4.0 Environmental Effects of Exploration and Production Activities

Offshore oil and gas activity has been ongoing at least since the 1940s and therefore, most environmental effects are reasonably well known. The SEA (C-NLOPB 2005) focused on such sources as sound, drilling fluids and cuttings, attraction of animals, discharges, and accidental events. Important potential interactions were identified, and the potential effects of underwater sound (particularly seismic surveying) and non-sound aspects of exploration/production drilling were discussed in detail. Mitigations for the potential effects were also considered.

4.1 Sound

Section 4.1 of the SEA (C-NLOPB 2005) discusses underwater acoustics, in-air sound, ambient sound, offshore oil and gas industrial sounds, and the potential effects of industrial sounds on marine animals. This discussion remains relevant for the SEA Amendment.

Additions to the literature on the effects of exposure to sound on marine invertebrates and fish since completion of the SEA (C-NLOPB 2005) include Christian et al. (2004) (snow crab), Parry and Gason (2006) (lobster), Payne et al. (2007) (lobster), Popper et al. (2005) (freshwater fish), Nedwell et al. (2006) (salmonids), Røstad et al. (2006) (marine fish), Mann et al. (2007) (freshwater fish), and Sarà et al. (2007) (tuna).

Christian et al. (2004) did not find any significant differences of chronic effect (e.g., haemotological indices, eye tissue histopathology, time to mortality in stress test) of exposure to seismic energy between treated and control male and female snow crabs. Parry and Gason (2006) did not see any significant impact of seismic surveys on catch rates of rock lobsters in Australia. Payne et al. (2007) did not observe any significant differences between lobsters treated with exposure to seismic sound and control lobsters in terms of delayed mortality, damage to mechanosensory systems, or appendage loss. However, Payne et al. (2007) did observe differences in feeding, serum biochemistry and histochemistry of the hepatopancreas. Payne et al. (2007) did state the *caveat* that their studies were meant to be exploratory in nature and cautioned about over-interpretation.

Popper et al. (2005) found that the degree of hearing threshold shift differed between three freshwater fish species exposed to the same level of seismic sound. The two species that did exhibit threshold shift recovered within 24 hours of exposure. Nedwell et al. (2006) investigated the effects of exposure to underwater impact and vibro pile-driving noise on brown trout (*Salmo trutta*). They did not observe any obvious signs of trauma during the experiments. Røstad et al. (2006) investigated the attraction of pelagic marine fish to both stationary and moving vessels. Their study suggested more complex relationships between fish, vessels and noise than previously anticipated. Mann et al. (2007) measured the hearing thresholds of eight freshwater fishes and discovered substantial variability between species. Sarà et al. (2007) investigated the effect of boat noise on the behaviour of bluefin tuna (*Thunnus thynnus*). They found that noise generated by various vessel types produced behavioural deviations in the tuna schools (e.g., change of swimming direction, increased vertical movement, less concentrated school structure, less coordinated swimming behaviour).

A variety of review documents relating to the potential impacts of seismic sound on aquatic animals have been published by DFO during recent years (DFO 2004a; Payne 2004; Moriyasu et al. 2004; Worcester 2006). In addition, DFO has also published two documents related to the potential effects of seismic sound on snow crab, specifically reviewing the results of a DFO study conducted in 2003 to 2004 (DFO 2004b,c).

A review of responses of cetaceans to anthropogenic noise has also been published recently by Nowacek et al. (2007).

4.1.1 Mitigations Related to Sound

There are standard environmental mitigative measures that are required during geophysical surveys in the offshore areas of Newfoundland and Labrador consistent with the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NOPB 2004). The following items are a list of typical mitigations that must be conducted in a manner consistent with the Guidelines (C-NOPB 2004).

4.1.1.1 Ramping up

Ramping-up or 'soft starting' the airgun array over a period of 20 to 30 minutes provides time for nearby fish, mobile invertebrates, marine mammals, sea turtles, and sea birds to leave the immediate area before the seismic sounds become sufficiently strong to have any potential of causing physical effects. This is a standard mitigation used in the East Coast offshore area.

4.1.1.2 Shutdown of Seismic Array

The Operator is required to shut down the airgun array if a *Species at Risk* is observed within a 500-m radius of the array.

4.1.1.3 Observers

The placement of trained observers aboard the seismic vessel to monitor the immediate area for presence of marine mammals and sea turtles is a typical practice during seismic operations. If marine mammals are observed within a set distance (i.e., 500 or 1,000-m monitoring zone) from the vessel during ramp-up, airguns are shut down. Shutdowns of the airgun array could be implemented if deemed necessary due to the proximity of particular species of concern. Shutdown 'triggers' may vary by location and species.

4.1.1.4 Optimal Scheduling of Seismic Surveys

Selected timing of the seismic surveys to minimize conflict with biota for fisheries in key areas (e.g., spawning, feeding, and migration) at particular times of the year can mitigate any potential effects. These spatial and temporal scheduling mitigations could potentially apply to the identified sensitive fish/fisheries areas in the Amendment Area. Optimal scheduling to avoid sensitive life stages is particularly important for *Species at Risk*. Surveys also should be coordinated with DFO to avoid conflicts with research vessel surveys.

It is likely that most periods of seismic surveying in the SEA Area would occur outside of the suggested period of blue whale migration into the Gulf of St. Lawrence (i.e., late march/early April). It is uncertain when and via what route whales leave the GSL. Operators will use spatial and temporal scheduling mitigations to avoid critical life stages of *Species at Risk, including the blue and fin whale.*

Seismic activities should be scheduled to avoid heavily fished areas, to the extent possible. The Operator should implement operational arrangements to ensure that the Operator/survey contractor and the local fishing interests are informed of each other's planned activities.

4.1.1.5 Other Mitigations

The Laurentian Subbasin SEA (C-NOPB and C-NSOPB 2003), Orphan Basin SEA (C-NOPB 2003), and the TGS-NOPEC 2002 EA (Canning and Pitt 2002) listed other mitigations including:

- Minimization of airgun source level to one practical for the survey
- Compliance with all applicable regulations concerning discharges

4.1.2 Planning Implications Related to Sound

Special mitigation measures may be required to reduce impacts in areas such as the Cod Spawning Area off the west coast of Port au Port Bay and will be determined in consultation with regulatory agencies. Mitigations could include timing restrictions for seismic surveys to avoid sensitive life stages of Atlantic cod and any other relevant species. Similarly, noise of drilling and support activities may be an issue near known concentrations of whales. Planning considerations for vertical seismic profiling (VSP) and wellhead severance include the standard mitigations and monitoring programs such as marine mammal monitoring, and that acoustic or chemical explosives (e.g., during wellhead severance) are not to be released when marine mammals are within a certain distance from the energy source.

Some baleen whales (e.g., bowhead whales and gray whales) attracted to an area for feeding seem to be quite tolerant of seismic survey activity and are not easily displaced (e.g., Miller et al. 2005; Gailey et al. 2007). As indicated in the SEA and this document, marine mammal monitoring will be implemented during seismic surveys. If blue (or fin) whales are observed to concentrate in or near a seismic area to forage, it would be prudent to acquire acoustic recordings of seismic sounds and monitor whale behaviour to ensure that whales were not being excluded from foraging areas. Section 4.1 of the SEA (C-NLOPB 2005) refers to the interaction between industrial sound and marine mammals.

4.1.3 Data Gaps Related to Sound

Data gaps specific to seismic exploration include the lack of sound measurement and modeling in the Amendment Area. There will likely be considerable variation in underwater sound propagation in the Amendment Area and, therefore, considerable uncertainty in predicting the sound propagation in the area. Sound measurements and modeling may be useful in impact assessment and in designing mitigations.

There are data gaps for specific marine faunal species or groups potentially affected by exposure to sound, particularly seismic sound. The fauna of greatest concern would vary depending on the location of proposed exploration activities. Data gaps relating to marine fauna include information on the general biology and distribution, as well as information on the specific effects of exposure to sound energy on the animals.

4.2 Routine Exploratory/Delineation Drilling and Production Activities (Non-Sound Issues)

Section 4.2 of the SEA (C-NLOPB 2005) discusses the routine exploratory/delineation drilling and production activities, and the non-sound issues associated with them. Included in this discussion is the interaction and potential effects of these routine activities on various marine animals. This discussion is relevant for the SEA Amendment.

4.2.1 Mitigations Related to Routine Activities (Non-sound Issues)

4.2.1.1 Drill Muds and Cuttings

Mitigation measures for the drilling include the selection of non-toxic or low toxicity chemicals and muds, and treating any oil-contaminated cuttings to meet the *OWTG*. The post-treatment non-toxic muds and cuttings are often put into a landfill. Hibernia now re-injects SBM-related cuttings as mitigation for production (not exploration) drilling. However, the Hibernia situation is atypical for the East Coast being a very large production development that does all its drilling from a centrally located gravity-base structure.

4.2.1.2 Potential Conflicts with Fisheries

Communications/Notification

Fisheries representatives have frequently noted that good communication at sea is an effective way to minimize interference between offshore oil and gas exploration projects and fishing activities. Communications will be maintained (directly at sea by the rig and project vessels) via marine radio to facilitate information exchange with fisheries participants. Relevant information about the rig locations, the safety zone, and other operations will also be publicized using established communications mechanisms, such as the *Notices to Shipping* (Continuous Marine Broadcast and NavTex) and CBC Radio's (Newfoundland and Labrador) *Fisheries Broadcast.* Fishery liaison observers (FLOs) are used to communicate and mitigate potential conflicts with fishing vessels.

Avoidance

With the information provided to the fishing industry, potential impacts on fishing (catch success as well as fishing gear interactions) can be mitigated by fishers avoiding the survey or drilling locations and any designated safety zones. This area will be kept as small as feasible to ensure mutual safety and minimize interference with fishing activities.

Guard Vessels

Guard vessels, preferably crewed by commercial fishermen, may accompany seismic vessels to monitor the immediate area for active commercial fishing vessels, thereby minimize potential conflict between the seismic survey activities and commercial fishing activities through good communication.

Compensation for Gear and Vessel Damage

In case of accidental damage to fishing gear or vessels, the Operator will implement damage compensation plans to provide appropriate and timely compensation to any affected fisheries participants. The Operator will follow the procedures employed successfully in the past for documenting any incidents. Procedures must be in place on the survey vessels to ensure that any incidents of contact with fishing gear are clearly detected and documented.

Safety Zones

Fishing (and other) vessels will not be able to enter a safety zone around the drill rig, and this information and the rig's location will be publicized and communicated to the fishing industry. The typical safety zones for a semi-submersible is the anchor pattern plus 50 m. The typical safety zone for a jack-up rig is 500 m from the at-surface structure. Thus, there should be no opportunity for conflict with fishing gear. Operators are required to check regulations regarding wellhead removal.

Interference Reduction Protocols Related to DFO Research Surveys

Protocols to reduce interference between drilling activities and DFO research surveys must be established between the Operator and DFO prior to the commencement of drilling activities.

4.2.1.3 Conflicts with Marine-associated Birds and Mammals

Concerns about birds and mammals are normally related to accidental events and/or the perceived importance of a particular area. Attraction of marine-associated birds to the lights of offshore facilities/vessels and marine mammal vessel strikes are two potential conflicts with routine activities.

4.2.2 Planning Implications Related to Routine Activities

Standard mitigative measures for routine exploratory/delineation drilling and production activities can be employed (see Section 5.0).

4.2.3 Data Gaps Related to Routine Activities

Data gaps exist for a number of non-sound issues associated with the offshore routine activities of the oil and gas industry. These issues include the effects of lights and flaring on birds, effects of drill muds and cuttings on the benthic environment, effects of other drilling waste products on the marine environment, and the artificial reef effect of drilling rigs. Information does exist for all of these issues but more is needed.

4.3 Accidental Events

Accidental events with potential for environmental damage offshore may range from small spills of fuels and chemicals (e.g., during loading or unloading), to medium spills of diesel fuel during a fuel tank rupture, to oil or gas blowouts. Section 4.3 of the SEA (C-NLOPB 2005) discusses accidental events in terms of blowout and spill probabilities, fate and behaviour of hydrocarbons, and potential interactions and effects of hydrocarbons on various marine biota. This discussion is relevant for the SEA Amendment. Based on work done by SL Ross for Husky (2003), Section 4.3 of the SEA addressed diesel fuel spills and oil blowouts, accidental events of most concern.

A review article on the effect of oil spills on fish populations has recently been published in the primary literature (Hjermann et al. 2007). This paper discusses how long-term population impact of oil spills depends on various ecological and oceanographic factors.

In the time since the SEA (C-NLOPB 2005) was completed, new peer-reviewed publications on the effects of exposure to hydrocarbons on marine-associated birds include the following studies.

Riffaut et al. (2005) examined population genetic structure of Common Murres in the North Atlantic and the colony origin of Common Murres killed by the spill from the wreck of the Erika in the Bay of Biscay in December 1999. They found that the breeding populations were weakly structured, i.e., there was little genetic differentiation among populations. Consequently, the populations of origin of birds oiled during the Erika spill could not be assigned. The lack of population structure is consistent with very little loss of genetic variability as a result of the spill. If the population structure observed were due to high rates of dispersal among colonies, then nesting population recovery following a spill would be likely. However, historical events other than oil spills could produce the same population structure. In addition, actual recruitment rates in nesting populations of Common Murre are poorly known.

Troisi and Borjesson (2005) modified a commercially available immunoassay to detect polyaromatic hydrocarbons (PAH) in plasma of Common Murres. This could provide a practical method of assessing internal exposure burden of PAH in oiled seabirds.

Velando et al. (2005) modeled reproductive performance of European Shag along the coast of Galicia, Spain, prior to the Prestige spill, based on population parameter data collected in the preceding ten years. They found that reproductive performance and chick condition following the spill was lower than that predicted by the model had the spill not occurred. This may have resulted from a dietary shift that was observed after the spill.

Oil spill effects on seabird populations are not well understood because spills usually occur in wintering areas distant from colonies and wintering birds are often spread over large areas. To evaluate the effects of oil spills on Common Murre populations in the North Atlantic, Votier et al. (2005) used a long-term data set to separate the effects of natural environmental variation. They found that over-winter survival was negatively affected by severe weather, i.e., high values of the North Atlantic Oscillation index, and by four major spills in wintering grounds. Major oil pollution incidents doubled winter mortality.

Pérez-López et al. (2006) used Common Murre, Atlantic Puffin and Razorbill carcasses salvaged from the Prestige spill to measure baseline levels of heavy metals. These levels did not appear different from those found in other studies of seabirds from other parts of Europe, except perhaps in the case of mercury, nor did they suggest increased environmental exposure.

Terra Nova, a production development southeast of Newfoundland, had an oil spill (1000 barrels of crude) in November 2004 caused by faulty equipment. Relatively few oiled seabirds were observed or collected, but sea states were high and conditions poor for collecting reliable data on the number of birds affected. Based on seabird densities recorded during helicopter and vessel-based surveys around the affected area and on the size of the slick, Wilhelm et al. (2006, 2007) estimated that 10,000 murres and Dovekies were at risk of exposure to oil from the spill.

4.3.1 Mitigations and Planning Implications Related to Accidental Events

The effects conclusions presented in the previous sections assume that mitigations will be in place and thus, the effects could be considered what is termed ‘residual.’ The oil industry operating in Newfoundland and Labrador waters has strict policies and procedures concerning spills of all sizes, which must be reported to the C-NLOPB. All offshore operators are required to submit to the Board and operate under an Oil Spill Response Plan (OSRP), or equivalent. In addition, all operators are required to have an arrangement with a spill response agency to provide spill response capabilities in the event of a spill.

Given the proximity of potential drilling activities to coastal areas and identified sensitive areas, spill response capabilities are even more critical than when activities are conducted further offshore. The increased probability of oil reaching shore or any of the identified offshore sensitive areas further necessitates that operators be prepared with a spill response strategy.

In summary, the most effective planning tool for minimizing the effects of oil spills is by all parties concentrating their efforts on avoidance firstly on accidents and secondly on sensitive areas and times. The latter are identified through efforts such as this SEA Amendment, generic EAs (where a scenario approach can be used to analyze different areas time and spill variables), and the site-specific EAs. All operators are required to submit OSRPs to the Board.

It should be noted that while rehabilitation programs are humane attempts to save individual animals impacted by oil, such programs cannot be considered a form of mitigation for population recovery.

4.3.2 Data Gaps Related to Accidental Events

While the effects of different types of petroleum hydrocarbons are fairly well known, the physical characteristics of hydrocarbons in the Amendment Area are not well known. The crude oil discovered thus far on the west coast of Newfoundland is lighter than that on the Grand Banks (51º API). The distribution of the fisheries in the Amendment Area is known in time and space. The key data gaps in assessing the potential effects of a large oil spill or blowout are listed below.

Distribution of key VECs such as fish eggs and larvae, seabirds, marine mammals, and sea turtles in the Amendment Area are not completely understood. As indicated in the Western Newfoundland and Labrador Offshore Area SEA (C-NLOPB 2005), surface and subsurface currents are important factors for nutrient and larvae dispersal in the Gulf of St. Lawrence. The occurrence of an accidental event in the Amendment Area could potentially affect such dispersal as well as adjacent sensitive feeding and spawning areas.

Specific characteristics, fate, and behaviour of oil spills in the Amendment Area are unknown. As indicated in the SEA (C-NLOPB 2005), spill modeling has been conducted for the oil of a well located less than 10 km southwest of Cape St. George but this release location is outside of the Amendment

Area. One cannot assume that this modeling would be entirely applicable to the Amendment Area. No oil spill trajectory modeling has been conducted thus far in the Amendment Area. Trajectory analyses as per guidelines will be run as part of the project-specific EA process.

Future project-specific environmental assessments, oil spill response plans and trajectory analyses should give special consideration to the sensitive cod and redfish areas identified in this SEA Amendment.

4.4 Cumulative Effects

For the purposes of the SEA Amendment, Section 4.4 of the SEA (C-NLOPB 2005) on cumulative effects remains relevant. Environmental assessments for proposed marine seismic (JW 2006, 2007) and onshore to offshore exploration drilling (LGL 2007a) in the Port au Port Peninsula area have recently been submitted to the C-NLOPB.

4.4.1 Oil and Gas Activities

4.4.1.1 Seismic Surveys

Any geophysical programs (2-D, 3-D, VSP, or other) will not likely overlap as they would interfere with data collection. Effects of noise may be additive on those animals such as certain species of fish (e.g., cod) and marine mammals (e.g., humpback whales) that may be sensitive to seismic survey noise. Although migratory animals may be subject to disturbance from noise outside the Amendment Area from other surveys in the Gulf, mitigations such as ramp ups and avoidance of sensitive areas and times should mitigate any potential cumulative effects to acceptable levels.

Environmental assessments to date have concluded that the effects of individual seismic programs on marine animals (e.g., marine mammals, marine birds, sea turtles, fish, and invertebrates) are minimal given the proper implementation of mitigation measures (Davis et al. 1998), and that spatial and temporal overlap between different seismic programs can be readily minimized. Therefore, the cumulative effects of seismic should be minimal. Nonetheless, individual seismic programs will still require a project-specific EA pursuant to the *Canadian Environmental Assessment Act* (*CEAA*), which will examine cumulative effects in detail. The more detailed cumulative effects assessment, including background noise levels, would be contained in the site-specific EA and would address the significance of the cumulative effects associated with seismic surveys. Standard mitigations such as a marine mammal monitoring program, ramp-up procedures, the use of FLOs, and spatial and temporal avoidance, are typically employed by operators to reduce potential effects.

4.4.1.2 Drilling

Any cumulative effects on the Gulf of St. Lawrence ecosystem from routine exploratory drilling in the Amendment Area will not likely overlap in time and space and thus, will be additive but not multiplicative. This level of activity will not likely change any effects predictions when viewed on a cumulative basis unless significant oil spills or blowouts occur.

Barring major accidents, effects of a single exploratory well in the Amendment Area should be minimal (Buchanan et al. 2003). In any event, it is unlikely that any effects, mostly confined to within 500 m, would overlap with another exploratory well; they will be simply additive. An exception could be the effects of drill rig noise and/or supply vessel noise. Nonetheless, individual drilling programs will still require a project-specific EA pursuant to *CEAA*, which will examine cumulative effects in detail. The lack of modeling and measurements of noise in the Amendment Area has already been identified as a data gap in this SEA Amendment.

Any cumulative effects will not likely overlap or be synergistic within the Western Newfoundland and Labrador Offshore Area Amendment Area, unless supply vessels follow the same routes at the same time. However, cumulative effects will be additive. This is a potential issue with migratory species that may be subject to repeated disturbances as they transit the area.

4.4.2 Commerical Fisheries

The Amendment Area does not appear to be subjected to intensive fishing pressure (Section 3.3.2). Effects of exploration activities would likely add some negligible additional stress on fish and fisheries.

4.4.3 Shipping

The west coast of Newfoundland has some shipping activity, nationally through ports in Stephenville and Corner Brook, and internationally through the Strait of Belle Isle, mostly during summer for ships coming from Europe. There is also local boat traffic, mostly fishing vessels. Seabirds, marine mammals, and sea turtles are the primarily affected VECs. These issues are typically considered at the EA stage.

4.4.4 Other Activities

Other activities with some potential for cumulative effects are hunting (marine birds), naval exercises (marine mammals), and research activity (e.g., DFO surveys). The specifics of these activities and potential effects will be considered during any site-specific assessments.