activity on marine fish are uncertain, indications exists, as described in above studies, that displacement of marine finfish is short-term.

If a seismic survey overlaps with the presence of migrating fish species (such as redfish and cod), startle responses and temporary changes in swimming direction and speed could be expected, but schooling behaviour is not expected to be affected (Blaxter *et al*. 1981). Any temporary change in behaviour is not expected to interrupt the natural migration instinct to a spawning or feeding area.

Behavioural effects of exposure of caged cephalopods (50 squid and two cuttlefish) to sound from a single 20-inch airgun have been reported (McCauley *et al*. 2000a). The behavioural responses included squid firing their ink sacs and moving away from the airgun, startle responses and increased swimming speeds. No squid or cuttlefish mortalities were reported from exposures to this airgun sources.

Increased stress as a response to external factors is generally difficult to measure in invertebrates. However, changes in relative movement when exposed to a sound field may be a good indicator of stress. Christian *et al*. (2004) discuss the startle responses observed by snow crabs held in a DFO tank and exposed to sounds produced by the clanging of metal bars. Snow crabs were observed immediately drawing in their legs and proceeding to escape the region of the imposing sound. When exposed to a 200 cu. in. array located at a distance of 50 m, caged as well as tagged snow crab demonstrated little to no movement; they did not draw in their legs, and they remained in their original position (Christian *et al*. 2004). Thus, seismic sound fields are not anticipated to cause adverse effects by increasing stress on snow crabs.

Statistical analysis of seismic survey data and commercial catch rate data (from Victoria, Australia from 1978 to 2004), was used to determine the effects of seismic activity on rock Lobster. Correlations show that there is no evidence to indicate that catch rates were affected by seismic activity (Parry and Gason 2006). Short term changes in catch rates in the Study Area coincided with changes in adjacent areas not subject to seismic activity (Parry and Gason 2006).

The ramping up procedure in these surveys will give fish an opportunity to temporarily leave the areas while noise levels are above ambient. DFO (2004c) concluded that some finfish exposed to seismic sounds are likely to exhibit a startle response, a change in swimming pattern and/or a change in vertical distribution. However, these effects are expected to be short term and of low ecological significance except where fish reproductive activity may be affected (DFO 2004c). Although there is no evidence of an adverse impact of seismic activity on the spawning success of fish, there is sufficient concern to suggest that a precautionary approach to the use of seismic equipment during spawning is adopted.

Noise levels will attenuate to ambient levels to 50 to 100 km from the survey vessel. A startle effect may occur within 8 km of the array over the Study Area at a sound exposure 30º from the vertical and within 200 m to 1000 m if sound exposure is at 45º from the vertical. To minimize sudden changes in noise levels, PGS/TGS will implement a ramp-up procedure. Nedwell *et al.* (2003) considered this effective mitigation for finfish.

6.2.9 Physical and Anatomical Effects

No mass fish kills associated with the operation of airguns have been recorded (Payne 2004). Since fish are likely to be driven away by approaching seismic shots, mortality of adult fish is not expected (Turnpenny and Nedwell 1994). Depending on source noise level, water depth, and distance of the fish relative to the source, injuries (such as eyes and internal organs) would only occur within a few tens of metres (Figure 6.1), with lesser symptoms such as hearing damage possible out to several hundred metres (Turnpenny and Nedwell 1994).

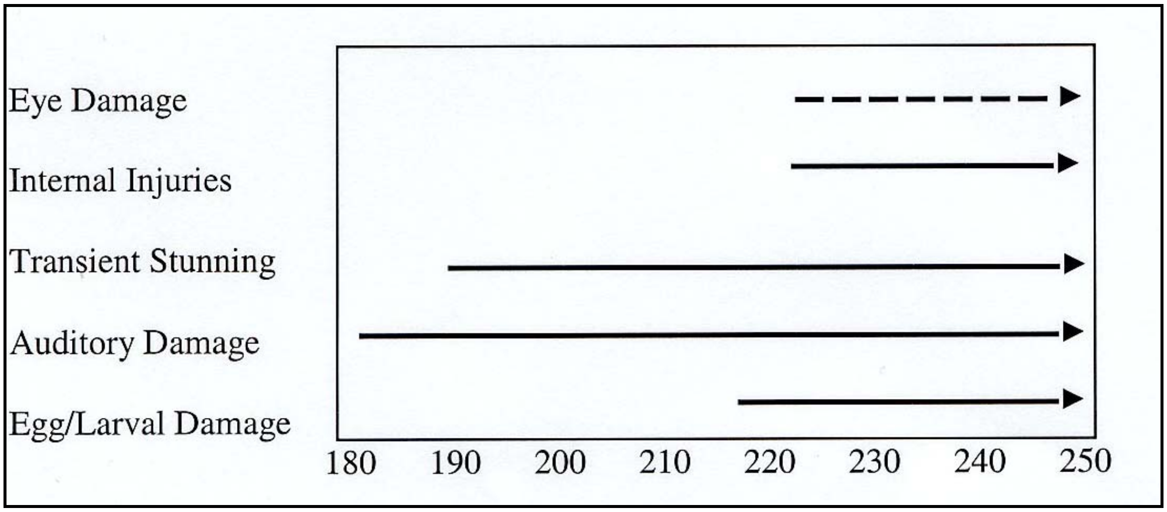

Figure 6.1: Sound Pressure Threshold for the Onset of Fish Injuries (dB)
Source: adapted from Turnpenny and Nedwell 1994.
Note: Dotted line indicates an assumed sound level rather than an estimated one.

Kosheleva (1992) reports no obvious physiological effects beyond 1 m from a source of 220 to 240 dB re 1 μPa. Hastings (1990) reports the lethal threshold for fish beginning at 229 dB and a stunning effect in the 192 to 198 dB range. Turnpenny and Nedwell (1994) deduce that blindness can be caused in fish exposed to air sleeve blasts approximately 214 dB. Auditory damage starts at 180 dB, transient stunning at 192 dB and internal injuries at 220 dB.

Invertebrates lack swim bladders and hearing organs, two anatomical features where physical damage most likely occurs in aquatic organisms. The Royal Society of Canada (2004) suggests that seismic surveys will have no effect on the marine benthos provided the water depth is greater than 20 m. Benthic invertebrates are less likely to be affected by seismic activity because few invertebrates have gas-filled spaces and benthic species are usually more than 20 m away from the seismic source. The resilience of various invertebrates has been tested by exposing them at a short distance to an active airgun (Table 6.3).

The subject of acoustic detection in decapod (crabs, lobster) crustaceans has been previously investigated over the past few decades to estimate invertebrate response to sound and vibration (Popper et al. 2001). Lobsters are thought to be resilient to seismic activity because decapods lack the gas-filled voids that would make them sensitive to changes in pressure. Decopods have surface hair-like cells that serve as chemoreceptors and mechanoreceptors to detect water flow and vibrational stimuli and they respond to frequencies up to 100 Hz with a single spike per cycle. Chorodontal organs, associated with flexible body appendages, signal joint position, movement and stress and they respond to low-frequency waterborne vibrations. Statocysts are located on the basal segment of each antennule in crabs and other body areas in other crustaceans are involved in maintaining equilibrium. They are unlikely to respond to acoustic stimulation. Norway lobster (Nephrops norvegicus) showed postural responses to sound frequencies of 20 to 180 Hz in the lab (Goodall et al. 1990). In the field the response was due to particle displacement and not pressure. Responses were analogous to fish lateral line which response to water motions produced within a fish-length of the detecting animal (Popper et al. 2001).

In response to concerns for seismic surveys in shallow water on the west coast of Newfoundland, Payne et al. (2007) conducted laboratory and field experimentations on lobsters subject to seismic sources. The endpoints measurements were lobster survival, food consumption, turnover rate, serum protein, serum enzymes, serum calcium and a histopathology examination. Over a period of days to several months, there were no effects of delayed mortality or damage to mechanosensory systems associated with animal equilibrium and posture. There was no evidence of leg loss or other appendages. Sublethal effects were observed with feeding (minor) and serum biochemistry and organ stress was apparent in the hepatopancreas.

No significant adverse effects of seismic noise on the behaviour, physiology or catch rates of snow crabs or lobsters are anticipated from the 2-D seismic surveys.

Table 6.3: Observation from Exposures of Marine Macro-invertebrates to Air Sleeves at Close Range

Organism	Exposure Distance from Air Sleeve (m)	Estimated Exposure Level (dB re 1 µ Pa)	Observed Response	Reference
Iceland Scallop	2	217	Shell split in 1 of 3 tested	Matishov 1992
Sea Urchin	2	217	15 % of spines fell off	Matishov 1992
Mussel	0.5	229	No detectable effect within 30 days	Kosheleva 1992
Periwinkle	0.5	229	No detectable effect within 30 days	Kosheleva 1992
Crustacean	0.5	229	No detectable effect within 30 days	Kosheleva1992
Brown Shrimp	1	190	No mortality	Webb and Kempf 1998

The mortality rate of plankton during seismic surveys has been estimated from several studies. Up to 1 % of the ichthyoplankton in the top 50 m of the water column could be killed during 3-D seismic survey off Nova Scotia (Davis *et al*. 1998). An estimated 0.45 % of planktonic organisms in the top 10 m of water in a Study Area off Norway could be killed (Sætre and Ona 1996). Kenchington *et al*. (2001) estimated a plankton mortality rate of 6 % if they were concentrated in the upper 10 m. Given that seismic-related mortality in fish has not been reported beyond 5 m during field and laboratory studies, these estimates are considered conservative and may apply more to phytoplankton and zooplankton than to planktonic life stages of fish and shellfish. Kostyuchenko (1973) reported more than 75 % survival of fish eggs at 0.5 m from the source (233 db at 1 m) and more than 90 % survival at 10 m from the source (Table 6.4).

Table 6.4: Observations of Exposures of Fish and Shellfish Planktonic Life Stages to Seismic Airguns at Close Range

Organism	Life Stage	Exposure Distance from Air Sleeve (m)	Estimated Exposure Level (dB re 1 µ pA)	Observed Response	Reference
Pollock	Egg	0.75	242	Some delayed mortality	Booman *et al*. 1996
Cod	Eggs	1 to 10	202 to 220	No signs of injury	Dalen and Knutsen 1987
	Larvae	5	220	Immediate mortality	Booman *et al*. 1996
	5-day-old larvae	1	250	Delimitation of retina	Matishov 1992
	Fry	1.3	234	Immediate mortality	Booman *et al*. 1996
Plaice	Eggs and larvae	1	220	High mortality (unspecified)	Kosheleva 1992
		2	214	No effect	Kosheleva 1992
Anchovy	Eggs	Unknown	223	8.2 % mortality	Holiday *et al*. in Turnpenny and Nedwell 1994
	2-day-old larvae	3	238	Swimbladder rupture	Holiday *et al*. in Turnpenny and Nedwell 1994
Red Mullet	Eggs	1	230	7.8 % injured	Kostyuchenko 1973
		10	210	No injuries	Kostyuchenko 1973
Fish (various species)	Eggs	0.5	236	17 % dead in 24 hours	Kostyuchenko 1973
		10	210	2.1 % dead in 24 hours	Kostyuchenko 1973
Dungeness Crab	Larvae	1	231	No observed effect on time to molt or long-term survival	Pearson *et al*. 1994

Mortality and development rates of Stage II Dungeness crab larvae exposed to single discharges from a seismic array were compared with those of unexposed larvae. No statistically significant differences between the exposed and unexposed larvae were observed with respect to immediate and long-term survival and time to molt, even for those exposed larvae within 1 m of the seismic source (Pearson *et al*. 1994).

Early life stages of invertebrates are generally the most sensitive to disturbance and other external factors potentially causing harmful effects. Effects on embryonic growth may result in loss of overall fitness of the snow crab population by delaying development and hatching out of normal phase, increasing susceptibility of predation, increasing mortality, etc. Most scientific evidence, however, is limited to fish and other vertebrate species. Christian *et al*. (2004) performed experiments on fertilized eggs, which indicated statistically significant differences in egg development rate which could be an important endpoint in future studies.

Mortality was demonstrated to be 1.6% higher in 2,000+ eggs when compared with controls. However, the exposure distance remained constant at 2 m, and Christian *et al*. (2004) discuss the limitations involved in using one pool of control eggs and one pool of exposed eggs. The authors caution that their study was a preliminary investigation and further research may be needed to confirm a safe exposure distance.

Payne et al. (2009) conducted laboratory studies on monkfish larvae and unfertilized capelin eggs. Monkfish eggs occur at surface in large extruded sheets or veils (Scott and Scott 1988). A portion of veils, near hatching stage, were collected that had become entangled in fishing gear. The veil portions were transported to the laboratory and maintained until airgun exposures were carried out on free swimming larvae. Seven separate trials (6 with 10 airgun discharges and 1 with 30) were carried out in which the sound pressure levels ~0.5 m below the surface container holding the larvae were at about 205 dB peak to peak. No significant differences were observed between control and exposed larvae examined 48 to 72 hours post exposure.

Although artificial fertilization was poor, the results of the pilot study on capelin eggs showed no significant differences in mortality were observed between control and capelin eggs exposed to seismic energy and examined 3 days post exposure to 20 airgun discharges. In this case, the sound pressure levels about 0.5 m below the container in which the slides were held were at about 199 dB peak-to-peak. Other trials were carried out on capelin eggs exposed 1 to 3 days after fertilization and held for 9 to 10 days post exposure. Five separate trials were carried out and conditions were the same as for the monkfish larvae. Egg clumping precluded accurate counting of control and exposed eggs. However, live embryos could be resolved and were found to be present 9 to 10 days after exposure in all five trials and on all slides—experimental as well as control.

Modeled pressure levels were markedly below levels measured at about 0.5 m under the monkfish larvae and capelin eggs in this study with no apparent mortality. The modeled levels were also orders of magnitude below levels reported in other studies to affect mortality in eggs and larvae. Taking into consideration: (a) the results obtained on larval and egg exposures in this study, (b) modeled estimates of pressure levels at the water surface, and (c) literature on levels reported to effect mortality in eggs and larvae, Payne et al (2009) report that it is unlikely that seismic surveys pose any real risk to either monkfish eggs or near hatch larvae that may float in veils on the sea surface during monkfish spawning or affect populations of capelin.

It is assumed that a sound pressure level of 220 dB re 1 µPa0-P is required for egg/larval damage (Figure 6.1). A ‘worst-case scenario’ mathematical model was applied to investigate the effects of seismic energy on fish eggs and larvae and concluded that mortality rates caused by exposure to seismic were so low compared to natural mortality, the environmental effect of seismic activity on recruitment to a fish stock would be not significant (Sætre and Ona 1996). In addition, mortality of phytoplankton and zooplankton near the seismic vessel should be sufficiently localized as to negligibly affect food availability for fish, shellfish, birds, and mammals.

The abundance or distribution of any population (including larvae and eggs) will not likely be affected by seismic activity (Sætre and Ona 1996 in Dalen *et al*. 2007, Dalen *et al.* 1996 in Dalen *et al*. 2007). Modelling has indicated that a typical seismic survey results in a 0.45% mortality of the larvae population (Sætre and Ona 1996, in Dalen *et al*. 2007). Compared to the natural mortality of cod, herring, and capelin larvae or 5 to 15 % per day, seismic-induced mortality in these species is so low as to have no effect at the population level (Dalen *et al* 1996, in Dalen *et al*. 2007). A review of the current scientific literature (Table 6.2) indicates that egg and larval mortality is limited to within a few metres of the seismic array, physical injury to fish is limited to tens of metres and auditory damage is potentially limited to hundreds of metres (Kostyuchenko 1973, Turnpenny and Nedwell 1994, Sætre and Ona 1996, Kenchington *et al*. 2001).

Christian *et al*. (2004) used a variety of chemical and biochemical indicators in the haemolymph and serum of crustaceans to detect stress or dysfunction when exposed to air gun arrays. When exposed to a 40 cu. in. sleeve gun at 2 m, a 200 cu. in. array at 4 m, and a 200 cu. in. seven gun array at 2 m, they found no significant differences to crustacean physiology between control and experimental groups. Furthermore, Christian *et al*. (2004) did not find any discernible signs of external damage (i.e., carapace, appendages, statocysts) as a result of exposure to the guns and arrays. DFO (2004c) conducted a field survey, in winter 2003 and spring 2004, on potential impact of low-level seismic energy on the reproductive biology of female snow crab. The survey used caged animals off the western coast of Cape Breton, as well as laboratory experiments. As with other studies, mortality did not occur in any crabs during experimental conditions (Kosheleva 1992, Christian *et al*. 2004, DFO 2004c); survival of the embryos and locomotion of the resulting larvae after hatch were unaffected; and gills, antennae and statocysts were soiled in the test group, but were found free of sediment five months later. Less definitive results were significant differences between test and control groups related to bruising of the hepatopancreas; bruising of ovaries; dilated oocytes with detached chorions; one test group had delayed embryo hatch and larvae were slightly smaller; and orientation as a function of being turned over (DFO 2004c).

Payne *et al.* (2008) reviewed studies on seismic-related studies on crustaceans and found that “regarding broad scale surveys over a number of years in which population level effects were questioned, Parry and Gason (2006) found no effects on overall lobster catches, but cautioned that seismic induced mortality rates would have to be relatively high before seismic impacts could be resolved from other factors. Snow crab catches were also found not to be affected after a seismic survey off Cape Breton, but again, although the weight of evidence from studies on effects at the individual level might suggest no impacts, a considerable population level impact would likely be required in order to resolve any seismic impacts from other factors. There was no evidence for delayed mortality, egg loss or reduction in feeding in snow crab exposed under the conditions of an actual seismic program in deep waters off Cape Breton and subsequently maintained in the laboratory for several months. There was also no evidence for effects on egg hatch with eggs of test groups hatching a few days later in animals held in Moncton yet a few days earlier in animals held in Newfoundland. There was indication of some slight histological differences between the control and test animals from the Cape Breton study but these can reasonably be attributed to different oceanographic and habitat conditions at the locations where the control and test animals were collected and held. This was supported in subsequent studies carried out in Newfoundland."

The U.S. Minerals Management Service's environmental assessment of geophysical exploration in the Gulf of Mexico supports the conclusion that there is no documented evidence of a measurable impact to benthic communities from streamer surveys (MMS 2004).

Mitigation measures to minimize the impact of seismic operations on fish spawning include:

- To minimize sudden changes in noise levels, a ramp up procedure will be implemented;
- All discharges will comply with Offshore Waste Treatment Guidelines;
- A Spill Prevention Program will be implemented; and
- An Emergency Spill Response Plan will be developed and implemented when required.

No significant adverse effects on fish, lobsters, snow crab or eggs and larvae are anticipated as a result of MKI's 2-D surveys.

6.2.10 Accidental Events

Oil spills may affect water quality, which in turn may affect the health and survival of plankton, fish eggs, and larvae, juvenile and adult fish in the immediate vicinity of the vessel. While risk to adult fish and shellfish is low, pelagic fish eggs and larvae may be affected to different degrees by an accidental spill of hydrocarbons in the water. The nature and degree of such an interaction depends on the severity, timing, and location of the spill. The risk of such vessel accidents is low, and the volumes potentially released would be limited. Therefore, incidents involving survey vessels are not likely to result in significant effects on fish.

According to a literature review by Thomson *et al*. 2000, the sensitivity of fish larvae to an oil spill varies depending on the type of oil (*e.g.,* crude, light condensate, etc.) as well as the yolk sac stage and feeding conditions. Spill investigations have focused on dramatic events from vessels or offshore platforms. The Argo Merchant spill of 7.7 million gallons of No. 6 fuel in December 1976 on Nantucket Shoals off Massachusetts affected some fish eggs. Some of the eggs collapsed or had malformed shells, while others had oil spots on the outer membrane. Eggs and larvae exposed to oil generally exhibit morphological malformations, genetic damage and reduced growth (Thomson *et al*. 2000). However, these effects are short lived since these changes are not observed in subsequent years at the same location. No conclusive evidence in the literature exists to suggest that these oiled sites posed a long-term hazard to fish embryo or larval survival. The Regional Environmental Emergencies Team (REET) report on the Uniacke G-72 gas and condensate blowout concluded that there were no observed signs of long-term impacts on renewable resources or the marine environment around Sable Island from the blowout (Riley 1984). Although oil spills and blowouts can result in fish kills, neither event has been found to result in a decrease in fish stocks (Environment Canada 1984, Martec Limited 1984, Armstrong *et al*. 1995).

6.2.11 Cumulative Effects

The main projects and activities that may interact cumulatively with finfish, shellfish and spawning includes: commercial shipping traffic, commercial fishing, and commercial fishing traffic.

MKI foresees a ship-borne geophysical program consisting between 9,600 km 2-D seismic survey in the summer of 2011 while other 2-D surveys may occur at various times between 2011 and 2013.

In addition to these human activities, marine fish populations in the Study Area may be affected by natural factors, such as changes in prey and predator populations in areas within their natural range that may occur outside the Study Area. Certain populations of marine fish are more vulnerable to changes in their environment. This is especially true of species at risk. This seismic program is not resulting in mass removal of these species. The distribution of most fish species varies seasonally in response to physical or chemical changes in the surrounding environment (*e.g.,* depth, substrate, salinity, temperature) and as a result of seasonal habitat requirements (*e.g.,* spawning, feeding).

Long annual migrations are undertaken by groundfish species, such as cod, and pelagic species such as Atlantic salmon and sharks. The Project will not change the physical or chemical requirements that dictate fish presence, and their ability to reproduce.

Although non-significant, the residual effects of the Project components on finfish and shellfish that may be cumulative with the effects of other human activities in the region are expected to be very limited, consisting primarily of short-term avoidance behaviour. The predicted cumulative effects of the proposed seismic survey with other seismic projects, noise from vessel traffic, and commercial fishing are likely similar to those discussed in the assessment above. Seismic surveys produce repetitive, localised and short-term increases in ambient noise levels, with the period between potential exposures ranging from hours to days. Within the near field of an array, about 30 to 60 m at 45º from the array, received noise levels may reach or is less than 180 dB re 1 µPa at a sound source at water depths over the Study Area. Beyond this distance, sound from a seismic survey is similar to commercial vessels (MMS 2004). Given the existing and future seismic survey activity, the incremental sound made by fishing vessels and commercial vessel traffic will not add significantly to existing ambient noise levels in the Study Area.

Considering the significance criteria provided for fish and given that impacts from cumulative vessel traffic, individual projects and other activities in the Study and Regional Areas are not likely to contribute to significant adverse effects. The Project components are predicted to have minimal interaction with fish species at risk, and the 2-D seismic surveys are not anticipated to result in significant cumulative adverse effects to marine fish and shellfish.

The main cumulative impact on fish population is the fishing activities that potentially occur at the same time as the seismic exploration. Fish and shellfish are subject to mortality (direct and indirect) and population (stock) decreases as a result of harvesting in the order of 100s to 100,000s of tonnes. And in some species harvesting is conducted at unsustainable levels and on species that are listed as species-at-risk. Research indicates that adverse seismic related effects are largely of a temporary behavioural level effect. Therefore, seismic surveys will not contribute significant adverse cumulative effects to fish and shellfish populations to the removal effects of fishing. A smaller number of surveys are anticipated over the three year period (2011 to 2013), compared to the number of fishing activities occurring for Greenland halibut, shrimp and snow crab. In general, the cumulative effect on fish populations is short-term and localized and not significant to the overall well-being of the fish and shellfish invertebrate species. The proposed Project components are not expected to result in or contribute to any significant cumulative impacts on fish populations. Seismic surveys have been undertaken in the Regional Area and other locations in Newfoundland and Nova Scotia with no apparent measurable effects to fish or fisheries.

6.2.12 Monitoring and Follow-up

Follow-up and monitoring are not recommended for fish and shellfish for routine seismic activities.

6.2.13 Summary

Table 6.5 provides a summary of the potential for interaction, impact analysis, mitigations and cumulative and residual effects for marine fish and shellfish.

Table 6.5: Summary of Environmental Assessment for Marine Fish and Shellfish

Interactions and Issues

- Behavioural changes
- Physiological changes
- Masking of sound
- Hearing impairment
- Mortality

Impact Analysis

Noise levels from geophysical activities and vessel traffic for this Project are predicted to be less than the limits that cause physical effects on fish. Turnpenny and Nedwell (1994) summarized the following physical effects of noise on fish (worse case within 10 m of a 255 db re 1 μPa source):

- transient stunning of marine fish occurs at noise levels above 192 dB re 1μPa;
- internal injuries at 200 dB re 1μPa;
- egg/larval damage due to noise occurs at 220 dB re 1 μPa; and
- fish mortality at 230-240 db re 1μPa.

McCauley *et al.* (2000) conducted trials with captive fish and found that increases in swimming behaviour occurred when seismic sound levels reached 156 dB re 1 μPa. In the survey proposed by MKI, sound is estimated to attenuate to 156 dB re 1 μPa @ 1 m_{rms} at a distance of 200m m at 90° from vertical (horizontal from array) and 2-8 km at 45° and attenuate to161 to 171 dB re 1 μPa @ 1 m_{rms} distance of 200 m at 45° emission angle in the Study Area. Noise levels should attenuate to ambient levels 35 to 50 from the survey vessel.

The various components and activities associated with the proposed Project are not predicted to result in significant environmental effects on fish and shellfish because the effects are reversible, of limited duration, magnitude, and geographic extent. Although there are few studies on the effects of seismic surveys on specific fish species in Newfoundland waters, research studies show that mortality or serious injury is unlikely beyond a distance of approximately 2 m from the sound source. Effects of the Project on marine fish and shellfish in the Study Area are predicted to be non-significant.

Mitigation

- Adherence to the *Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment,* to the extent reasonably practical.
- To minimize sudden changes in noise levels, a 20 to 40 minute ramp up procedure will be implemented.
- Avoidance of known spawning areas at times when fish are known to be spawning, where appropriate.
- Compliance with OWTG (NEB *et al.* 2002) for all discharges.

Project Activity	**Magnitude**	**Geographic**	**Frequency**	**Duration**	**Reversibility**	**Ecological/Socio-Cultural and Economic Content**
Vessel Presence/Lights	1	0	3	3	R	2
2-D programme	1	2-3	2	2	R	2
Accidental Spill	0	1	1	1	R	2

Significance of Effect

- Not adversely significant

Confidence

- Limited peer-reviewed literature specifically addressing impairment to the auditory system following intense sound exposure. Regualtors are highly confidence on range of effects.
- No masking data for intermittent, impulsive air gun source points.
- Understanding the use of sound by fishes is very poor with few relevant published papers.
- Lack of specific knowledge about critical fish areas in Newfoundland waters other than for a few species.

Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**
0=negligible	**1= 10s of metres**	**1= isolated**	**1=days**	**R=reversible**
1=low	**2= <500 m**	**2= intermittent**	**2=two weeks**	**I=Irreversible**
2=medium	**3= 1-10 km**	**3 = continuous**	**3= one month**	
3=high	**4= 10-50 km**		**4=two months**	
	5= >50 km			

Ecological/Socio-cultural and Economic Context

1= Relatively pristine area or area not adversely affected by human activity;

2=Evidence of existing adverse effects

6.3 MARINE MAMMALS

Marine mammals are considered a VEC due to their significant role in the offshore ecosystem, and because of regulatory protection, and scientific and public concern. While the understanding of the effects of noise on marine mammals and sea turtles is increasing, it is still unclear whether or how noise and other anthropogenic factors affect species at population levels (Nowacek *et al*. 2007). This analysis considers cetaceans and pinnipeds that may live and/or migrate through the Study Area.

6.3.1 Boundaries

The spatial boundary of interaction is primarily the zone of influence of both the presence of the seismic vessel and generated noise. The spatial distribution of individual species of marine mammals in the Northwest Atlantic is not well known, however, as data continues to be gathered, the diversity and seasonalities of many marine mammals is becoming better known.

Temporal boundaries for this analysis are defined by the Project schedule (July to December). Temporal ecological boundaries for cetaceans and pinnipeds vary according to species. Most cetaceans are migratory and occur in the Study and Regional Areas predominantly during the summer and fall months. Pinnipeds will occur year round.

Canada does not currently have established received-level standards for potential effects of noise on marine mammals but typically uses criteria developed by the US National Marine Fisheries Service (NMFS). Some values of root mean square (rms) sound pressure levels have been estimated and proposed as impact criteria. Impact criteria for potential damage or disturbance to marine mammals have been developed for peak-to-peak and energy flux density values; however, the results of this analysis are not yet publically available (Southall *et al*. 2007).

Knowledge gaps are related to information on potential effects of seismic noise, which remain an area of uncertainty. DFO reviewed literature on laboratory and field studies on the effects of sound on marine organisms (DFO 2004b) and concluded that due to the lack of direct studies on marine mammals, it is unknown if exposure to seismic sound could reduce communication, reduce echolocation, hamper prey detection, hamper predator detection and or hamper parental care. Existing scientific information has been reviewed and applied where appropriate to the proposed Project.

6.3.2 Potential Issues

Pulsed sound from seismic exploration has the potential to affect marine mammals. The highest energy output is at relatively low frequencies of 10 to 200 Hz. These frequencies overlap with the low frequency sound produced by baleen whales (12 to 500 Hz). The airgun arrays can still produce high frequency sound energy (up to 22 kHz) within a few kilometres of the source. These frequencies overlap with sound frequencies to which small odontocete (toothed whales) species use and are sensitive to in the 0.5 to 20 kHz range (Weir and Dolman 2007). Therefore, both odontocete and mysticete species may potentially be adversely affected by airgun noise.

There is a considerable amount of literature on potential impacts of seismic surveys on marine mammals; however, almost all the impacts have been inferred or assumed by implication rather than observed (MMS 2004). There have been no documented instances of deaths, physical injuries or auditory effects on marine mammals from seismic surveys (MMS 2004). Behavioural responses have been documented; the importance of this has yet to be determined. Potential interactions between the Project and marine mammals relate primarily to noise disturbance and direct physical effects associated with the vessel and air source operations. These disturbances may lead to the following effects:

- communication masking (*e.g.,* interception of vocalizations);
- behavioural effects associated with seismic noise (*e.g.,* avoidance, changes in migration, reproductive and feeding behaviours); and

- direct physical effects associated with seismic noise from air gun during 2-D programs (*e.g.,* auditory damage, mortality).

Potential interactions between the seismic vessel and individual animals (*e.g.,* collisions) are also considered.

6.3.3 Significance Criteria

A significant adverse environmental effect occurs when:

- population or portion thereof is affected in such a way as to cause a decline or change in abundance and/or distribution of the population over one or more generations (may be due to loss of an individual(s) in the case of an endangered species); and/or
- the displacement of any species at risk from critical habitat; and/or
- long term avoidance of the area; and/or
- a disturbance of behavioural patterns adversely affects the ecological functioning of the species population.

A non-significant adverse environmental effect on marine mammals occurs when:

- mortality or serious injury to marine mammals occurs, but does not affect the stock or species at risk; or
- short term displacement from preferred habitat; or
- limited disturbance that does not affect the ecological functioning of the species or stock.

6.3.4 Effects Assessment

6.3.4.1 Vessel Presence

The potential effects from vessels on marine mammals include strikes, temporary behavioural (aversion or attraction) effects, and effects from vessel noise. The physical presence of the vessel during seismic surveys does not typically result in significant adverse effects such as collisions. Marine species, in particular marine mammals, are expected to easily avoid the vessel during seismic surveys due to exhibited avoidance behaviour to noise and the slow speed of the ship. The survey vessel will likely travel at an average speed of 4.5 knots when the survey gear is deployed and will increase to about 10 knots while in transit. These speeds are within operational activities of fishing and commercial marine traffic. While the potential for collision exists, collision events are predicted to be unlikely. Collision with an endangered species would be considered significant; however, since there are no records of collision between the listed species at risk and seismic vessels, the probability of occurrence is low. Bow wave-riding delphinids is considered an attraction behaviour response and unavoidable, and is not considered an adverse effect.

Based on anecdotal evidence, pinnipeds appear to show little reaction to vessels in open water (Richardson and Malme, 1993). However, few studies describe the responses of pinnipeds in the water to vessel traffic.

Seismic vessels activity is a minor component of total marine transportation in comparison with the hundreds of commercial tankers, cargo ships, research vessels, and fishing vessels in the vicinity of the Study Area. The additional vessel activity from the survey is negligible compared to the other vessels and cumulative impacts on species at risk are not significant.

6.3.4.1 Noise Emissions

Physical Effects

There are no documented cases of marine mammal mortality from exposure to seismic sounds and DFO (2004c) considers it unlikely that marine mammal mortality would be caused by seismic sound exposure.

For pulsed sounds, a broadband received sound pressure level of 180 dB re 1 µPa (rms) or greater was proposed as an indication of potential concern about temporary and/or permanent hearing impairment (Level A Harassment in the USA) to cetaceans (NMFS 2003; Madsen 2005). Level A Harassment is defined as “any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild” (NRC 2003b). The criterion proposed for Level A Harassment to pinnipeds from pulsive sounds is exposure to received levels of 190 dB re 1 µPa (rms) or greater.

Extended periods of moderate noise levels under water can cause a temporary threshold shift (TTS) in some marine mammals, resulting in a reduction in hearing sensitivity and a small degree of permanent loss (Kastak *et al*. 2005). At TTS exposure levels, hearing sensitivity is generally restored quickly after the sound dissipates. Noises of greater intensity may result in a permanent threshold shift (PTS), in which hearing loss is not recovered (Finneran *et al*. 2002). A PTS may be a symptom of physical damage and may alter the functional hearing sensitivity at some or all frequencies. Although there are no data to quantify sound levels required to cause a PTS, it is believed that a source level would have to far exceed the level required for a TTS, the exposure would have to be prolonged, or the rise level would be extremely short (LGL Limited 2009). Richardson *et al*. (1995) hypothesized that permanent hearing impairment of marine mammals would not likely occur unless prolonged exposure to continuous anthropogenic sounds exceeding 200 dB re 1 µPa-m was experienced.

Research has shown that marine mammals exposed to intense sounds may exhibit decreased hearing sensitivities (TTS) following cessation of the sound (Au *et al*. 1999; Kastak *et al*. 1999; Schlundt *et al*. 2000). TTS have been observed in captive marine mammals exposed to pulsed sounds in experimental conditions (Finneran *et al*. 2002), but the likelihood of these effects occurring have not been evaluated under field operating conditions. There is currently no agreement as to what level of TTS and time to recovery would present unacceptable risk to a marine mammal. NMFS policy is under review and currently states that cetaceans and pinnipeds should not be exposed to pulsive sounds exceeding 180 and 190 dB re 1 µPa (rms), respectively (NMFS 2000).

Criteria can be established for zones of influence based on ambient sound levels, absolute hearing thresholds of the species of interest, slight changes in behavior of the species of interest (including habituation), stronger disturbance effects (*e.g.,* avoidance), temporary hearing impairment and permanent hearing or other physical damage, as illustrated in Figure 6.2 (Lawson *et al*. 2000, LGL Limited 2009).

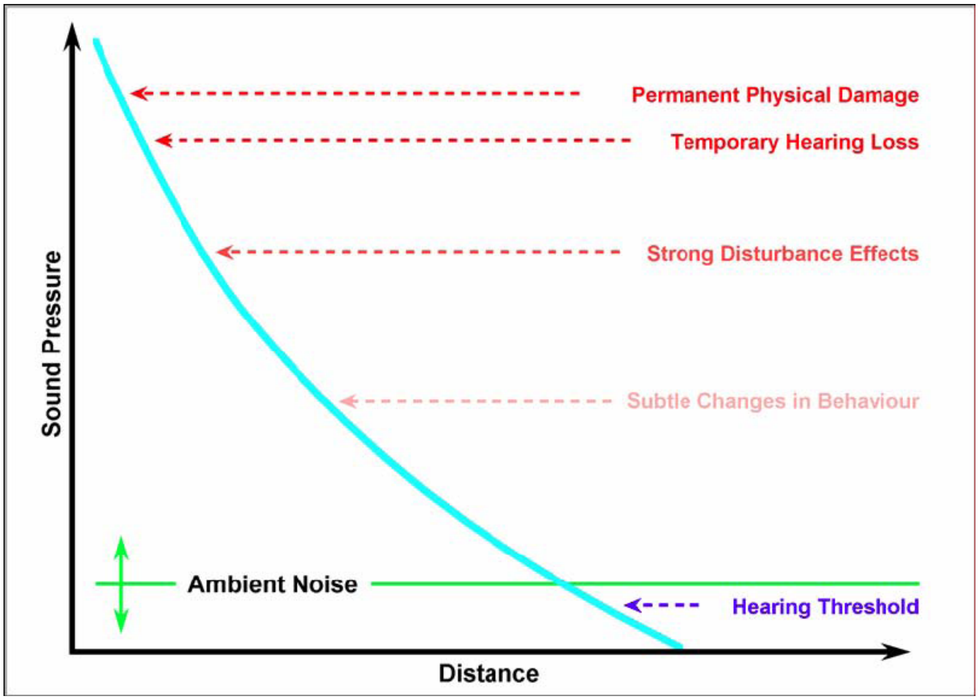

Figure 6.2: Schematic Representation of Zones of Potential Effects Associated with Anthropogenic Sounds on Marine Mammals
Source: Lawson et al. 2000, in LGL Limited 2009
Note: Vertical distances between various effects are not drawn to scale.

Exposure to high-intensity pulsed sound such as explosions can cause other, non-auditory physical effects such as stress, neurological effects, bubble formation, resonance effects and other types of organ or tissue damage (NRC 2003b; LGL Limited 2009). Little is known about the potential for the sounds produced during geophysical surveys to cause auditory threshold shifts or other effects in marine mammals and turtles. However, data suggest that if these effects do occur, they would only occur in close proximity to the sound sources. Thus, species that show behavioural avoidance of seismic vessels, including most baleen whales, some toothed whales and some pinnipeds, would not likely experience threshold shifts or other physical effects (LGL Limited 2009).

Physical harm is expected to be mitigated by using ramp-up or soft-start procedures which will encourage whales to move from the area prior to physical effects occurring. As well, a survey of the area for mammals is conducted prior to starting ramp-up.

The Statement of Canadian Practice for Mitigation of Seismic Noise in the Marine Environment will also provide guidance to the seismic program. The Statement aims to formalise and standardise the mitigation measures used in Canada with respect to the conduct of seismic surveys in the marine environment. It is based on a DFO-sponsored peer review by Canadian and international experts. The following points outline the mitigation measures described in the Statement of Canadian Practice (Appendix 2 of the C-NLOPB Geophysical Program Guidelines):

- Avoid death, harm, or harassment of individuals of marine mammals listed as endangered or threatened on SARA;
- Avoid, to the extent reasonably practical, causing a displacement of a group of breeding, feeding or nursing, or migrating, marine mammals, if it is known there are no alternate areas available to those marine mammals for those activities.
- Avoid, to the extent reasonably practical, displacing an individual marine mammal listed as endangered or threatened on SARA from breeding, feeding or nursing, or migrating, if it is known there are no alternate areas for those activities that the individual could be expected to use.
- Establish a safety zone of 500 metres from the centre of the seismic source array or arrays.
- Delay start up if a whale, other than a dolphin or a porpoise, is seen within the safety zone during the 30 minute visual survey until the whale has not been observed for at least 30 minutes within the safety zone or has been observed leaving the safety zone.
- Conduct regular on-going visual monitoring of the safety zone by a qualified Marine Mammal Observer, including continuous visual monitoring during a period of at least 30 minutes prior to start-up of the seismic array.
- Shut down seismic array when a marine mammal listed as endangered or threatened on Schedule 1 of the Species at Risk Act has been observed in the 500 m safety zone.
- Operations may re-commence, using ramp-up/soft-start measures if the array has been shut down for more than 30 minutes. This includes commencing the ramp-up by firing a single source, preferably the smallest source in terms of energy output and volume; and continually activating additional sources in ascending order of size over a 20 to 40 minute period until desired operating level is attained.
- Shut down seismic source array(s) or reduce to a single energy source for line changes. If shut down occurs, ramp-up/soft-start procedures will not be required as alternative measures to maintain the safety zone will be used.

MKI will conduct a marine mammal monitoring program for whale species at risk during survey data acquisition. The reporting of marine mammal observations will use the forms developed under the Joint Nature Conservation Committee (JNCC) Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys (April 2004). A trained Environmental Observer will watch for marine mammals from the bridge, forward and aft, of the seismic vessel throughout the survey. MKI will establish a 500 m safety zone for the program and will delay start up of the air guns if a turtle or whale is observed at surface within the safety zone and will shut down the seismic array if a SARA listed whale or turtle is observed within the safety zone. Prior to arriving at the start of a line, the air source array will be slowly brought up to maximum power, a procedure referred to as a “soft start” or “ramping up”. An approved ramp-up procedure will be followed when air source operations begin or after every shutdown. Vessels towing streamers have limited manoeuvrability when the equipment is deployed. MKI will include a turn-around perimeter around the Study Area, during which time the array will be powered down to a single air source (likely the smallest) to warn marine mammals of the presence of the seismic vessel. If the air sources are completely shut down due to maintenance or other purposes, the procedure will be followed again.

Behavioural Effects

Anthropogenic sounds have the potential to disturb behaviour and/or interfere with important functions (Richardson and Malme 1995, NRC 2003b). A broadband-received sound pressure level of 160 dB re 1 µPa (rms) or greater is currently the best estimate available to cause disruption of behavioural patterns (Level B Harassment) to marine mammals (NRC 2003b). Level B Harassment is defined as “any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild” (NRC 2003b).

Nowacek *et al*. (2007) and Richardson *et al*. (1995) provide good reviews of the current knowledge of anthropogenic noise effects on marine mammals.

Behavioural responses of marine mammals to noise are highly variable and dependent on a suite of internal and external factors (NRC 2003b). Internal factors include:

- individual hearing sensitivity, activity pattern and motivational and behavioural state at time of exposure;
- past exposure of the animal to the noise, which may have led to habituation or sensitization;
- individual noise tolerance; and
- demographic factors such as age, sex and presence of dependent offspring.

External factors include:

- non-acoustic characteristics of the sound source, such as whether it is stationary or moving;
- environmental factors that influence sound transmission;
- habitat characteristics, such as being in a confined area; and
- location, such as proximity to a shoreline.

Behavioural changes in whales resulting from seismic surveys will vary by species and even by individuals of the same species. Migrating humpback, grey, and bowhead whales have reacted to sound pulses from marine seismic exploration by deviating from their normal migration route and/or interrupting their feeding and moving away (*e.g.,* Malme *et al*. 1984, 1985, 1988, Richardson *et al*. 1986, 1995, Ljungblad *et al*. 1988, Richardson and Malme 1993, McCauley *et al*. 1998, 2000a, b, Miller *et al*. 1999). Some baleen whales may show strong avoidance at received levels lower than 160 to 170 dB re 1 µPa (rms). The observed avoidance reactions included movement away from feeding locations or statistically significant deviations in the whales’ direction of swimming and/or migration corridor as they approached or passed the sound sources. In the case of the migrating whales, the observed changes in behaviour appeared to be of little biological consequence to the animals. They simply avoided the sound source by slightly displacing their migration route yet remained within the natural boundaries of the migration corridors.

Few studies have been conducted on the reaction of toothed whales to seismic activity, but there are numerous observations of dolphins and porpoises bow riding active seismic vessels (*e.g.,* Duncan 1985, Arnold 1996, Stone 2003). However, some studies, especially near the UK, showed localized (~one kilometre) avoidance (Calambokidis and Osmek 1998, Goold 1996a). There are no specific data on responses of beaked whales to seismic surveys (Würsig *et al*. 1998, Kasuya 1986). One incident of stranding of Cuvier's beaked whale (*Ziphius cavirostris*) in September 2002 in the Gulf of California after exposure to multi-beam bathymetric sonar, which emits high-frequency sound was thought to be in the best hearing range of toothed whales like the Cuvier's beaked whale (Malakoff 2002). The evidence linking the Gulf of California strandings to the seismic surveys is inconclusive, and to this date is not based on any physical evidence.

Baleen whales generally avoid an operating air gun, but the avoidance radii appear to be quite variable. Baleen whales, like the listed fin and blue whales, may deviate from a migratory route, suspend feeding or avoid the area. The biological significance of such a change in behaviour is considered slight since there are no uniquely significant habitats (feeding, nursery, mating) identified within the Study Area and there are alternate feeding areas. Fin whales are expected to avoid the area of 160 dB and higher. They may tolerate higher decibel levels if they are feeding, rather than migrating, as bowheads apparently do (Miller *et al*. 2005). For instance, migratory bowhead whales may begin to avoid a seismic source 35 km away, but continue feeding until the sound source comes to within 3 km.

Ringed seals near an artificial island drilling site were monitored before and during development of the site. Although air and underwater sound was audible to the seals for up to 5 km, there was no change in their density in that area between breeding seasons before and breeding seasons after development began (Moulton *et al*. 2003).

Very little information exists on the reactions of pinnipeds to sounds from seismic exploration in open water (Richardson and Malme 1995). Visual monitoring from seismic vessels has shown that pinnipeds frequently do not avoid the area within a few hundred metres of an operating airgun array (Harris *et al.* 2001). However, the telemetry research of Thompson *et al*. (1998) suggests that reactions may be stronger than has been evident from visual studies.

Exposure to sounds higher than 130 dB re 1 μPa_{rms} is possible for marine mammals within 30 to 60 km horizontal to the array at horizontal (at surface). The US NMFS has developed criteria for marine mammal seismic exposure. The level considered harmful to whales is 180 dB re 1 μPa and sound levels of 160 dB re 1 μPa are considered to cause harassment to whales (NMFS 2000). The harmful level is predicted within 8 m horizontal to the array, and 30 m distance from the array at 45° emission angle.. From modelling, the harassment level is predicted within 128 m horizontal to the array and to 500 m at 45° emission angle. Whales are not expected to be exposed to these sound levels since they will likely be deterred from the immediate area by the presence of the vessel and ramp-up procedure. The impact of mammal species at risk would depend on the duration and timing of the seismic survey as well as availability of alternate locations for activities the whales were engaged in.

Masking Effects

When anthropogenic noise from ships, seismic and sonar are layered on natural ambient sounds, the level of noise underwater can be quite loud in some areas. In areas where natural background noise is relatively high, such as near a shelf break or high surf, anthropogenic noise itself can be masked and reduce the area in which it is detectable. The anthropogenic noise is undetectable for marine mammals once it falls below ambient noise level or the hearing threshold of the animal. Given this and the fact that mammal response will vary by species and between individuals, the zone of potential influence of noise on marine mammals is highly variable.

Although masking is a natural phenomenon to which marine mammals must be adapted, introduction of strong sounds into the sea at frequencies important to marine mammals will inevitably increase the severity and the frequency of occurrence of masking. For example, if a baleen whale is exposed to continuous low-frequency sound from an industrial source, this will reduce the size of the area around that whale within which it will be able to hear the calls of another whale. In general, little is known about the importance to marine mammals of detecting sounds from con-specifics, predators, prey, or other natural sources. In the absence of much information about the importance of detecting these natural sounds, it is not possible to predict the impacts if mammals are unable to hear these sounds as often, or from as far away, because of masking by industrial sound (Richardson *et al.* 1995). In general, masking effects are expected to be less severe when sounds are transient than when they are continuous.

Although some degree of masking is inevitable when high levels of man-made broadband sounds are introduced into the sea, marine mammals have evolved systems and behaviour that function to reduce the impacts of masking. Structured signals such as echolocation click sequences of small toothed whales may be readily detected even in the presence of strong background sound because their frequency content and temporal features usually differ strongly from those of the background sound (Au and Moore 1988, 1990). It is primarily the components of background sound that are similar in frequency to the sound signal in question that determine the degree of masking of that signal. Low-frequency industrial sound has little or no masking effect on high-frequency echolocation sounds.

Masking effects of seismic survey sound on marine mammal calls and other natural sounds are expected to be limited. Some whales are known to continue calling in the presence of seismic pulses, which are typically 20 msecond in duration and occur every 11 second. Their calls can be heard between seismic pulses (*e.g.*, Richardson *et al.* 1986, McDonald *et al.* 1995, Greene and McLennan 2000). Although there was one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles *et al.* 1994), more recent studies have reported that sperm whales continued calling in the presence of seismic pulses (Madsen *et al.* 2002a, Jochens and Biggs 2003). Toothed whales, and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with much ambient sound toward frequencies with less sound (Au *et al.* 1974, 1985, Moore and Pawloski 1990, Thomas and Turl 1990, Romanenko and Kitain 1992, Lesage *et al.* 1999). A few marine mammal species are known to increase the source levels of their calls in the presence of elevated sound levels (Dahlheim 1987, Au 1993, Lesage *et al.* 1999, Terhune 1999).

Whale species at risk are highly dependent on sound for communicating, detecting predators, locating prey, and in toothed whales, echolocation (Lawson *et al.* 2000). Natural ambient noise created by wind, waves, ice and precipitation alone can cause masking or interfere with an animal's ability to detect a sound. Whales themselves also contribute to the level of natural ambient noise. The calls of a blue whale have been recorded for 600 km (Stafford *et al.* 1998). A sperm whale call can be as loud as 232 dB re 1μPa at 1 m (rms) (Møhl *et al.* 2003).

Masking effects of seismic pulses are expected to be negligible in the case of the smaller odontocete cetaceans, given the intermittent nature of seismic pulses and the fact that sounds important to them are predominantly at much higher frequencies than air gun sounds. Most of the energy in the sound pulses emitted by air source arrays is at low frequencies, with the strongest spectrum levels below 200 Hz, and considerably lower spectrum levels above 1,000 Hz. These frequencies are mainly used by baleen whales, but not by toothed whales or true seals. Furthermore, the discontinuous nature of seismic pulses makes significant masking effects unlikely even for baleen whales. There are reports of whales altering vocalization patterns when exposed to industrial and seismic noise and there are reports of no alteration in vocalization during seismic exposure (DFO 2004b). Whether there is a consequence to any change in vocalization pattern is difficult to determine, but there is potential for reduced ability to communicate information about feeding, breeding, parental care, predator avoidance or maintenance of social grouping. DFO (2004b) has therefore determined it is presently unknown, whether mammal exposure to seismic sound results in reduced communication efficiency. It is also unknown, since there have been no direct studies, of the potential for seismic sound to reduce the efficiency of echolocation in cetaceans (including species at risk), or the potential to hamper passive acoustic detection of prey or predators by marine mammals (DFO 2004b). There is a concern however, that whales exposed to seismic sounds can have a reduced ability to avoid anthropogenic threats such as ship strikes and fishing net entanglements, but the threat has not been demonstrated (DFO 2004b).

Most pinnipeds produce sounds with dominant frequencies between 0.1 and 3 kHz (Richardson and Malme 1995). The individual calls of harp seals range from less than 0.1 second to greater than 1 second in duration (Watkins and Schevill 1979). The frequencies contained in seismic and sub-bottom profiler pulses do overlap with some frequencies used by pinnipeds, but the discontinuous, short duration nature of the pulses is expected to result in limited masking of pinniped calls. Side-scan sonar and echo-sounder signals do not overlap with the predominant frequencies of pinniped calls, which avoid measurable masking.

Data on underwater hearing sensitivities are available for three species of phocoenid seals, two species of monachid seals, two species of otariids and the walrus (*Odobenus rosmarus*)

(Richardson and Malme 1995, Kastak and Schusterman 1998, Kastak *et al*. 1999, Kastelein *et al*. 2002). The hearing sensitivity of most pinniped species that have been tested ranges between 60 and 85 dB re 1 µPa from 1 kHz to 30 to 50 kHz. In the harbour seal, thresholds deteriorate gradually below 1 kHz to approximately 97 dB re 1 µPa at 100 Hz (Kastak and Schusterman 1998). Based on these data, it is likely that airgun pulses are readily audible to pinnipeds. Pinnipeds exposed to 2,500 Hz at 80 and 95 dB for 22, 25 and 50 minutes experienced TTS ranging from 2.9 to 12.2 minutes, but recovered fully within 24 hours of noise exposure (Kastak *et al*. 2005).

6.3.4.2 Accidental Events

Spilled oil may affect marine mammals through dermal contact, inhalation, ingestion and/or fouling of baleen plates. Potential impacts will be short-lived due to the high volatility and relatively small volume of the spilled oil (diesel) and confinement to surface water. No significant adverse effects are anticipated for marine mammals as a result of small volume accidental spills.

6.3.4.3 Cumulative Effects

In general, because the sounds generated by seismic surveys are transient and do not "accumulate" in the environment, the most likely cumulative effects will be associated with other concurrent activities (*e.g.,* cargo ships, tankers, and production activities, other seismic surveys (offshore Labrador) and fishing vessels). Studies in the Gulf of Mexico showed that seismic surveys produce a relatively minor contribution to the overall underwater noise environment (MMS 2004). The cumulative effect is short term, intermittent and localised, and therefore, not significant with respect to effects on species at risk.

In general, the individual seismic survey vessel activity and noise will constitute a minor percentage contribution to the overall noise generated by other such sources and space-user conflict, and will be of short duration in local areas. Based on current knowledge, and especially with the proposed mitigation procedures in place, the proposed Project is not expected to result in, or contribute to, any significant cumulative impacts on species at risk.

6.3.4.3 Monitoring and Follow-up

A dedicated Environmental Observer will be onboard the seismic vessel. If a concentration of marine mammals is observed in a particular area, it is possible for the survey to shift to another part of the Study Area until the concentration has moved away. This, along with a whale survey before ramp up, a 30-minute ramp-up procedure, and the shut-in protocol if a SARA species is observed within 500m during active air gun firing, will ensure that whale species at risk in the Study Area are not significantly affected in an adverse manner.

MKI will conduct a periodic review of the EA Report to determine the validity of species at risk assessment and acknowledges that additional mitigation may be necessary should new species be added to Schedule 1 over the life of the Project.

6.3.5 Summary

Table 6.6 summarizes the environmental effects on marine mammals from the MKI 2-D surveys.

Table 6.6: Summary of Environmental Assessment for Marine Mammals

Interactions and Issues

- Disturbance of marine mammals caused by the presence of vessels, particularly with regard to collisions with species at risk.
- Noise from seismic leading to masking of cetacean vocalization; behavioural changes; temporary threshold shift or hearing impairment; or
- physical injury.

Impact Analysis

There is lack of published information regarding avoidance thresholds in odontocete whales, however, baleen whales exhibit clear avoidance behaviours at threshold levels of approximately 160 to 170 dB re 1μPa (rms) (Davis *et al*, 1998). NMFS policy regarding exposure of marine mammals to high-level sounds is that whales should not be exposed to impulse sounds exceeding 180 dB re 1μPa (rms), although behavioural changes are apparent at 160 dB re 1μPa (rms) (NMFS 2000). Therefore, using 170 dB re 1μPa (rms) (≈160 dB re 1μPa (SEL)) as a received sound level boundary, the minimum and maximum distance from a 243 dB re 1μPa$_{(rms)}$ @ 1m broadband source to an attenuation of 170 dB re 1μPa $_{(rms)}$ is predicted at 32 m at 0° from the array (horizon) and 128 m at 45° in over the water depth ranges.

Effects from seismic activities may result in physical injury and auditory impairment in cetaceans that are in close proximity to the firing air source array, a distance that should be avoided by marine mammals through ramping-up or when they hear the approaching seismic vessel. Auditory damage and mortality as a result of seismic activities and/or vessel traffic is not considered to be a major concern with respect to the proposed Project. The proposed Project may result in behavioural effects on marine mammals; however, most studies indicate that such behavioural disturbances are likely to be transitory with normal behaviour resuming within an hour or two after vessel passage. Mortality, serious injury or displacement from behavioural patterns that disrupt the ecological functioning of a species are not expected as there is no evidence nor expectation that seismic activities will result in these effects (MMS 2004).

Mitigation

- Collision avoidance practices, including constant speed and course maintained by seismic and support vessels.
- Trained observer on the seismic vessel to ensure that air sources are shut down if SARA species are present within 500 m of the seismic vessel.
- Prior to start, survey of a 500 m zone from the array for whales before ramp-up procedure
- Ramp-up procedure will be implemented, prior to start. Ramp-up will be delayed if a marine mammal is present within 500 m of the seismic vessel. Ramp-up will commence again once marine mammal vacates 500 m zone..

Project Activity	**Magnitude**	**Geographic**	**Frequency**	**Duration**	**Reversibility**	**Ecological/Socio-Cultural and Economic Content**
Vessel Presence	1	1	3	3	R	2
2-D programme	2	2	2	3	R	2
Accidental Spill	1	3	1	1	R	2

<table>
<tr><td colspan="5">Significance of Effect
• Not adversely significant</td></tr>
<tr><td colspan="5">Confidence
• Medium level of confidence related to significance rating given international and local industry experience</td></tr>
<tr><td>Magnitude
0=negligible
1=low
2=medium
3=high</td><td>Geographic Extent
1= 10s of metres
2= <500 m
3= 1-10 km
4= 10-50 km
5= >50 km</td><td>Frequency
1= isolated
2= intermittent
3 = continuous</td><td>Duration
1=days
2=two weeks
3= one month
4=two months</td><td>Reversibility
R=reversible
I=Irreversible</td></tr>
<tr><td colspan="5">Ecological/Socio-cultural and Economic Context
1 Relatively pristine area or area not adversely affected by human activity
2 Evidence of existing adverse effects</td></tr>
</table>

6.4 SEA TURTLES

Sea turtles are considered a VEC due to their special conservation status and uncertainty regarding their distribution in the Study Area. Any loss of breeding adults, above that caused by natural predation and disease, can lead to significant declines in population. As well, the leatherback is a SARA-listed species.

6.4.1 Boundaries

The spatial boundaries for the assessment of sea turtles include the Study Area, although it is recognized that sea turtles have widespread distribution patterns from the Caribbean to the Northwest Atlantic, as far north as Labrador.

Temporal boundaries are defined by the Project schedule (July to December 2013). Based on data collected by DFO, marine turtles are likely to occur in the Study Area during the summer and fall months. For the purpose of this assessment, it is assumed that any species of sea turtle that could potentially be present offshore Labrador could be present within the Study Area.

6.4.2 Potential Issues

Potential interactions between the Project seismic surveys and sea turtles relate primarily to auditory damage and behavioural effects (*e.g.,* avoidance behaviour, increased swimming speeds).

6.4.3 Significance Criteria

A significant adverse environmental effect on sea turtles is one that may result in:

- mortality or serious injury of one or more individuals of a species at risk;
- long-term displacement from preferred or critical habitat; and/or
- change in the preferred or critical habitat.

A non-significant adverse environmental effect on sea turtles is one that may result in:

- minor injury of one or more individual of any sea turtles species; and/or
- short term displacement from preferred or critical habitat.

6.4.4 Effects Assessment

6.4.4.1 Vessel Presence

There is some risk to marine turtles from collision with seismic vessels, as they would be with fishing and commercial marine traffic. As they are submerged for the most part and may avoid seismic arrays, the risk of mortality or serious injury to sea turtles is anticipated to be low (MMS 2004).

6.4.4.2 Noise Emission

Physical Effects

Sea turtles remain submerged for the majority of time and thus may be exposed to the highest sound levels as the vessel and towed equipment pass overhead. Studies on sea turtle hearing are limited and the role in their ecological functioning is not well known. It has been suggested that sound may play a role in sea turtle navigation. However, recent studies suggest that visual, wave and magnetic cues are the principal navigational cues used by hatchling and juvenile sea turtles (Lohmann and Lohmann 1996, Lohmann *et al*. 2001).

Maximum hearing sensitivity in sea turtles has been observed in the 100 to 700 Hz range (Ridgway *et al*. 1969, McCauley 1994, Davis *et al*. 1998). TTS was observed by Moein *et al*. (1994) when loggerhead turtles were exposed to a few hundred air source pulses approximately 65 m away. Moein *et al*. (1994) do not describe the received sound levels or size of the air source used, making it difficult to estimate the sound level that caused TTS in loggerhead turtles. The hearing capabilities of the loggerhead turtles returned to normal two weeks later. Temporary or permanent hearing impairment may occur at close range, but life-threatening injury or mortality is unlikely.

Behavioural Effects

Research has shown that sea turtles modify their behavioral patterns when exposed to high-intensity sound. For example, studies carried out by Lenhart (1994) showed that sea turtles increase their movements after airgun shots and do not return to the depth where they usually rest.

The Australian Petroleum Production and Exploration Association sponsored an experimental program between 1996 and 1999 to study the environmental implications of marine seismic surveys. One of the components of this program, run by the Centre for Marine Science and Technology of Curtin University in Western Australia, involved trials with an air gun approaching caged sea turtles, fishes and squid (McCauley *et al*. 2000). Observers noted erratic behaviour ("alarm response") of caged loggerhead and green turtles at received sound levels of 175 dB re µPa(rms) (or 185 dB re 1 µPa(0-p)) while received sound levels of 166 dB re µPa(rms) (or 176 dB re 1µPa(0-p)) triggered avoidance behaviour. Marine turtles displayed no long-term neurophysical damage. Although a reduction in hearing capability was evident, the effect was temporary and returned to normal within a short period of time (McCauley *et al*. 2000). The avoidance reaction could be generated by this 2-D program array of 240 dB re 1µPa(rms)is predicted not to occur in the water column beyond the immediate air gun. Erratic behaviour could result between 32 m and 128 m based on 0° and 45° angles of emission, respectively. Marine turtles are expected to display behavioural changes at around 128 to 50 m from the seismic array (McCauley *et al*, 2000). These results were consistent with other similar studies (*e.g.,* O'Hara and Wilcox 1990; Moein *et al*. 1994) that demonstrated avoidance of operating air guns.

Moein *et al* (1994) observed avoidance behaviour during the first presentation of the airgun exposure at a mean range of 24 m. Further trials several days afterwards did not elicit statistically significant avoidance behaviour. Physiological measurements showed evidence of increased stress; however, the effect of handling the turtles was not taken into account within the study and, therefore, the increased stress could not be attributed to the airgun operations. A temporary reduction in hearing capability was evident from the neurophysiological measurements but this effect was temporary and the turtles hearing returned to pre-test levels at the end of two weeks. Moein *et al*. (1994) concluded that this might have been due to either habituation or a temporary shift in the turtles hearing capability. Recent monitoring studies have shown that some sea turtle's show localized movement away from approaching airguns (Holst *et al*. 2005).

It is therefore reasonable to assume that marine turtles in the Study Areas would attempt to avoid the operating seismic vessel, thereby limiting their exposure to increased noise levels. Eckert *et al*. (1989) stated that the leatherback turtle can achieve a sustainable swimming speed of 3.6 km/hr.

The available evidence from the scientific literature suggests that sea turtles may show behavioural responses to an approaching airgun array at a received level of approximately 166 dB re 1 µPa(rms) and if avoidance behaviour is trigged at 176 dB re 1 µPa(0-p), the ramp-up procedure will provide sufficient time for turtles to move away from the source.

The Science Review Working Group, in their evaluation of two proposed seismic surveys near Cape Breton agreed that based on the limited knowledge of marine turtle response to sound; effects from seismic activities are likely to be sub-lethal, affecting fitness of exposed individuals only. MKI will ramp up for 30 minutes to allow for the marine turtle's swimming speed. Any avoidance behaviour caused by the Project is expected to be temporary and is not predicted to affect migration patterns and reproductive behaviour, particularly as the marine turtles found in the Study Area are considered migrants, with major breeding grounds located well to the south in the Caribbean. Survey activities are not expected to affect the distribution or abundance of marine turtle prey items (*e.g.,* jellyfish). The MKI geophysical surveys are, therefore, not predicted to result in a significant adverse effect on the foraging leatherback turtle population on the southern Newfoundland waters.

6.4.4.3 Accidental Events

Oil may affect marine turtles through dermal contact, inhalation or ingestion. This risk of such events occurring is very low. Potential impacts will be short-lived and confined to the surface water. No significant adverse effects are likely to occur as a result of an accidental event associated with this Project.

6.4.4.4 Cumulative Effects

DFO reviewed literature on lab and field studies of the effects of sound on marine organisms (DFO 2004b). Because sea turtles are visually and acoustically difficult to detect, the mitigation of observing to avoid is considered less effective than for marine mammals. However, the air source array will be shut down if a sea turtle is observed within 500 m of the seismic vessel (500 m from the vessel is more conservative than 500 m from the arrays, as the vessel is moving forward at approximately 4 to 5 kn). A trained Environmental Observer will keep records of marine turtles within visual range, weather permitting. Given the lack of systematic surveys for marine turtles in the Study Area, this opportunity for observation of marine turtles will add to the understanding of their distribution in the area and may provide additional insight into their behavioural response to seismic activities.

6.4.4.5 Monitoring and Follow-up

In general, because the sounds generated by seismic surveys are transient and do not "accumulate" in the environment, the most likely cumulative effects will be associated with other concurrent activities (*e.g.,* cargo ships, tankers, fishing and research vessels). Studies in the Gulf of Mexico showed that seismic surveys produce a relatively minor contribution to the overall underwater noise environment (MMS 2004). The cumulative effect is short term, intermittent and localized, and therefore, not significant with respect to affects on species at risk.

In general, the seismic survey vessel activity and noise will constitute a minor percentage contribution to the overall noise generated by other such sources and space-user conflict, and will be of short duration in local areas. Based on current knowledge, and especially with the proposed mitigation procedures in place, the proposed Project is not expected to result in or contribute to any significant cumulative impacts on sea turtles.

6.4.4.6 Summary

Table 6.5 summarizes potential interactions, environmental effects, mitigation, residual and cumulative effects on marine turtles from the geophysical surveys.

Table 6.5: Summary of Environmental Assessment for Marine Turtles

Interactions and Issues

- noise from seismic surveys
- entanglement and vessel cables

Impact Analysis

Potential interactions between marine turtles and the Project are expected to be adverse, but not significant, if at all, based on their transitory presence in the Study Area and tendency to avoid seismic operations. Ramp up procedures will also serve to further minimize direct effects on marine turtles. With the implementation of the recommended mitigation measures, the residual environmental effects of planned Project components on marine turtles are evaluated as not significant.

Mitigation

- A 30-minute ramp-up procedure will be implemented for seismic surveys
- Pre-survey for marine mammals or turtles.
- Air source s will be shut down if a Leatherback turtle is observed within 500 m.
- Ramping up will be delayed if a sea turtle is observed within 500 m.

Project Activity	**Magnitude**	**Geographic**	**Frequency**	**Duration**	**Reversibility**	**Ecological/Socio-Cultural and Economic Content**
Vessel Presence	0	1	3	3	R	2
2-D program	1	2	2	3	R	1
Accidental Spill	1	1	1	1	R	1

Significance of Effect

- Not adversely significant

Confidence

- High level of confidence based on previous seismic surveys, monitoring observations and research.

Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**
0=negligible 1=low 2=medium 3=high	1= 10s of metres 2= <500 m 3= 1-10 km 4= 10-50 km 5= >50 km	1= isolated 2= intermittent 3 = continuous	1=days 2=two weeks 3=one month 4=two months	R=reversible I=Irreversible

Ecological/Socio-cultural and Economic Context

1=Relatively pristine area or area not adversely affected by human activity

2=Evidence of existing adverse effects

6.5 EFFECTS ASSESSMENT - SPECIES AT RISK

SAR that may be found in and around the Project Area include marine fish, mammals, birds and sea turtles. These species are listed under SARA and/or have COSEWIC designations as well.

The assessment of environmental effects on SAR considers only those species that are listed on Schedule 1 of SARA, and designated as Endangered, Threatened, or Special Concern by COSEWIC, which are most likely to occur within the Study Area and thus will potentially interact with the Project. The effects of accidental events and cumulative effects (except potential vessel strikes to marine mammal species at risk, considered herein) are assessed below.

The Project will comply with SARA, which serves to protect listed species by prohibiting activities that may harm individuals or critical habitat.

There are three at risk bird species considered in this section, the Ivory Gull, Harlequin Duck and Barrow's Goldeneye. The Eskimo Curlew is likely extinct and the Recovery Strategy notes that scientists are not aware of the existence or location of any individuals of this species. Three fish SAR are known to or may occur in the Study Area (Atlantic Wolffish, Northern Wolffish, and Spotted Wolffish) and there are three marine mammals (North Atlantic Right Whale, Blue Whale, Fin Whale) and one reptile (Leatherback Turtle) SAR that are known to or may occur in the Study area:

6.5.1 Boundaries

Spatial boundaries for the assessment of potential environmental effects on SAR encompass the entire area within which interactions with the Project are likely to occur. These boundaries were established through consideration of the probable geographical extent of the environmental effects (i.e., the zone of influence) on the VEC and generally reflect the maximum area where Program-specific environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence.

Spatial boundaries may vary by species, but for SAR, boundaries are considered to be the spatial extent of the 2-D survey area (depending on the stage of the Project) plus an additional 30 km buffer.

Ecological spatial boundaries also vary between the noted SAR although it is recognized that most of these species have ranges beyond the Study Area:

- For marine bird SAR, the spatial boundary includes the breeding, nesting, foraging and overwintering habitat. There are no known nesting grounds for the Ivory Gull in the Study Area, and any presence in the area is expected to be incidental. Harlequin Duck uses the nearshore coastal waters and Gannet Island, thus there is limited potential for interaction with this Project. Observations of Barrow's Goldeneye have been documented at nearshore locations (although not in the Project footprint) and the species is reported to have a moulting site at Nain Bay. There therefore is limited potential for interaction with this Project.
- Wolffish eggs and larvae are demersal.
- The three species of cetaceans that are listed at risk occur in the Laurentian Channel and can be potentially affected by Project activities.
- Spatial distribution for sea turtles is vast and encompasses and extends into the southern Newfoundland waters. Leatherback turtles generally migrate between the

warm and cold waters seasonally, and are therefore likely to occur in the Study Area during the summer and fall months.

With respect to temporal boundaries, the potential interactions of concern are those related to the seismic activities that could occur at any time of year:

- The temporal boundaries of Harlequin Ducks occur largely during the moulting months. The timing of male and female moulting are not the same but do overlap with peak activity occurring from early July to late September and from late August to early October, respectively (Robertson and Goudie 1999). The presence of Ivory Gull and Barrow's Goldeneye in the Affected Area would be incidental and therefore there are no relevant temporal boundaries for this species.
- Spawning habitat for fish SAR is not known to occur in the Project Area.
- The temporal ecological boundaries for cetaceans vary according to species. Most cetaceans are migratory and occur predominantly during the summer and fall months (Reeves and Brown 1994), and thus may be in the Project Area during surveys.
- Sea turtles are likely to occur in the Project Area during the summer and fall months due to the timing of seasonal migrations.

Administrative boundaries for SAR include legal protection for wildlife species under SARA. SARA is a federal commitment to prevent Canadian indigenous wildlife species from becoming extirpated or extinct, to secure the necessary actions for their recovery, and to encourage wildlife management to prevent more species from becoming at-risk. COSEWIC ranks species according to conservation concern. Schedule 1 of SARA, which is the official list of wildlife species at risk in Canada, includes species that are extirpated (locally extinct), endangered, threatened, or of special concern (DFO 2009)

Once added to Schedule 1, species (and their critical habitats) are afforded legal protection and recovery measures are developed and implemented. Under SARA, it is an offence to:

- kill, harm, harass, capture or take an individual of a listed species that is extirpated, endangered or threatened;
- possess, collect, buy, sell or trade an individual of a listed species that is extirpated, endangered or threatened, or its part or derivative; and
- damage or destroy the residence of one or more individuals of a listed endangered or threatened species or of a listed extirpated species if a recovery strategy has recommended its reintroduction.

The boundaries of the critical habitat for each species are defined in species recovery strategies, action plans and management plans. Currently, recovery strategies and/or management plans are in place for the following species:

- Eskimo Curlew (determined to be not feasible);
- Harlequin Duck (eastern population in Atlantic Canada and Quebec) (Management Plan);
- Ivory Gull (for Northwest Territories, Nunavut, Newfoundland and Labrador);
- All three species of wolffish (Management Plan for Atlantic Wolffish);

- Blue Whale (Northwest Atlantic population) (finalized December 2009);
- North Atlantic Right Whale (Atlantic Ocean); and
- Leatherback turtle (Atlantic Ocean).

Marine mammals and fish, including those species designated at risk, are further protected in Canada through federal legislation under the *Fisheries Act*. Amongst other things, the *Fisheries Act* mandates no harmful alteration, disruption or destruction of fish habitat (Section 35; administered by DFO). Marine mammals are included in the definition of fish under the Act. Furthermore, the Marine Mammal Regulations under the *Fisheries Act* stipulate, "No person shall disturb a marine mammal except when fishing or marine mammals under the authority of these regulations".

Marine birds are protected federally under the MBCA, which is administered by Environment Canada.

Technical boundaries relate to limitations of available data for SAR within the Study Area as well as limits to scientific knowledge (including effects of seismic operations on marine species). Marine mammal and sea turtle distribution can be unpredictable, and the majority of available information on marine mammals and sea turtles relates to a very broad regional scale. Detailed data characterizing the existing environment for marine mammals and sea turtles on the Labrador Shelf are somewhat limited. Still, many of the species have similar limiting factors (*e.g.,* vulnerability to ship strikes and anthropogenic noise), such that mitigation procedures for more well-known species may provide protection for species that are data deficient.

6.5.2 Potential Issues

Potential interactions between Project activities and SAR relate primarily to behavioural and physiological effects associated with air source operations and oiling for an accidental release of hydrocarbons. These disturbances may lead to the following effects:

- direct physical effects associated with seismic noise;
- behavioural effects associated with seismic noise and electromagnetic field;
- auditory and communication masking by seismic noise in fish, marine mammals and sea turtles; and
- physical effects from oiling, particularly marine birds.

With the exception of the Ivory Gull, it is unlikely that the bird SAR will interact with the Project, as the species are found either in rivers (Harlequin Duck), along shorelines (Barrows Goldeneye) or are believed to be extirpated (Eskimo Curlew). Potential interactions for the Ivory Gull include are associated with operation of the seismic survey vessels and vessel traffic, including attraction to vessel lighting and to vessels through the discard of organic waste, noise and lights, and oiling.

Potential interactions for fish SAR include effects of noise from all routine activities (vessels, helicopters, seismic array, sounder, side-scan sonar, boomer, etc.). Environmental effects of seismic acquisition on marine fish SAR could potentially result in an environmental effect of concern, even with mitigation. Therefore, the potential environmental effects of seismic acquisition on these species are the primary focus of this environmental assessment and are discussed in detail later in this section.

Maine mammal and sea turtle interactions are also possible. Potential interactions include effects from collisions with vessels; effects associated with the presence of vessel lights; and effects of noise from all routine activities (vessels, helicopters, seismic array, sounder, side-scan sonar, boomer, etc.).

6.5.3 Significance Criteria

A significant, adverse environmental effect is one that, after application of all feasible mitigation and consideration of all reasonable Project alternatives:

- will prevent the achievement of self-sustaining population objectives or recovery goals;
- will result in exceedance of applicable allowable harm assessments; and
- for which an incidental harm permit would not likely be issued.

Due to the sensitive nature of SAR, residual adverse effects on one individual may be considered significant; and/or will result in species being permanently displaced from critical habitat.

A non-significant, adverse environmental effect is one that, after application of all feasible mitigation and consideration of all reasonable Project alternatives:

- results in threats to individuals, residences or critical habitat of listed species that does not jeopardize the survival or recovery of the species;
- does not result in exceedance of applicable allowable harm assessments; and/or
- for which an incidental harm permit would likely be issued.

6.5.4 Effects Assessment and Mitigation

Potential effects on SAR are discussed above in Section 6.1 (for marine and migratory birds), Section 6.2 (for marine fish), Section 6.3 (for marine mammals) and Section 6.4 (for sea turtles). Recovery plans for the SAR that may or do occur in the Affected Area are discussed below with respect to mitigation measures applied to the Project.

6.5.4.1 Bird Species at Risk

The Ivory Gull is very vulnerable to any type of disturbance at certain times of the breeding season. They may abandon eggs if approached. The Ivory Gull breeds in high-Arctic coastal areas with permanent pack ice and open water and winters primarily in Arctic seas, though may be seen along the Atlantic coast to New York (COSEWIC 2006). There are no known nesting grounds for the Ivory Gull in the Study Area, and any presence in the area are expected to be incidental.

The threat level to the eastern Harlequin Duck varies across its range with the more northern breeders generally faced with fewer threats during the breeding season than the eastern North.

America wintering population that breeds, by and large, in southern Labrador, the Gaspé Peninsula of Québec, the Québec North Shore, insular Newfoundland, and northern New Brunswick (Environment Canada 2007). Additionally, some individual Harlequin Ducks may cross through northern and southern sections of the species' range within any given year. As a result, it is difficult to assign threat severity without assessing all occupied regions for each specific threat. The most significant threat to the North American wintering population of Harlequin Duck in eastern Canada is the potential for oil contamination. This type of a spill in magnitude and location is unlikely to occur during Project activities and therefore potential impacts to the species is expected to be negligible.

6.5.4.2 Fish Species at Risk

Potential impacts of vessel traffic on the three species of wolffishes have been identified in the 'Recovery Strategy for the Northern Wolffish (*Anarhichas denticulatus*) and Spotted Wolffish (*Anarhichas minor*)', and Management Plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada' (Kulka *et al*. 2007), respectively. Areas of concern and mitigation measures are addressed below.

The recovery strategies for Northern and Spotted wolffishes state that: "Impact of incidental capture of wolffish in many fisheries is thought to be the leading cause of human induced mortality. However, the live release of spotted and northern wolffish mitigates the affect of incidental capture to some degree". Other potential sources of harm (habitat alteration, oil exploration and production, pollution, shipping, cables and lines, military activities, ecotourism and scientific research) are considered to have negligible impacts on the ability of both spotted and northern wolffish to survive and recover (DFO 2004b).

Effects of auditory masking on fish are discussed in detail in Section 6.2.7. The proposed seismic surveys are not expected to cause long-term or permanent displacement of any listed species from critical habitat or other preferred habitat nor result in destruction or adverse modification of critical or essential fish habitat.

Overall, potential impacts to fish SAR will be negligible most of the time with occasional impacts being potentially adverse but not significant.

6.5.4.3 Marine Mammals at Risk

Several potential impacts of vessel traffic and noise on North Atlantic right whales have been identified in the recovery strategy for this species (COSEWIC 2003). Vessel collisions, noise disturbance and habitat degradation have been identified as three of the main threats to North Atlantic right whale recovery. To mitigate these potential risks, vessels will gradually increase the intensity of the air source discharge to allow time for whales to avoid the sound. In addition, a qualified offshore Environmental Observer from the vessel will be assigned to look for evidence of north Atlantic right whales (*i.e.,* whale footprints, surfacing) in the vicinity of the vessel. In the event of this species' presence within the 500 m zone, the vessel will cease seismic activity and take appropriate measures to avoid collision. Vessel operations will only commence when North Atlantic right whales are outside a 500 m safety radius of the seismic activity.

Entanglement with fishing gear is a well-documented and publicized impact on the North Atlantic right whale. No fishing gear will be aboard the vessel, therefore, no mitigation measures are required. There are no records of marine mammals becoming entangled in seismic arrays or hydrophone cables.

Petroleum spills are potentially a threat to North Atlantic right whale recovery. Minimal amounts of oil will be aboard the seismic vessel. Potential oil spillage may occur from ballast and bilge water discharge but will be regulated to ensure that oil concentrations in the discharge do not exceed 15 mg/L as required by the MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships 1972, and the Protocol of 1978 related thereto), International Maritime Organization and OWTG. Any accidental spills will be reported to the C-NLOPB immediately.

Marine noise is a highly emotive issue as it affects cetaceans (large marine mammals, such as whales, dolphins and porpoises). Initial studies have established that noise generated from offshore operations present a low risk to marine life, but due to a lack of data for sensitive species, this statement cannot be adequately defined in all cases.

In the proposed recovery strategy for the Blue Whale (COSEWIC 2002) seismic noise is considered a high risk threat to blue whale recovery and vessel collision as a medium risk threat. The potential effects of noise have been discussed at length. Large vessels traveling between 8.6 and 15 knots, such as container ships and other large vessels (i.e., measuring 80 m long and more), have been found to be the principal source of severe or fatal injuries for large whales. The recommended recovery approaches to meet recovery objectives for noise and collision include:

- implementation of adequate mitigation measures for all inshore and offshore projects within the range of the Bue Whale;
- minimize Blue Whale exposure to vessel noise and risk of collisions; and
- raise awareness in the marine shipping industry and on large cruise vessels of their negative impact on the Blue Whale population.

Performance measures for noise and collision include:

- percentage of noise reduction from anthropogenic sources (*e.g.,* seismic exploration, military operations, explosions, drilling) within the Canadian portion of the range;
- boats will use shipping lanes in the Gulf of the St. Lawrence and off the North American coast to reduce impact on Blue Whales; and
- identification of target audiences and carrying out of appropriate activities to raise awareness.

There are no documented cases of marine mammal mortality from exposure to seismic sounds and DFO (2004b) considers it unlikely that mammal mortality would be caused by seismic sound exposure.

The potential effects from vessels on marine mammals include strikes, temporary behavioural (aversion or attraction) effects, and effects from vessel noise. The physical presence of the vessel during seismic surveys does not typically result in significant adverse effects. Marine species, in particular marine mammals, are expected to easily avoid the vessel during seismic surveys due to exhibited avoidance behaviour to noise and the slow speed of the ship. The survey vessel will likely travel at an average speed of 4.5 kn when the survey gear is deployed and will increase to approximately 10 km while in transit. While the potential for collision exists, collision events are predicted to be unlikely, the presence of Environmental Observers will further mitigate vessel and whale collisions. Collision with an endangered species would be considered significant; however, since there are no records of collision between the listed species at risk and seismic vessels, the probability of occurrence is considered low.

6.5.4.4 Sea Turtle Species at Risk

Several potential impacts of vessel traffic on leatherback turtles have been identified in the 'Recovery Strategy for the Leatherback Turtle (*Dermochelys coriacea*) in Atlantic Canada' (ALRT 2006). Areas of concern related to vessel traffic and mitigation measures are addressed below.

There is some risk to marine turtles from collision with seismic vessels. As they are submerged for the most part and may avoid seismic arrays, the risk of mortality or serious injury is anticipated to be low (MMS 2004). Environmental observers have not noted the presence of marine turtles during seismic surveys; however, visual monitoring provides limited mitigation due to the low profile of marine turtles in the water, limited surface time, and solitary nature at sea.

Physical harm is expected to be mitigated by using ramp-up or soft-start procedures which will encourage whales to move from the area prior to physical effects occurring. The *Statement of Canadian Practice for Mitigation of Seismic Noise in the Marine Environment* for ramp-up and shut down of the air sleeves will be closely followed to avoid death, harm or harassment of individuals of sea turtles listed under *SARA*. Specifically, the ramp-up of the air sleeve to seismic survey capacity will occur over a 20- to 40-minute period to initiate a behavioural avoidance response in sea turtles whereby they will leave the Project Study Area prior to experiencing hearing damage.

MKI will make the necessary arrangements to ensure that a qualified Environmental Observer will be on board the survey vessel at all times during the survey period. The observer will conduct continuous monitoring for sea turtles for 30 minutes prior to start-up of the seismic array. Should any sea turtle be observed in a 500-m zone from the centre of the seismic source array, start-up will be delayed until the animal has not been observed for 30 minutes. The survey will also shut down should the observer detect a turtle within 500 m from the centre of the seismic source array.

6.5.5 Cumulative Effects

Seismic vessel activity is a minor component of total marine transportation. Compared with the multitude of commercial tanker, cargo ships, research vessels, coastal ferries, and fishing vessels in the vicinity of the coast of Labrador, the additional vessel activity from the survey is negligible and cumulative impacts on species at risk are not significant.

In general, because the sounds generated by seismic surveys are transient and do not "accumulate" in the environment, the most likely cumulative effects will be associated with other concurrent activities (*e.g.*, cargo ships, tankers, fishing vessels). Studies in the Gulf of Mexico showed that seismic surveys produce a relatively minor contribution to the overall underwater noise environment (MMS 2004). The cumulative effect is short term, intermittent and localised, and therefore, not significant with respect to affects on species at risk.

If other seismic surveys are being conducted off Labrador within the proposed timeframe, a significant distance between surveys exists to prevent both operational conflict and acoustical interference; however; migratory species may be affected as they pass by them. Such species are capable of avoiding the ensonified areas to prevent harmful and disruptive effects.

In general, the seismic survey vessel activity and noise will constitute a minor percentage contribution to the overall noise generated by other such sources and space-user conflict, and will be of short duration in local areas. Based on current knowledge, and especially with the proposed mitigation procedures in place, the proposed Project is not expected to result in or contribute to any significant cumulative impacts on species at risk.

6.5.6 Monitoring and Follow-up

Monitoring of species at risk is the same as for unlisted species discussed in the appropriate VEC sections above.

6.5.7 Summary

A summary of potential interactions, environmental effects, mitigation, and cumulative and residual environmental effects is provided in below.

Table 6.6: Summary of Environmental Assessment for Species at Risk

Interactions and Issues

- Direct physical effects associated with seismic noise (*e.g.,* auditory damage, egg and larval mortality).
- Behavioural effects associated with seismic noise (*e.g.,* avoidance, changes in migration, reproduction and feeding).
- Communication masking by seismic noise in fish and mammals (*e.g.,* during spawning/mating, feeding, etc.).
- Disturbance from vessel noise and lights.

Impact Analysis

Seismic activities may potentially impact wolffish recovery in Atlantic Canada; however, no evidence is documented to support the claim that seismic activity results in serious or irreversible harm exists. Nonetheless, mitigation measures will include a gradual increase in intensity of air gun discharge to allow fish to avoid the source of the sound, public notices to alert fishers of the seismic activity, and avoidance of seismic activities during known sensitive areas and timeframes. The Project is unlikely to result in population level effects on that fish species at risk based on scientific research to date. Behavioural effects on fish and spawning fish have been discussed above in detail.

Potential adverse environmental effects on species at risk will be unlikely because of planned monitoring and mitigation measures. In addition, species at risk are expected to show some avoidance of the areas of highest received levels of seismic sounds. Therefore, there is not likely to be a significant adverse environment effect on species at risk.

Mitigation

- Adherence to the *Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment* to the extent reasonably practical.
- A 500-m safety zone monitoring program for whale species at risk during survey data acquisition will be implemented.
- A dedicated Environmental Observer will be onboard the seismic vessel. If a concentration of marine mammals is observed in a particular area, the survey can shift to another part of the Study Area until the concentration has moved away.
- To minimize sudden changes in noise levels, a ramp up procedure will be implemented.
- Collision avoidance practices, including constant speed and course maintained by seismic vessels.
- Compliance with OWTG (NEB *et al.* 2002) for all discharges.
- Avoidance of bird colonies

Project Activity	**Magnitude**	**Geographic**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Content**
Vessel Presence	0	1	3	3	R	2
2-D program	1	4	2	3	R	1
Accidental Spill	1	2	1	1	R	2

Significance of Effect

- Not adversely significant

Confidence

• High level of confidence based on previous seismic surveys, monitoring observations and research.				
Magnitude 0=negligible 1=low 2=medium 3=high	**Geographic Extent** 1= 10s of metres 2= <500 m 3= 1-10 km 4= 10-50 km 5= >50 km	**Frequency** 1= isolated 2= intermittent 3 = continuous	**Duration** 1=days 2=two weeks 3=one month 4=two months	**Reversibility** R=reversible I=Irreversible
Ecological/Socio-cultural and Economic Context 1=Relatively pristine area or area not adversely affected by human activity 2=Evidence of existing adverse effects				

6.6 EFFECTS ASSESSMENT - SENSITIVE AREAS

Sensitive areas include important or critical habitat that may be affected by the Project, or areas that have special conservation status by law. There are a number of sensitive areas occurring in the vicinity of the Study Area. These include

- Nain Bight and Hamilton Inlet (NMCA);
- Torngat Mountains National Park (National Park/Historic Site);
- Battle Harbour National Historic District (National Park/Historic Site);
- Mealy Mountains National Park (proposed) (National Park/Historic Site);
- Gannet Islands Ecological Reserve; and
- IBAs.

6.6.1 Boundaries

Navigation of the seismic vessel for turning purposes will be a minimum of 10 km distance. There will be no excursions of approach into IBAs or NMCAs.

With respect to temporal boundaries, the potential interaction of concern is related to fish, turtle and cetacean migrations.

With regards to administrative boundaries, Parks Canada is responsible for NMCA’s, while Environment Canada/CWS is responsible for the protection of birds.

6.6.2 Potential Issues

The potential issue is direct effects to protected or special areas in the coastal environment and their ecosystems.

6.6.3 Significance Criteria

A significant adverse environmental effect for sensitive areas is one that disturbs, damages, destroys or removes any living marine organism or any part of its habitat. Disturbance, damage and destruction for the purpose of this EA includes:

- an alteration of critical or essential habitat physically, chemically or biologically, in quality or extent, to such a degree that there is a measurable decline in species diversity;

- mortality or serious injury to individuals of a SAR;
- the abundance of one or more non-listed species is reduced to a level from which recovery of the population is uncertain or more than one season would be required for a locally depleted population or altered community to be restored to pre-event conditions;
- impairment of ecosystem functioning; and/or
- long-term or permanent displacement of any species from critical habitats.

A non-significant adverse environmental effect is one that does not meet the criteria for disturbance or damage to habitat within the sensitive areas.

6.6.4 Effects Assessment and Mitigation

The most northerly boundary of the Study Area is located about 30 km from the coastline. There is no approach to birds nesting colonies or the coastline. There will therefore, be no interaction with coastal special areas for routine activities and no mitigative measures required.

The impacts of oil on birds have been well documented (*e.g.,* Hartung 1995); however, no oil from discharge is expected to occur and thus, should not have any severe adverse effects of avifauna. Discharge from vessels will be standard for any marine vessel and will follow Offshore Waste Treatment Guidelines (OWTG) (NEB et al. 2002). Potential oil spillage may occur from ballast and bilge water discharge, however, if oil is suspected to be in the water, it will be tested and if necessary, treated using an oil/water separator to ensure that oil concentrations in the discharge do not exceed 15 mg/L as required by the MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships 1972, and the Protocol of 1978 related thereto), International Maritime Organization and OWTG.

Although the Affected Area may overlap slightly with two NMCAs (Nain Bank and Hamilton Bank), no seismic surveys will take place within the boundaries. The vessel presence will not be cumulative to the current activity of marine traffic.

Vessel Presence

The short term presence of the various seismic related vessels, ranging from 60 to 90 m in length, in the sensitive areas identified will be negligible compared to the daily and regular year round marine traffic currently experienced in the Study and Regional Areas.

There will be no approach by vessels to bird nesting colonies or the potential NCMAs, and hence no interaction with critical coastal habitats from routine activities.

The effect of vessel presence was assessed previously. The risk to fish, marine bird and migratory birds, marine mammals and sea turtles in the sensitive areas is anticipated to be negligible to low, as these animal groups are somewhat acclimated and accustomed to marine vessel traffic of ferries, commercial vessels and fishing vessels.

6.6.5 Noise Emissions

Seismic noise from air gun sources from will not alter critical or essential seafloor habitat or prey sources and supply for Atlantic wolfish, seafloor habitat in general or sea turtle food sources in sensitive areas.

The seismic surveys will not alter the physical or chemical nature of the sensitive areas that result in marine animal aggregations for spawning, calving or feeding.

6.6.6 Cumulative Effects

Marine traffic from seismic surveys does not impinge physically on the seafloor habitat, therefore, no cumulative effects from this Project are likely.

There are potential issues with the discharge of oil and oily waste from all manner of marine traffic on the shoreline and marine species. The seismic vessels will comply with OWTG and MARPOL regulations with respect to onboard petroleum hydrocarbons.

Overall, there are no cumulative effects of this Project expected to occur on the sensitive areas inside or outside the Study Area.

6.6.7 Monitoring and Follow-up

Sensitive areas are categorized by the species they support as well as critical habitat. Follow-up and monitoring for those VECS are discussed in detail in other appropriate sections of this assessment. Habitat is not altered by seismic activity.

6.6.8 Summary

A summary of potential impacts, mitigation, residual and cumulative environmental effects is provided below for routine Project activities and accidental events on sensitive areas.

Table 6.7: Summary of Environmental Assessment for Sensitive Areas

Interactions and Issues

- Direct effects to protected or special areas in the coastal environment and their ecosystems

Impact Analysis

- Seismic surveys do not alter the seafloor habitat or coastal areas
- Seismic surveys will not alter the physical or chemical nature of the sensitive areas

Mitigation

- Vessel compliant with audit prior to survey.
- Compliance with OWTG (NEB *et al.* 2002) for maintenance issues and MARPOL (bilge) for all discharges.
- Avoidance of bird colonies by vessel.
- Seismic vessel will have an oil spill prevention program and Oil Spill Response Plan

Project Activity	**Magnitude**	**Geographic**	**Frequency**	**Duration**	**Reversibility**	**Ecological/Socio-Cultural and Economic Content**
Vessel Presence/Lights	1	3	3	4	R	2
2-D programme	1	2	2	3	R	2
Accidental Spill	1	3	1	1	R	2

Significance of Effect

- Not adversely significant

Confidence

- High level of confidence based on previous seismic surveys, monitoring observations and research.

Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**
0=negligible	1= 10s of metres	1= isolated	1=days	R=reversible
1=low	2= <500 m	2= intermittent	2=two weeks	I=Irreversible
2=medium	3= 1-10 km	3 = continuous	3=one month	
3=high	4= 10-50 km		4=two months	
	5= >50 km			

Ecological/Socio-cultural and Economic Context

1 Relatively pristine area or area not adversely affected by human activity
2 Evidence of existing adverse effects

6.7 TRADITIONAL AND COMMERCIAL FISHERIES AND SURVEYS

It is extremely important to the Nunatsiavut Government that the aboriginal fisheries, both offshore and nearshore, are not disturbed or adversely affected by the proposed seismic program in 2011 to 2013. The area proposed for seismic activity is important the Nunatsiavut fishery and may become more important in the future.

Commercial fisheries are important to the economy of Newfoundland and Labrador and considered a VEC for this assessment due to potential interactions between the seismic vessel and fishing gear and vessels. The potential effect of underwater noise on the catchability of fish is also assessed. This impact analysis also considers potential impacts on DFO research/industry surveys.

6.7.1 Boundaries

The boundary of the interaction with other users (traditional and commercial fisheries, scientific surveys) includes primarily the exclusion area surrounding the working sites, although activity of other users within the Study Area has been considered.

With respect to temporal boundaries, the potential interactions of concern are those related to the exploration seismic activities that are planned to occur intermittently between July and November in 2011 to 2013.

With regard to administrative boundaries, NAFO and DFO manages the fisheries resources in the area and is DFO primarily responsible for scientific surveys within the area.

The technical boundaries, and the information available for this study, vary according to location of the fisheries. Georeferencing of catch is inconsistent and does not exist for inshore (coastal) fisheries and is sporadic at best for midshore fisheries, and the further offshore fisheries data are incomplete for 2010.

6.7.2 Potential Interactions and Issues

The seismic survey vessel and Project-related support vessel traffic will be present within 2G, 2H, 2J, 3K, 0B, and 1F. Conflict with harvesting activities and fishing gear was raised as a potential issue during the consultations with fishers for this assessment. There is potential for interference from seismic activities with DFO activities and catch success. Seismic streamers and vessels can conflict with and damage fishing gear, particularly fixed gear, and such conflicts typically occur three or four times a season in Atlantic Canada. Potential interactions between the Project and commercial fisheries relate primarily to:

- Behavioural changes in target species in relation to catchability;
- Conflict with harvesting activities/fishing gear; and
- Potential interaction with DFO surveys.

6.7.3 Significance Criteria and Evaluation

A significant adverse environmental effect on commercial fisheries is defined as one that:

- excludes fishers from using 10% or more of the fishable area for the targeted species for all or most of the fishing season; and/or
- 10% of more fishers are excluded from the fishable area of the targeted species for all or most of the fishing season; and/or
- results in erroneous survey data, as a result of effects on 10% of the target marine fish populations; and/or
- causes damage to fishing gear or vessels.

A non-significant adverse environmental effect on commercial fisheries is defined as one that:

- excludes fishers from using less than 10% of the fishable area for the targeted species for all or most of the season; and/or
- less than 10% of fishers are excluded from a targeted species fishable area for all or most of the fishing season; and/or

- results in a reduction in profits due to a decrease in catchability of target species in less than 10% of the fishable area for the targeted species.

6.7.4 Effects Assessment and Mitigation

6.7.4.1 Vessel Presence

Traditional and commercial fish harvesting activities occur throughout the July to November survey period being assessed, although the timing of specific fisheries varies. Of these, the fixed gear: long-line fishery, gill net fishery and pot fishery for snow crab pose the highest potential for interaction conflict, particularly if they are concurrent with seismic survey operations. For the 2-D program, the seismic vessel will operate intermittently on a 24 hour basis period for a 40 to 60 day.

Because of the length of equipment towed behind the survey vessel, their maneuverability is restricted and other vessels must give way. Also, as noted in the project description, the turning radius, between each track line extends the assessment area beyond the 2-D survey grid. Therefore, fixed gear has the potential for entanglement with seismic gear.

Depending on the scheduling of surveys, moderate to concentrated fisheries activity is expected within the assessment period. Operation of the seismic survey vessel and associated support vessels may overlap with most groundfish and shrimp fisheries from Pelagic fisheries are mainly inshore. The DFO RV surveys should be concluded prior to the 2-D seismic surveys and or well outside the area.

Aboriginal fishing industry representatives agree that the best way to mitigate potential conflicts at sea is through good communications and information exchange. This will require careful plotting and monitoring of gear locations so they can be avoided, as well as radio communication (via the on-board Fisheries Liaison Observer) with fishers in the area. There will also be a scout vessel preceding 2-D programs to look for gear and obstructions. Also, Notice to Shipping and the CBC Fisheries Broadcast will be provided during the survey program. This is a mitigation measure that liaison personnel for the survey operator have employed successfully in the past. During the survey, information about the seismic program will be relayed using established communications venues, such as the Notice to Mariners, and CBC's Radio's Fisheries Broadcast, as well as direct communications between the survey vessel and fishing craft via regular VHF marine channels. MKI will also communicate, through its dedicated Fisheries Liaison Observer, with fishers at sea during the survey, to exchange information about gear and planned fishing activities, and to identify specific locations of vessels and any fixed gear that they have deployed. This is key for avoiding interactions and promoting good communications.

Preventing any potential impact will be achieved through the exchange of information with industry participants. Because the fisheries are dynamic, there will be an annual review of catch effort data with industry representatives in the local communities. . MKI is committed to ongoing Aboriginal stakeholder relations and will include all interested communities and organisation that developed from the engagement meetings to be kept informed of all program developments and future surveys. In addition, communications with relevant DFO contacts will be utilized. MKI will keep affected parties informed about their plans and schedule. These measures will minimize interference with RV surveys, DFO sentinel fisheries research and commercial fishing activities.

MKI will review this program with the FFAW through the Petroleum Liaison and FFAW representatives and will make the necessary arrangements to ensure that a qualified Fisheries Liaison Observer is onboard the survey vessel at all times during the survey periods. MKI is open to including trained members of the Aboriginal and First Nation communities in this role.

The Operator will arrange for the services of a Single Point of Contact (SPOC) with the fisheries industry. The SPOC role will include updating vessel personnel (i.e. the FLO, the Captain, and the Party Manager) about known fishing activities in the area, and will relay relevant information from Fisheries and Oceans Canada.

If survey operations inadvertently damage fishing gear or vessels, the MKI will implement their compensation plan to provide appropriate and timely compensation to affected fisheries. This compensation plan is provided in the Environmental Management System. This will be consistent with the C-NLOPB Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity (March 2002).

6.7.4.2 Noise Emissions

Potential effects on marine fish behaviour were assessed in Section 5.0. While adult fish could be injured by seismic arrays if they are within a few metres of an air source, this is not likely to happen as most fish disperse when the array ramps up and becomes active, or when the vessel approaches (McCauley *et al*. 2003). Thus, the most likely type of impacts will be on fish behaviour. Seismic surveys can result in reduced trawl and longline catches immediately following a survey as the fish temporarily move from the area. There are various research studies on this subject (*e.g.,* Chapman and Hawkins 1969; Skalski *et al*. 1992; Turnpenny and Nedwell 1994; Engas *et al*. 1996). Although all indicated some impacts on fish behaviour, they reached different conclusions about the duration of the change in behaviour and/or the degree of the effect on catch. For instance, Engas *et al*. (1996) suggest that fishing for some gear types in the Barents Sea did not return to normal for approximately a week after sound exposure, although the study conducted by Engas *et al*. (1996) is the only one to report effects over a large area and to show no recovery in catches (Davis *et al*. 1998).

On the St. Pierre Bank in 1999, a trawler reported experiencing decreased trawl catches after a seismic vessel began surveying in the area. The captain of a National Sea Products fishing vessel reported that, on one occasion, catch dropped from 25,000-30,000 pounds per tow, to several thousand pounds per tow, after the seismic vessel began recording. About one day later, the catch rate appeared to have returned to pre-recording levels. Fish brought to the surface in the trawl after seismic began, however, seemed more active. They also reported that after recording started, aggregations of fish were seen on the sounder, but could not be caught (Thompson *et al*. 2000b).

In other instances, specific seismic surveys were not observed to have caused impacts on catches. For example, nearshore and shallow water seismic surveys in Port au Port Bay and

Bay St. George, Newfoundland in 1995 and 1996 were not reported to affect catches of snow crab and other fisheries (CEF 2002). McCauley *et al*. (2000) observed a return to normal behaviour patterns for some caged finfish within 14 to 30 minutes of the array ceasing. There are a number of reasons why studies may have reached different conclusions about the impacts of seismic noise on fish behaviour, including possible differences in species response, differences in the receiving environments (depth, seabed formations), as well as the different experimental methodologies used. Payne *et al* (2008) commented that some attention should also be given to the potential for chronic effects during surveys that may last some weeks. However, regarding animal behavior and ambient noise in the ocean, the constant cacophony of noise associated with ships could be of much greater importance than seismic sounds.

Effects on groundfish catchability are anticipated to be within 18 km of the seismic vessel for a 24-hour period following air source emissions. These 2-D surveys are operational 30 to 40% of the time, thus there is time for recovery of catch rates. For example, a 40 to 60 day seismic program may not be operational for the whole time. Approximately 24 hours after air source emissions cease, catch rates within 18 km of the seismic vessel are expected to recover. During a seismic program, it is therefore expected that fishing could occur. Based on catch data for 2005 to 2009, March to September are the months with the highest potential to affect commercial groundfish catchability. As commercial catches are quota based, the overlap between fishing and seismic activity is unknown, but will be determined prior to the commencement of the surveys. The effects of seismic surveys on the catchability of fish were predicted to be minor, sub-local, short-term and likely to occur.

6.7.4.3 Follow-up and Monitoring

Ongoing communications during the survey period, through the avenues described, will be instrumental in minimising Project effects on commercial fisheries. A Fisheries Liaison Observer onboard the seismic vessel will play a large role in communications with fishing vessels to help avoid potential conflicts at sea. MKI will also work collaboratively on the operational issues associated with the survey with the Petroleum Liason. Another important follow-up aspect will require scheduling of survey lines to avoid as much as possible areas where fisheries are active. The Fisheries Liaison Observer will document any contact with fishing vessels (including those outside the Study Area), including the date and time, their location, and any action which may have been taken to avoid a potential conflict. Key shore-based personnel will monitor the progress of key fisheries and completion of quotas in the Study Area to facilitate line scheduling.

6.7.4.4 Cumulative Effects

Seismic vessels activity is considered a minor component of marine transportation. A single geophysical survey in any year from July to November in 2011 to 2013, is minor compared with the thousands of commercial tanker, cargo ships, research vessels, cruise ships, and fishing vessels trips in the vicinity of Labrador. The additional vessel activity from the survey is negligible compared to the other vessels and cumulative impacts on species at risk are not significant.

None of the proposed seismic surveys will result in population level effects on fish. Therefore, no cumulative effect on fish harvesting that fish and shellfish populations currently and historically experience will result from this Project. Any potential short-term behavioural effects of fish will be reversible and are unlikely to be cumulative to harvesting or other marine traffic. Harvesting is not likely to result in behavioural effects similar to those observed from seismic activity.

In general, because the sounds generated by seismic surveys are transient and do not "accumulate" in the environment, the most likely cumulative effects will be associated with other concurrent activities (*e.g.,* cargo ships, tankers, and fishing vessels). Studies in the Gulf of Mexico showed that seismic surveys produce a relatively minor contribution to the overall underwater noise environment (MMS 2004). The cumulative effect is short term, intermittent and localized, and therefore, not significant with respect to affects on commercial fisheries or scientific research surveys.

6.7.4.5 Summary

A summary of potential interactions, effects, mitigation, residual and cumulative environmental effects is provided in Table 6.8.

Table 6.8: Summary of Environmental Assessment for Commercial Fisheries

Interactions and Issues

- Presence of seismic vessel causing loss of access to fishing grounds and/or potential gear interaction.
- Noise from seismic recording causing behavioural changes resulting in reduced short-term catchability.
- Interaction with DFO and industry surveys and commercial fisheries.

Impact Analysis

Potential adverse environmental effects on commercial fisheries will be mitigated through the implementation of various proven mitigative measures, including: enhanced communications with fishing industry representatives and individual fishing vessels; use of a Fisheries Liaison Observer; monitoring of gear locations and research survey locations; scheduling of survey lines to minimize potential conflicts with harvesting and research activities; and, as required, implementation of a gear and vessel damage compensation contingency plan.

Mitigation

- Communication with fishing industry representatives, Petroleum Liaison, and DFO
- Avoidance of fishing gear through communication tools; Notice to Shipping, CBC Fisheries Broadcast
- Notice to Mariners on the location and scheduling of seismic activities
- Dedicated FLO onboard
- Developed communication mechanisms with the fishing industry programs; and
- Compliance with C-NLOPB guidelines respecting compensation.

Project Activity	**Magnitude**	**Geographic**	**Frequency**	**Duration**	**Reversibility**	**Ecological/Socio-Cultural and Economic Content**
Vessel Presence/Lights	1	3	3	3	R	2
2-D program	1	3	2	3	R	2
3-D program	1	3	2	4	R	2
Well Site Survey	1	3	2	2	R	2

VSP Survey	1	3	2	1	R	2
Accidental Spill	1	3	1	1	R	2

Significance of Effect

- Not adversely significant

Confidence

- High level of confidence based on previous seismic surveys, monitoring observations and research.

Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**
0=negligible 1=low 2=medium 3=high	1= 10s of metres 2= <500 m 3= 1-10 km 4= 10-50 km 5= >50 km	1= isolated 2= intermittent 3 = continuous	1=days 2=two weeks 3=one month 4=two months	R=reversible I=Irreversible

Ecological/Socio-cultural and Economic Context

1-Relatively pristine area or area not adversely affected by human activity
2 -Evidence of existing adverse effects

7.0 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

Sea and ice conditions are the primary sources of potential effects of the environment on the project. If sea states exceed a Beaufort wind scale value of 5, with sea waves in excess of 3-4 metres in height, seismic activity cannot take place. Additionally, if pack-ice is covering the proposed survey area, no seismic data can be acquired in that region and another; ice-free survey area must be visited.

8.0 SUMMARIES AND CONCLUSIONS

8.1 Zones of Influence

The EA Report includes prediction of sound levels off vertical based on spherical and cylindrical spreading transmission loss at various distances from the array source over water depths in the Study Area. Table 6.9 presents a summary of observed effects on marine animals from sound levels and the distances those effects could be exhibited from the Project at 45° and 0° from horizon (both crossline and inline). There are no underwater sound level criteria for marine birds.

Table 8.1: Predicted Zones of Influence and Direct and Indirect Effects on Marine Species Expected in the Study and Regional Areas at 0° and 45° Angles of Emission

Species	Effects	Sound Level (RMS)	Predicted Distance From Source Over 300 to 3000 m Water Depth	
			45º	0º Off Horizon
marine fish	startle	156 dB re 1µPa	1 km	250 m
marine fish	transient stunning	192 dB re 1µPa	8 m	2 m
marine fish	internal injuries	200 dB re 1µPa	4 m	1 m
marine fish	egg/larval damage	220 dB re 1 µPa	<1 m	<1 m
marine fish	mortality	230-240 db re 1µPa	<1 m	<1 m
marine mammals	temporary threshold shift	200-205 dB re 1 µPa	4 m	1 m
cetaceans	harassment	180 dB re 1 µPa	32 m	8 m
pinnipeds	harassment	190 dB re 1 µPa	32 m	4 m
marine mammals	strong avoidance	160-170 dB re 1 µPa	500 m	128 m
marine turtles	avoidance	166 dB re µPa	250 m	64 m
marine turtles	erratic behaviour	175 dB re µPa	100 m	30 m

The zone of influence for fish catchability is expected to occur within 30 km of the active 2-D air gun array for a short time period.

8.2 Summary of Mitigation and Follow-Up

Table 8.2 summarizes mitigating measures and follow-up procedures that are recommended in this EA Report.

Table 8.2: VEC-Specific Mitigative Measures and Follow-Up

VEC	Mitigation Measures	Follow up and Monitoring
Marine and Migratory Birds	• Compliance with TGS vessel WMP, *Canada Shipping Act,* OWTG and MARPOL for all discharges. • A fuel transfer plan will be developed and implemented. • Any handling of stranded birds will follow CWS	• Sightings data for seabirds, will be summarized in a monitoring report which will be submitted to C-NLOPB, and CWS.

VEC	Mitigation Measures	Follow up and Monitoring
	and industry protocols. - A dedicated Environmental Observer will be on board the seismic vessel to record marine birds. - Vessel compliant with audit prior to survey. - Avoidance of bird colonies.	- Records of bird strandings will be provided to the C-NLOPB, and CWS for distribution to interested parties.
Marine Fish and Shellfish	- Adherence to the *Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment,* to the extent reasonably practical. - To minimize sudden changes in noise levels, a 20 to 40 minute ramp up procedure will be implemented.	- No follow up or monitoring required for routine activities
Marine Mammals and Turtles	- Before start of the operations, a meeting will be held with MKI representatives and TGS seismic company representatives to review sail lines, scheduling, anticipated fishing vessels and gear types, mitigating measures, expectations of all parties and Emergency Response Plans. - An Environmental Observer will be onboard the vessel throughout the duration of the survey. - The Environmental Observer will record sightings of marine mammals on a daily basis as per protocol. - A 20 to 40 minute ramp-up procedure will be undertaken for seismic surveys. - Ramping up will be delayed if a marine mammal is observed in the 500 m safety zone. - Air sources will be shut down or reduced to a smaller air source while the vessel is doing turns between survey lines. - The Environmental Observer will ensure the delay or shut down of seismic operations if SARA-listed Schedule 1 mammals or turtles are present within 500 m. - Collision avoidance practices, including constant speed and course maintained by seismic and support vessels. - Vessels will maintain a steady course and speed, and use existing travel routes, where possible. MARPOL standard procedures.	- A trained Environmental Observer will record marine mammal, turtle and seabird observations. - All spills will be reported.

VEC	Mitigation Measures	Follow up and Monitoring
Species at Risk	• Adherence to the *Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment* to the extent reasonably practical. • Same as above for marine birds, marine turtles and marine mammals	• A trained Environmental Observer will record marine mammal, sea turtles and seabird observations. • All spills will be reported.
Sensitive Areas	• Dedicated Environmental Observer will be on board the seismic vessel to record marine birds and marine mammals. • Vessel compliant with audit prior to survey. • Maintenance of streamer equipment and responsible management of such equipment. • Compliance with OWTG (NEB *et al.* 2002) for all discharges. • Avoidance of bird colonies by vessel.	• No follow up or monitoring required for routine activities • All spills will be reported.
Commercial Fisheries	• A Notice to Shipping and notification on the CBC Fisheries Broadcast on the location and scheduling of seismic activities will be issued. • Communication mechanisms will be developed with the fishing industry and DFO research surveys. • The Fisheries Liaison Observer on the vessel will monitor fishing activity in the vicinity of the seismic vessel and serve as a liaison between the fishing vessels and the seismic vessel; • Arrange for a Single Point of Contact • MKI will comply with C-NLOPB compensation guidelines.	• No follow up or monitoring required for routine activities

8.3 Conclusions

The vessel presence, noise emissions and accidental events associated with the proposed seismic surveys are not predicted to result in significant adverse environmental effects on fish and shellfish, marine and migratory birds, marine mammals, sea turtles, species-at-risk, sensitive areas or fisheries in the Labrador Shelf Study Area following mitigation. Ecological processes will not be disturbed outside natural variability, and ecosystem structure and function will not be critically affected. All effects are reversible, of limited duration, magnitude, and geographic extent.

Previous 2-D seismic surveys conducted in this area have not resulted in claims that significant adverse effects to biological or socio-economic VECs. These operations throughout Atlantic Canada have not resulted in measureable effects on the marine environment. Therefore, there is high confidence that the mitigation in place is effective to ensure that no harm to listed species, critical habitats or fisheries harvesting is anticipated to occur as a result of the Project. This is consistent with the review by the Mineral Management Service (2004) on environmental effects of seismic activities in the Gulf of

Mexico, which have shown that adverse significant effects from a much larger number of seismic programs are not apparent beyond the immediate localised project areas.

MKI acknowledges that the scope of the Project being assessed in this EA Report extends over five years, during which time the regulatory, biophysical, and socio-economic environment may change from that assessed in this report. MKI will periodically review the EA Report, as directed by the CN-LOPB for current applicability and will work with regulatory authorities to ensure that this EA remains fit for purpose.

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