Environmental Assessment of Petro-Canada's Vertical Seismic Profiling Program at the Terra Nova Development

Prepared by

LGL LIMITED
environmental research associates

Prepared for

PETRO-CANADA

November 2006
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Prepared by

LGL Limited
environmental research associates
P.O. Box 13248, Stn. A
St. John's, NL A1B 4A5
709-754-1992 (p)
709 754-7718 (f)

Prepared for

Petro-Canada
235 Water Street
St. John's, NL A1C 1B6

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1.0 Introduction

Petro-Canada proposes to undertake vertical seismic profiling (VSP) activities at its Terra Nova Development in the Jeanne d'Arc Basin (see Figure 1) in support of remaining delineation and production wells at Terra Nova. This document provides a description and environmental assessment of the proposed VSP activities that may occur for the duration of the life of the Terra Nova Development. Vertical seismic profiling consists of an airgun array sound source, typically less powerful than those used during routine seismic surveys, deployed at locations near (or on) the rig with receivers placed in the well. The purpose of the technique is to tie in or ground-truth the geological data with geophysical information.

This document updates and incorporates regulatory agency comments of an Environmental Assessment (EA) prepared for the proposed Petro-Canada VSP Program in June 2006 (LGL 2006a). The reviewer is referred to the EIS and associated documents for detailed information on the Terra Nova Development and associated activities, the biophysical environment, and the effects assessment for activities other than VSP (Petro-Canada 1996a,b, 1997, 1998). Additional relevant information is also contained in the *Terra Nova Baseline Environmental Characterization Data Report* (Petro-Canada 1998).

1.1 Regulatory Context

'Check shots,' of which VSP surveys can be considered an extension (A. Kaderali, Husky, pers. comm.), are now required by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB or the 'Board'). The following is excerpted from the *Joint Guidelines Respecting Data Acquisition and Reporting* (C-NOPB and C-NSOPB 2003).

"A check shot survey is required for all exploration and delineation wells. The Board, in consultation with the operator, may request the operator to acquire a vertical seismic profile (VSP), where it would contribute to resolving uncertainty associated with seismic interpretation.

It is likely that geophysical surveys will be needed in some development wells to acquire additional control for the seismic interpretation of the field. In such instances, the Board may request that an operator conduct such survey(s) should they be necessary."

The Board is mandated by the *Atlantic Accord* acts. Offshore seismic on federal lands is now subject to screening under the *Canadian Environmental Assessment Act* (*CEAA*). Because seismic survey activities have the potential to affect seabirds, marine mammals, and fish and fisheries, Fisheries and Oceans and Environment Canada are the primarily interested agencies. Relevant environmental legislation, in addition to *CEAA*, includes the *Fisheries Act*, the *Oceans Act*, the *Migratory Bird Act,* and the *Species at Risk Act* (*SARA*). As the VSP will be conducted from the drill rig with the assistance of a typical standby supply vessel, there are no new issues related to the *Navigable Waters Act* other than those previously considered under the Terra Nova Development EIS.

1.2 Rationale

The rationale for conducting VSP surveys is that they allow operators to tie in or ground-truth the geological data with geophysical information. In addition, the surveys are required to meet C-NLOPB and operator requirements.

1.3 Consultations

Consultations for Petro-Canada's VSP Program were undertaken with relevant agencies and interest groups via email and telephone. The purpose of these consultations was to describe the proposed program, gather any additional information relevant to the EA, and identify any issues or concerns. None of the stakeholders contacted had any particular questions or concerns about these proposed activities. In previous, similar VSP Programs, these groups have not raised any issues or questions regarding these types of offshore exploration activities (S. Canning, Canning & Pitt, pers. comm.). The agencies/persons contacted regarding Petro-Canada's VSP program included:

- DFO : Randy Power and Sigrid Kuehnemund
- Environment Canada : Glenn Troke
- One Ocean : Maureen Murphy
- FPI : Derek Fudge
- Association for Seafood Producers : E. Derek Butler
- Natural History Society : Len Zedel

1.4 The Operator

Petro-Canada is one of the largest integrated oil and gas companies in Canada, with significant international interests. Headquartered in Calgary, Alberta, Petro-Canada (the Operator) is a Canadian-based integrated energy company serving global customers, committed to conducting its offshore oil and gas operations in an environmentally responsible manner.

The Operator is the management and operating company for the Operator's 10 Significant Discovery Licenses, three Production Licenses, and four Exploration Licenses, offshore Newfoundland. The Terra Nova field, the largest of the Operator's Significant Discovery Areas, is estimated to contain approximately 370-470 million barrels of recoverable reserves. Petro-Canada is also a major partner in the Hibernia and White Rose developments.

1.5 Contacts at Petro-Canada

Relevant contacts at Petro-Canada for the VSP activities and related documentation include:

Executive Contact:

William Fleming
Asset Manager, Terra Nova
Scotia Centre, 235 Water Street
St. John's, NL
A1C 1B6
Telephone: 709 778-3541

Drilling Contact:

Jason Evans
Well Design Lead
Petro-Canada East Coast Operations
Suite 201, Scotia Centre
235 Water Street
St. John's, NL
(709) 778-3684
Email: jevans@petro-canada.ca

Environment Contact:

Urban Williams
Team Lead
Environment, Emergency Response & Security
Petro-Canada
235 Water Street
St. John’s, NL
A1C 1B6
Phone: (709) 778-3764
Email: uwilliams@petro-canada.ca

2.0 Project Description

The Project Description is based upon information available at the time of writing. Currently, not all project details are known because the specific number and locations of VSP surveys depend upon uncertainties regarding requirements for delineation and exploration wells that will be drilled over the life of the Terra Nova Development. Nonetheless, this Project Description is an accurate reflection of Petro-Canada's present level of knowledge.

2.1 Name and Location

The official name of the Project is the Terra Nova Development Vertical Seismic Profiling Program. It is located in the Jeanne d'Arc Basin within the boundaries of the Terra Nova Development (see Figures 1 and 2) about 350 km east-southeast of St. John's. Water depths in the Terra Nova area range from 90 m to 95 m.

2.2 Alternatives to the Project

As the VSP surveys are a regulatory requirement by the Board and a technical requirement for operations, there is no alternative to them *per se*. However, there are alternatives within the Project in the form of different types of VSP survey as described below.

2.3 Physical Site Conditions

Meteorological and oceanographic conditions are described in Sections 3.1 and 3.2 of Petro-Canada (1996a). The most recent oceanographic review of the area is contained in Oceans (2005). This report is appended in its entirety in Appendix A.

2.4 Site layout

The site layout for the Terra Nova Development wells is shown in Figure 2. This area can be considered to be the Project Area and includes all of Petro-Canada's production licenses.

2.5 Scheduling

VSP surveys typically occur during the summer season (although they could occur at any time throughout the year) and will continue on an as-needed basis for the life of the Terra Nova Development project (15-17 years). Within a given year, there would be a maximum of two VSP surveys, with each VSP acquisition period lasting from 8-36 hours.

2.6 Description of Activities

During the life of the Terra Nova Development, Petro-Canada intends to conduct VSP activities at its wells at Terra Nova (see Figure 2) on an as-needed basis. In the current program with the *Henry*

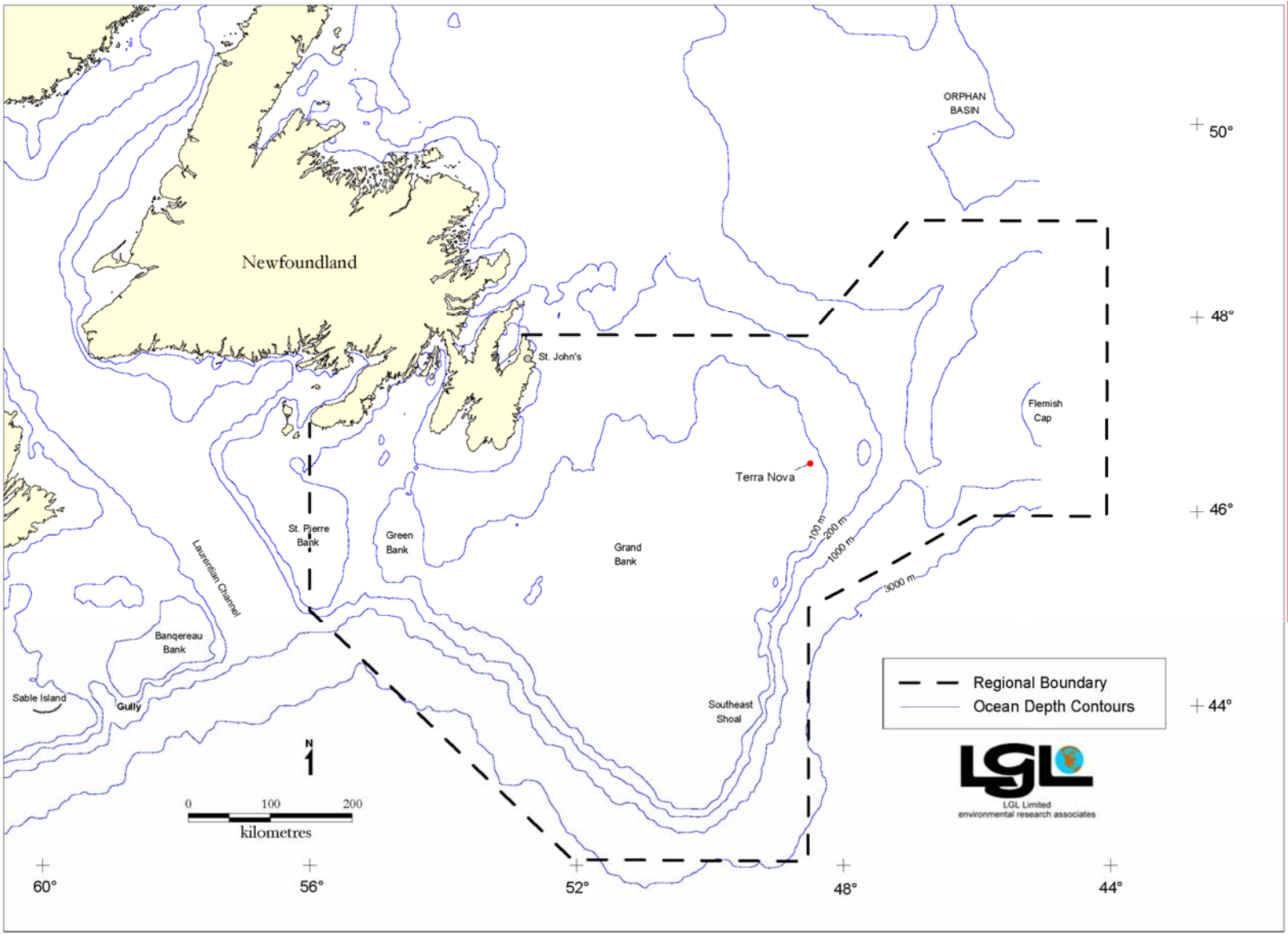


Figure 1. Location of the Terra Nova Development and proposed VSP survey.

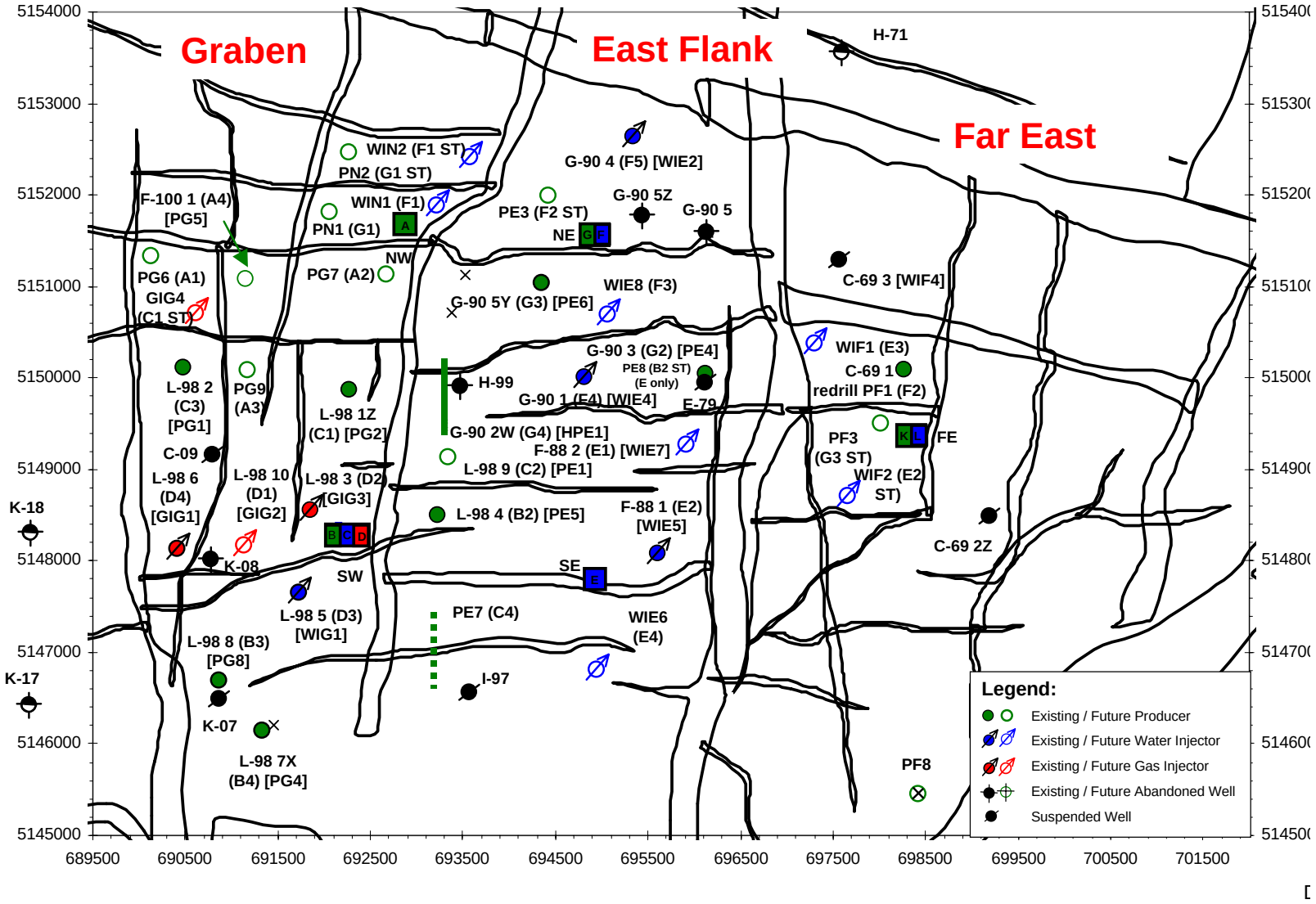


Figure 2. Terra Nova Development site layout.

Goodrich, there are six more wells to be drilled. This is the current base case scenario and may change as wells are drilled (J. Evans, Petro-Canada, pers. comm.). The VSP is used to measure acoustic waves between a well bore and the surface. It differs from surface seismic in that it has higher resolution and can provide wave fields *in situ*. This permits calibration of surface seismic data and provides "images" within the vicinity of the well bore that could otherwise not be defined by surface seismic data.

A VSP can be regarded as an extension of a 'checkshot survey'. Typically, the same source and downhole receivers are used for both types of survey. The difference is in the higher spatial sampling and longer recording time for VSPs versus checkshots. Acquisition times are dependent on the type of VSP and acquisition tool but they normally vary between 8-36 hours per well.

2.6.1 Checkshots

A checkshot can be defined as measurement of travel time between the surface and a given depth. This is achieved by placement of a downhole geophone that records direct arrivals, at defined depths in a well. A hydrophone monitors the signature and timing of the source signal. Several shots are usually acquired at the same level (depth) and stacked in order to improve the signal-to-noise ratio. Checkshots are usually acquired at the tops of significant formations, at the top of the sonic log, above and below the casing shoe and at zones where the borehole is in bad condition.

Sonic logs are calibrated by reference to check shot surveys to correct the velocities obtained by the integration of the sonic interval transit times. The calibrated sonic log may then be used for the translation of surface seismic time into depth and for the generation of synthetic seismograms and for other applications.

2.6.2 ZVSP (Zero-offset VSP)

This is the basic type of VSP that is normally acquired for vertical or near-vertical wells. The source is placed at a fixed distance of between 40 m and 125 m offset from the wellhead. Wherever possible, the source is deployed from the drill rig.

2.6.3 DVSP (Deviated VSP)

This is a variation on the ZVSP above due to deviation of the well trajectory. For this type of VSP, the source is positioned at several (usually between one and three) fixed distances of between 40 m and the maximum horizontal displacement of the well. Wherever possible, the source is deployed from the drill rig. A vessel for the source may be used if the well trajectory is such, that offsets are required that cannot be attained from the rig.

2.6.4 OVSP (Offset VSP)

In addition to a ZVSP or DVSP, a VSP may be acquired in the same well with the source positioned in any direction at fixed distances between 500 m and 2.0 km from the wellhead. In this case, the source would be deployed off a vessel.

2.6.5 Walkaway VSP

For a Walkaway VSP the source is deployed at uniform intervals (between 15 m and 100 m) in particular directions from the wellhead for distances of up to 5.0 km. In the case of a Walkaway VSP only a limited number of receiver levels would be acquired (usually between 8 to 40) and in a particular zone only. The source would be deployed from a vessel in this case.

2.6.6 VSP Method Proposed for Terra Nova

The sound source to be used at Terra Nova will include a four sleeve-gun tuned array comprised of 2x 100 in^3 and 2x 150 in^3 guns for a total volume of 500 in^3. The guns will be charged with nitrogen or compressed air, suspended at a constant depth of four to seven metres, depending on sea-state and operated at 2,000 psi pressure. The 0-to-peak source level is 8.45 Bar-m which converts to 238.5 dB re 1 µPa 0-P @ 1 m; maximum output occurs between 20 and 140 Hz (R. Dugal, Petro-Canada, pers. comm.).

The Terra Nova VSP surveys may range from a zero-offset VSP (i.e., fixed distance from the wellhead) with the source deployed from the rig to a walkaway VSP (uniform intervals up to 5.0 km from the rig). At each well, the survey would be a one-time event potentially occurring as early as July 2006 (and occurring over the life of the project) and extend for eight to 36 hours per survey.

Petro-Canada's preference is to use the Baker Atlas Multi-Level Receiver (MLR) tool as a receiver. The MLR tool is generally deployed with five receivers at a spacing of 15 metres between tools but can also be deployed with up to thirteen receivers if required. The MLR tool can be used in both open hole and cased hole environments. Alternatively, a Slim-Hole Receiver (SHR) tool is available if borehole conditions warrant its use. A normal job using the standard MLR configuration would result in the acquisition of up to 400 levels within the well bore that the receiver tool would acquire recordings of the airgun pulses (R. Dugal, Petro-Canada, pers. comm.).

2.7 Mitigations

Prior to the onset of VSP, the airgun array will be gradually ramped up. The smallest airgun will be activated first and then the volume of the array will be increased gradually over a recommended 20 to 30-min period. An observer aboard the rig or vessel with the seismic source will watch for marine mammals and sea turtles 30 min prior to ramp-up. If a marine mammal or sea turtle is sighted within 500 m of the array then ramp-up will not commence until the animal has moved beyond the 500 m zone. The observer will watch for marine mammals and sea turtles when the airgun array is active; airguns will be shutdown if a threatened or endangered marine mammal or turtle is sighted within or about to enter the 500 m safety zone. More details about mitigation (and monitoring) are presented in Section 6.

3.0 Physical Environment

The physical environment of the Terra Nova Development was described in detail in Section 3 of the Terra Nova EIS (Petro-Canada 1996a). For details about the physical setting at the Terra Nova Development, the reader is referred to the following:

- Section 3.1, Atmospheric Environment (climate including severe weather conditions);
- Section 3.2, Oceanic Environment (bathymetry, water masses, currents, tides, fronts, upwellings, and waves;
- Section 3.3, Sea Ice and Icebergs;
- Section 3.4, Geology (bedrock, sediments, hydrocarbon occurrence, and seismicity);
- Section 3.5, Shoreline Environment (coastal geomorphology, hydrology, oceanography and ice); and
- Section 3.6, Chemical Environment (water quality and sediment chemistry)

A recent review of oceanographic conditions in the Jeanne d'Arc Basin was prepared by Oceans (2005; see Appendix A). The report includes updated analyses for wind and wave conditions, water masses and currents. The physical environment of the Grand Banks has not changed greatly since the Terra Nova EIS was prepared.

4.0 Biological Environment

The biological environment of the Terra Nova Development and adjacent areas of the Jeanne d'Arc Basin have been reviewed in detail the Terra Nova EIS (Petro-Canada 1996a,b, 1997), the White Rose EA (Husky 2000), and the Husky exploratory drilling EA (Husky 2002). There appears to have been no significant changes in the biological resources of the Study Area since the preparation of these documents, although the nature of the fishery has changed since the Terra Nova EIS (see below). There are no apparent unique biological features at the Terra Nova Development relative to those in the adjacent areas of the Jeanne d'Arc Basin. The following sections provide updated information on VECs, especially those considered threatened or endangered under the *SARA*.

4.1 Commercial Fisheries/DFO and Industry Surveys

The Terra Nova Development occurs in NAFO Unit Area (UA) 3Lt. Commercial fish harvesting within the Study Area and on the Newfoundland Grand Banks generally has changed significantly over the last two decades, shifting from a groundfish-based industry to primarily invertebrate harvesting. Until the early 1990s, the eastern Grand Banks fisheries were dominated by stern otter trawlers harvesting groundfish, primarily Atlantic cod, as well as redfish, American plaice and several other species. In 1992, with the acknowledgement of the collapse of several groundfish stocks, a harvesting moratorium was declared and directed fisheries for cod are no longer permitted in these areas. Since the collapse of the groundfish fisheries, formerly underutilized species – mainly shrimp and snow crab – have come to replace them as the principal harvest in the general region, as they have in many other areas offshore Newfoundland and Labrador.

4.1.1 Data Sources

This update is based on an analysis of 2005 DFO catch and effort data (LGL 2006b). The DFO catch and effort data utilized are from DFO Newfoundland and Labrador Region and DFO Maritimes Region. They were supplied in digital form by the Statistics Division (NL) and Commercial Data Division (Maritimes) in February 2006.

4.1.2 DFO RV Survey Data

Analysis of DFO RV survey data collected in the western portion of 3Lt between 2002 and 2005 indicated that the mean depth of catches ranged between 59 and 119 m. Sand lance dominated the catches in terms of both weight (78%) and number of individuals (92%). The mailed sculpin was the only other species to account for more than 1% of the total number of specimens caught. Other species that accounted for more than 1% of the catch weight included unspecified invertebrates (7%), American plaice (4%), mailed sculpin (2%), thorny skate (2%), shrimp (2%, and snow crab (2%). The update below focuses on any new information or changes since the completion of recent EAs for the area (LGL 2004a,b; LGL 2005, LGL 2006b).

4.1.3 Domestic Fisheries in 2005

Commercial harvesting in 3Lt in 2005 was very similar to that in 2004. Snow crab accounted for essentially all of the harvest in the vicinity of the Project Area. Spatial and temporal aspects of the crab harvest in 2005 were similar to those observed in 2004. Most of the crab harvested in 3Lt was caught in the eastern part of the UA, east of the project Area. In terms of timing, most 2005 crab harvesting occurred between May and July, just as in 2004. The difference in 2005 was that July was peak harvest time compared to May/June in recent years. This was likely due to the delayed start of the snow crab fishery in 2005. The 3Lex and 3L200 snow crab fisheries closed officially on 31 July 2005, though some of the harvest was not landed until the beginning of August. Snow crabs are harvested in 3Lt using bottom-fished crab pots/traps (fixed gear).

Snow Crab

Snow crab (*Chionoecetes opilio*) in the northwest Atlantic occurs over a broad depth range (20 to >400 m). The distribution of this crustacean in waters off Newfoundland and southern Labrador is widespread but the stock structure remains unclear (DFO 2006). While commercial-sized snow crabs (≥95 mm carapace width) typically occur on mud or mud/sand substrate, smaller snow crabs are often found on harder substrates as well as on the softer ones. Snow crab mating generally occurs during the spring months. Depending on location, female snow crabs carry the fertilized eggs for one to two years prior to larval hatch. Hatching normally occurs in late spring and summer after which time the larvae remain planktonic for up to three to four months before settling to the benthic habitat (DFO 2006). Snow crab diet includes fish, clams, polychaetes, brittle stars, shrimp, crabs and other crustaceans. Common predators of snow crabs include various ground fish, seals and snow crabs themselves (DFO 2006).

Based on recent DFO multispecies bottom trawl surveys data, fishery logbook data and observer sampling data, there are indications of decline of both exploitable biomass and recruitment in NAFO Divisions 2J3KL. There has also been an apparent contraction of resource within these Divisions during recent years (DFO 2006).

4.1.4 2006 Fisheries

No significant changes in the domestic fisheries data in the vicinity of the Project Area are expected in 2006.

4.1.5 DFO Science and Industry Surveys

Fisheries research surveys conducted by DFO, and sometimes by the fishing industry, are important to the commercial fisheries to determine stock status, as well as for scientific investigation. There is some potential for overlap with the DFO research vessel (*R/V Teleost*) survey in 3KL in 2006. Table 1 provides the relevant 2006 DFO research survey schedule plan for Newfoundland and Labrador Region as of 2 June 2006 (J. Tillman, DFO St. John's, pers. comm.). Effects on DFO research are unlikely but the Proponents will communicate with DFO on this issue.

FFAWU biologists have recently noted that the FFAWU and relevant fishers are involved in an industry survey for crab in various offshore harvesting locations. This relatively short (24 hour) survey typically takes place in September.

Table 1. DFO science survey schedule, Newfoundland and Labrador, 2006.

Scientist	Trawler	Survey Type	Start	End	Days
Brodie	Teleost	Multi-species 2J 3KLMNO (and possibly 2H)	03-Oct-06	13-Oct-06	11
			13-Oct-06	24-Oct-06	12
			24-Oct-06	07-Nov-06	15
			07-Nov-06	21-Nov-06	15
			21-Nov-06	05-Dec-06	15
			05-Dec-06	19-Dec-06	15
Brodie	Templeman/Needler	Multi-species – Grand Banks	29-Sep-06	10-Oct-06	12
			10-Oct-06	24-Oct-06	15
			24-Oct-06	7-Nov-06	15
			7-Nov-06	21-Nov-06	15
			21-Nov-06	5-Dec-06	15
			5-Dec-06	19-Dec-06	15

4.2 Seabirds

The avifauna community of the Terra Nova Development Area is composed mainly of true pelagic species. The area lies on the eastern Grand Banks just inside two hundred nautical mile limit. This is beyond the range of most species not fully adapted for prolonged periods on the open sea. Even most members of the Laridae family (gulls) do not range as far off shore as the Terra Nova Development Area. The main species groups that occur in the Project Area are Procellariidae (fulmars and shearwaters), Hydrobatidae (storm-petrels), Sulidae (gannets), Phalaropodinae (phalaropes), Laridae (skuas, jaegers, gulls and terns) and Alcidae (auks) (Table 2).

The avifaunal richness of the Grand Banks is demonstrated by the high numbers of seabird colonies on the Avalon Peninsula and the northeast coast of Newfoundland. The nearly five million pairs of seabirds nesting at these colonies use the waters off eastern Newfoundland for feeding and the rearing of young (Table 3). These birds plus their young and non-breeding sub-adults use the Grand Banks for at least part of the year. It is thought that migrant seabirds outnumber local breeders on the Grand Banks at all seasons (Lock et al. 1994). Seabirds that nest in Labrador, the Canadian Arctic and Greenland, especially Northern Fulmars, Thick-billed Murres, Dovekies, and Black-legged Kittiwakes migrate through eastern Newfoundland waters or spend the winter there. In addition, millions of marine birds, mostly Greater Shearwaters, migrate from the Southern Hemisphere to spend the summer in eastern Newfoundland waters, especially the Grand Banks.

Table 2. Bird species occurring in the Project Area and predicted monthly abundances.

Common Name	Scientific Name	Monthly Abundance											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Procellariidae													
Northern Fulmar	*Fulmarus glacialis*	C	C	C	C	C	C	C	C	C	C	C	C
Greater Shearwater	*Puffinus gravis*					C	C	C	C	C	C	U	
Sooty Shearwater	*Puffinus griseus*					S	U	U	U	U	U	S	
Manx Shearwater	*Puffinus puffinus*					S	S	S	S	S	S		
Hydrobatidae													
Wilson's Storm-Petrel	*Oceanites oceanicus*						S	S	S	S			
Leach's Storm-Petrel	*Oceanodroma leucorhoa*				C	C	C	C	C	C	C	S	
Sulidae													
Northern Gannet	*Morus bassanus*				S	S	S	S	S	S	S		
Phalaropodinae													
Red Phalarope	*Phalaropus fulicarius*					S	S	S	S	S	S		
Red-necked Phalarope	*Phalaropus lobatus*					S	S	S	S	S			
Laridae													
Great Skua	*Stercorarius skua*					S	S	S	S	S	S		
South Polar Skua	*Stercorarius maccormicki*					S	S	S	S	S	S		
Pomarine Jaeger	*Stercorarius pomarinus*					S	S	S	S	S	S		
Parasitic Jaeger	*Stercorarius parasiticus*					S	S	S	S	S	S		
Long-tailed Jaeger	*Stercorarius longicaudus*					S	S	S	S	S			
Herring Gull	*Larus argentatus*	S	S	S	S	S	S	S	S	S	S	S	S
Lesser Black-backed	*Larus fuscus*				VS	VS	VS	VS	VS	VS	VS	VS	
Iceland Gull	*Larus glaucoides*	S	S	S	S						S	S	S
Glaucous Gull	*Larus hyperboreus*	S	S	S	S	S						S	S
Great Black-backed Gull	*Larus marinus*	U	S	S	S	S	VS	VS	S	U	U	U	U
Ivory Gull	*Pagophila eburnea*		VS	VS									
Sabine's Gull	*Xema sabini*					VS	VS	VS	VS	VS			
Black-legged Kittiwake	*Rissa tridactyla*	C	C	C	C	C	S	S	S	S	C	C	C
Arctic Tern	*Sterna paradisaea*					S	S	S	S	S			
Alcidae													
Dovekie	*Alle alle*	U	U	U	U	U	S	VS	VS	VS	U	U	U
Common Murre	*Uria aalge*	S	S	S	S	S	S	S	S	S	S	S	S
Thick-billed Murre	*Uria lomvia*	U	U	U	U	U	S	VS	VS	VS	U	U	U
Atlantic Puffin	*Fratercula arctica*					S	S	S	S	S	S	S	

Source: Brown (1986); Lock et al. (1994); Baillie et al. (2005); Moulton et al. (2005); Moulton et al (2006b)
C = Common, U = Uncommon, S = Scarce, VS = Very Scarce.

Table 3. Numbers of pairs of seabirds nesting at seabird colonies in Eastern Newfoundland.

Species	Wadham Islands	Funk Island	Cape Freels and Cabot Island	Baccalieu Island	Witless Bay Islands	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island
Procellariidae									
Northern Fulmar	-	13[a]	-	20[a]	40[a,f]	Present[a]	-	-	-
Manx Shearwater	-	-	-	-	-	-	100[a]	-	-
Hydrobatidae									
Leach's Storm-Petrel	1,038[d]	-	250[a]	3,336,000[a]	621,651[a,f]	-	26,313[a]	100,000[a]	72,000[a]
Sulidae									
Northern Gannet		9,837[b]		1,712[b]	-	6,726[b]	-	-	-
Laridae									
Herring Gull	-	500[a]	-	Present[a]	4,638[a,e]	Present[a]	20[a]	5,000[a]	-
Great Black-backed Gull	Present[d]	100[a]	-	Present[l]	166[a,e]	Present[a]	6[a]	25[a]	-
Black-legged Kittiwake	-	810[a]	-	12,975[a]	23,606[a,f]	10,000[a]	-	50[a]	-
Arctic and Common Terns	376[a]	-	250[a]	-	-	-	-	-	-
Alcidae									
Common Murre	-	412,524[c]	2,600[a]	4,000[a]	83,001[a,f]	10,000[a]	-	-	-
Thick-billed Murre		250[a]	-	181[a]	600[a]	1,000[a]	-	-	-
Razorbill	273[d]	200[a]	25[a]	100[a]	676[a,f]	100[a]	-	-	-
Black Guillemot	25[a]	1[a]	-	100[a]	20+[a]	Present[a]	-	-	-
Atlantic Puffin	6,190[d]	2,000[a]	20[a]	30,000[a]	272,729[a,f,g]	-	-	-	-
TOTALS	7,902	426,235	3,145	3,385,088	1,007,107	27,826	26,413	105,075	72,000

Sources:
[a] Cairns et al. (1989)
[b] Chardine (2000)
[c] Chardine et al. (2003)
[d] Robertson and Elliot (2002)
[e] Robertson et al. (2001) in Robertson et al (2004)
[f] Robertson et al. (2004)
[g] Rodway et al. (2003) in Robertson et al. (2004)

The Ivory Gull is the only bird listed on *SARA* (special concern on Schedule 1) that might occur in the Study Area in winter or early spring (January-April). The Ivory Gull lives among the pack ice and thus may occur in the Terra Nova Development Area in late winter if and when the pack ice reaches the southern limit for the year. It would likely be a rare and less than annual occurrence in the Terra Nova Development Area.

4.2.1 Seasonal Occurrence and Abundance of Seabirds

Table 2 summaries the abundance status by month for each species expected to occur regularly in the Terra Nova Development Area. Information was derived from Brown (1986), Lock et al. (1994), Baillie et al. (2005), Moulton et al. (2005) and Moulton et al. (2006b). The table uses categories to define a relative abundance of seabirds species observed. Four categories of abundance were used: Common, Uncommon, Scarce and Very Scarce:

- Common = expected daily in moderate to high numbers,
- Uncommon = expected regularly in small numbers,
- Scarce = a few individuals expected, and
- Very Scarce = very few individuals.

Overall world populations a species is taken into consideration for example Greater Shearwater are far more numerous on a world wide scale compared to a predator like the Long-tailed Jaeger.

4.2.1.1 Procellariidae (fulmars and shearwaters)

Northern Fulmar and Greater Shearwater are two of the most abundant species on the Terra Nova Development Area. In the northwest Atlantic Northern Fulmar breeds mainly in the Arctic and Greenland. It is present year around in Newfoundland waters but is more abundant in winter. Greater and Sooty Shearwater breed in the Southern Hemisphere and come to Newfoundland in the summer during their non-breeding season to moult. A significant percentage of the total world population Greater Shearwater migrates to eastern Newfoundland, particularly the Grand Banks for the annual moult in June and July (Lock et al. 1994). Manx Shearwater is a European species with a small population in Atlantic Canada. It is relatively rare on the Terra Nova Development Area.

4.2.1.2 Hydrobatidae (storm-petrels)

Two species of storm-petrel occur in Atlantic Canada. They are absent from Atlantic Canada in winter. Leach's Storm-Petrel is an abundant breeder in eastern Newfoundland (Table 3). It is common in most Newfoundland waters during the summer months and it is the species most commonly associated with stranding on vessel decks. Wilson's Storm-Petrel visits the Northern Hemisphere from May to October after breeding in the Southern Hemisphere. The Terra Nova Development Area is on the northern limit of its range.

4.2.1.3 Sulidae (gannets)

Northern Gannet

Northern Gannet is the only member of the Sulidae family to occur in Newfoundland. Three of the five major Northern Gannet colonies in North America are located in eastern Newfoundland at Cape St. Mary's, Baccalieu Island and Funk Island (Table 3). Gannets usually feed in shelf waters. Northern Gannet is expected to be a scarce visitor to the Terra Nova Development Area, May to October.

Phalaropodinae (phalaropes)

Red Phalarope and Red-necked Phalarope breed in the Arctic to sub-Arctic in North America and Eurasia. Phalaropes migrate at sea and both species winter at sea in the Southern Hemisphere. The two phalarope species are often difficult to distinguish at sea. Red Phalarope usually outnumbers Red-necked Phalarope in Newfoundland waters (Brown 1986). Phalaropes seek out areas of upwelling and convergence where rich sources of zooplankton are found. Red and Red-necked Phalarope are expected to be very scarce to scarce in the Terra Nova Development Area from May to September.

Stercorariidae (Skuas and Jaegers)

Skuas

The two species of skua known to occur in the northwest Atlantic have been recorded on the Terra Nova Development Area. Great Skua breeds in the Northern Hemisphere in Iceland and northwestern Europe. South Polar Skua breeds in the Southern Hemisphere and migrates to the Northern Hemisphere for the non-breeding season. Skuas are among the most difficult species to identify in the north Atlantic. Both species are expected to be scarce in the Terra Nova Development Area, May to October.

Pomarine, Parasitic and Long-tailed Jaeger are closely related species with similar habits and difficult to separate in the field. All three species of jaeger nest in the sub-Arctic to Arctic in North America and Eurasia and winter at sea in the middle latitudes of the Pacific and Atlantic oceans. Sub-adults usually don't migrate all the way back to the breeding grounds. Some are present in Newfoundland waters all summer. All three species of jaeger are expected to be scarce in the Terra Nova Development Area from May to October.

4.2.1.4 Laridae (Gulls)

Seven species of gull are expected to occur annually in the Terra Nova Development Area. They are Great Black-backed, Herring, Glaucous, Iceland, Lesser Black-backed, and Sabine's Gull and Black-legged Kittiwake. Great Black-backed Gull and Herring Gull are land based gulls breeding in Newfoundland. Small portions of the overall population live at sea during the non-breeding season. Great Black-backed Gull was fourth in abundance of all birds recorded from fixed platforms on the Grand Banks, 1999-2002 (Baillie et al. 2005). Glaucous Gull and Iceland Gull breed in the low Arctic

and include Newfoundland as part of their wintering grounds. They occur regularly offshore in small numbers during the winter. Black-legged Kittiwake breeds at seabird colonies in eastern Newfoundland and Arctic Canada and winters at sea (Table 3). It is common most of the year on the Grand Banks. Sabine's Gull (May-September) and Lesser Black-backed Gull (April to November) are regular in very small numbers.

Ivory Gull

Ivory Gull, listed as 'special concern' on Schedule 1 of *SARA*, might occasionally occur in the Terra Nova Development Area when pack ice reaches the annual southern extremity in February and March. See Section 13: Species at Risk for additional information.

4.2.1.5 Sterninae (Terns)

The Arctic Tern is only tern species expected in the Terra Nova Development Area. In the eastern North America, the breeding range extends from the Arctic south to Massachusetts. Arctic Terns migrate and winter at sea in the Southern Hemisphere. Arctic Tern is expected to be scarce in the Terra Nova Development Area, May to September.

Alcidae (Auks)

Four species of auks are expected in the Terra Nova Development Area: (1) Dovekie, (2) Common Murre, (3) Thick-billed Murre and (4) Atlantic Puffin. Dovekie and Thick-billed Murre are most numerous in Newfoundland waters during the winter and migration periods. Common Murre and Atlantic Puffin are abundant breeders in Newfoundland but winter mostly south of the Terra Nova Development Area.

Dovekie breeds in the North Atlantic, mainly in Greenland and east to Nova Zemlya, Jan Mayen and Franz Josef Land in northern Russia. Dovekie is an abundant bird with a world population estimated at 30 million (Brown 1986). It winters at sea south to 35°N. A large percentage of the Greenland breeding Dovekies winter in the western Atlantic, mainly off Newfoundland (Brown 1986). Dovekie is expected to be uncommon to occasionally common in fall, winter and spring in the Terra Nova Development Area.

Thick-billed Murre breeds in the sub-Arctic to Arctic regions of North America and Eurasia. In Atlantic Canada, it breeds as far south as Newfoundland. In the western Atlantic, Thick-billed Murre winters in open water within its breeding range and south to New Jersey. Thick-billed Murre is the "winter murre" in eastern Newfoundland. The sources of Thick-billed Murres in Newfoundland are the breeding grounds in the eastern Arctic and Greenland where two million plus pairs breed (Brown 1986, Lock et. al. 1994). Relatively small numbers (~2,000) breed in eastern Newfoundland (Table 3). Thick-billed Murre is expected to be uncommon to occasionally common fall, winter and spring in the Terra Nova Development Area.

Common Murre breeds in the north Pacific and north Atlantic. In the northwest Atlantic, it winters from southern Newfoundland south to Massachusetts. Nearly a half million pairs of Common Murres breed in eastern Newfoundland (Table 3). The maximum distance Common Murres are known to forage from breeding sites is 200 km, placing the Terra Nova Development Area beyond the reach of Newfoundland breeding colonies birds during the breeding season May to July. Common Murre is probably scarce on the Terra Nova Development Area throughout the year.

The Atlantic Puffin breeds in the north Atlantic in Maine, Newfoundland and Labrador, Greenland, Iceland and northwest Europe. In North America, it winters off southern Newfoundland and southern Nova Scotia. About 12 million pairs of Atlantic Puffins breed in the North Atlantic (Brown 1986). About 320,000 pairs nest in Atlantic Canada, mostly in eastern Newfoundland (Table 3). Atlantic Puffin is probably a scarce visitor to the Terra Nova Development Area, May to November.

4.3 Marine Mammals and Sea Turtles

4.3.1 Marine Mammals

At least 20 species of marine mammals may occur in the Project Area including 16 species of cetaceans (whales and dolphins) and three species of phocids (seals) (Husky 2000) (Table 4). Additional marine mammal species may occur rarely. Most marine mammals are seasonal inhabitants, the waters of the Grand Banks and surrounding areas being important feeding grounds for many of them. Recent marine mammal monitoring programs from seismic vessels in the Jeanne d'Arc and Orphan basins provide new information for the area. A marine mammal monitoring program was conducted from 3 October to 6 November 2005 during Husky's seismic program in the Jeanne d'Arc Basin, just north of the Project Area (see "Seismic Area" in Figure 3; Lang et al. 2006). In the Orphan Basin, marine mammal monitoring was conducted from seismic vessels during the summers of 2004 and 2005 on behalf of Chevron Canada Limited and co-venturers (Moulton et al. 2005, 2006b).

Population estimates and feeding information of many of the marine mammal species that occur within the Project Area are provided in Tables 5 and 6, respectively.

4.3.1.1 Baleen Whales (Mysticetes)

The five species of baleen whales that may occur in the Project Area include the blue, fin, sei, humpback and minke whale (Table 4). It is possible, but highly unlikely, that a North Atlantic right whale may occur in the Project Area. Although nearly all of these species experienced depletion due to whaling, it is likely that many are experiencing some recovery (Best 1993).

Humpback Whale.—The humpback whale has a cosmopolitan distribution. Its migrations between high-latitude summering grounds and low-latitude wintering grounds are reasonably well known (Winn and Reichley 1985). It is by far the most common baleen whale in Newfoundland waters. About 900 humpbacks are thought to use the Southeast Shoal of the Grand Banks as a summer feeding area, where

Table 4. Marine mammals that may or likely occur in the Project Area and their COSEWIC and *SARA* status.

Common Name	Scientific Name	COSEWIC Status (*SARA* listing/status)
Baleen Whales	**Mysticetes**	
Blue Whale	*Balaenoptera musculus*	Endangered (Schedule 1)
Fin Whale	*Balaenoptera physalus*	Special Concern (Schedule 1)
Sei Whale	*Balaenoptera borealis*	Data Deficient (No status)
Humpback Whale	*Megaptera novaeangliae*	Not At Risk (No status)
Minke Whale	*Balaenoptera acutorostrata*	Not At Risk (No status)
North Atlantic Right Whale	*Eubalaena glacialis*	Endangered (Schedule 1)
Toothed Whales	**Odontocetes**	
Sperm Whale	*Physeter macrocephalus*	Not At Risk (No status)
Northern Bottlenose Whale	*Hyperoodon ampullatus*	Endangered—Scotian Shelf Population (Schedule 1); Not At Risk—Davis Strait Population (No status)
Sowerby's Beaked Whale	*Mesoplodon bidens*	Special Concern (Schedule 3)
Bottlenose Dolphin	*Tursiops truncatus*	Not assessed (No status)
Killer Whale	*Orcinus orca*	Data Deficient (No status)
Long-finned Pilot Whale	*Globicephala melas*	Not assessed (No status)
Short-beaked Common Dolphin	*Delphinus delphis*	Not assessed (No status)
Atlantic White-sided Dolphin	*Lagenorhynchus acutus*	Not assessed (No status)
White-beaked Dolphin	*Lagenorhynchus albirostris*	Not assessed (No status)
Risso's Dolphin	*Grampus griseus*	Not At Risk (No status)
Striped Dolphin	*Stenella coeruleoalba*	Not assessed (No status)
Harbour Porpoise	*Phocoena phocoena*	Special Concern (No schedule or status; referred back to COSEWIC)
True Seals	**Phocids**	
Grey Seal	*Halichoerus grypus*	Not assessed (No status)
Harp Seal	*Phoca groenlandica*	Not assessed (No status)
Hooded Seal	*Cystophora cristata*	Not assessed (No status)

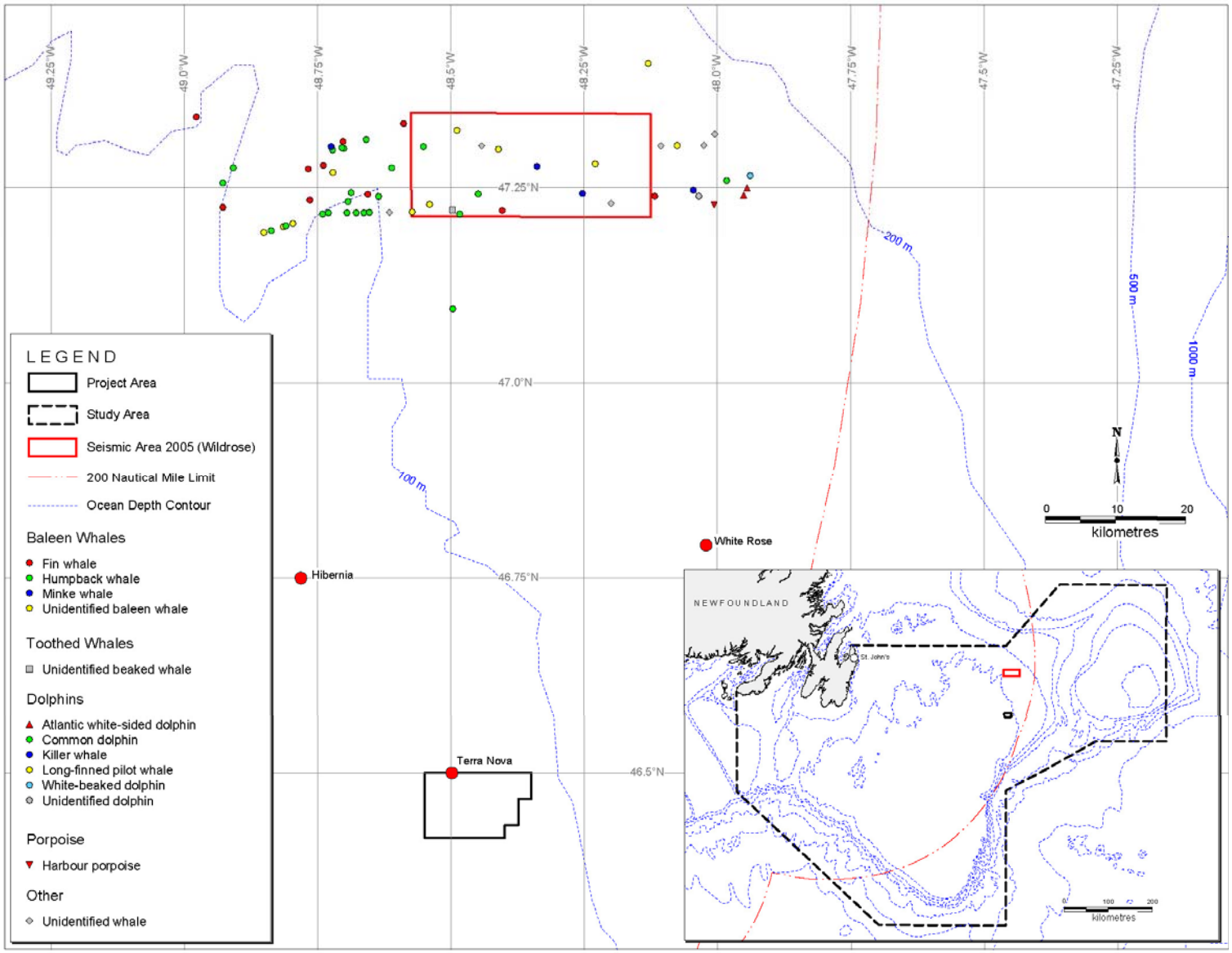


Figure 3. Marine mammal sightings made from the MV *Western Neptune* during Husky's Seismic Monitoring Program in the Jeanne d'Arc Basin during October and November 2005 (Lang et al. 2006). (Note that there was no survey effort at the Terra Nova site as effort was concentrated at Wildrose.)

Table 5. Population estimates of marine mammals that occur or may occur in the Study Area (updated from Buchanan et al. (2004)).

Species	Northwest Atlantic (NW) Population Size	Population Occurring in the Study Area		
	Estimated Number	Stock	Estimated Number	Source of Updated Information
Baleen Whales				
Blue Whale	308 [a]	NW Atlantic	Unknown	Waring et al. (2004: Appendix III)
Fin Whale	2814 [b]	Can. E. Coast	Unknown	Waring et al. (2004)
Sei Whale	Unknown	Nova Scotia	Unknown	COSEWIC (2004); Waring et al. (2004)
Humpback Whale	5505 (11,570 in North Atlantic)	NF/Labrador	1,700-3,200	Whitehead (1982); Katona and Beard (1990); Baird (2003)
Minke Whale	4018 [c]	Can. E. Coast	Unknown	Waring et al. (2004)
North Atlantic Right Whale	322	NW Atlantic	Unknown	Krauss et al. (2001)
Toothed Whales				
Sperm Whale	4702 [d]	North Atlantic	Unknown	Reeves and Whitehead (1997); Waring et al. (2004)
Northern Bottlenose Whale	Tens of thousands?	North Atlantic	Unknown	Reeves et al. (1993); Waring et al. (2004)
Sowerby's Beaked Whale	Unknown			Katona et al. (1993)
Common Bottlenose Dolphin (offshore stock)	29,774	NW Atlantic	Unknown	Waring et al. (2004)
Risso's Dolphin	30,000	US East Coast	Unknown	Reeves et al. (2003)
Killer Whale	Unavailable		Unknown	Lien et al. (1988); Waring et al. (2004)
Long-finned Pilot Whale	14,524	NW Atlantic	Abundant	Nelson and Lien (1996); Waring et al. (2004)
Short-beaked (Common) Dolphin	30,768	NW Atlantic	Unknown	Katona et al. (1993); Waring et al. (2004)
Atlantic White-sided Dolphin	51,640 [e]	NW Atlantic	Unknown	Palka et al. (1997); Waring et al. (2004)
White-beaked Dolphin	Unknown	NW Atlantic	Unknown	Waring et al. (2004)
Harbour Porpoise	Unknown	Newfoundland	Unknown	Wang et al. (1996); COSEWIC (2004); Waring et al. (2004)
True Seals				
Harp Seal	5.2 (±1.2) million	NW Atlantic	Unknown	DFO (2000)
Hooded Seal	626, 600	NW Atlantic	Unknown	Hammill and Stenson (2000)
Grey Seal	173,500	NW Atlantic	Unknown	Hammill and Stenson (2000)

[a] Based on surveys from the Gulf of St. Lawrence. This estimate deemed unsuitable for abundance estimation.
[b] Based on surveys from George's Bank to the mouth of the Gulf of St. Lawrence.
[c] Based on surveys from George's Bank to the mouth of the Gulf of St. Lawrence plus a survey in the Gulf of St. Lawrence.
[d] Based on surveys from Florida to the Gulf of St. Lawrence.
[e] Gulf of Maine Stock.

Table 6. Summary of marine mammal prey that occur or may occur in the Study Area.

Species	Prey	Source of Updated Information
Baleen Whales		
Humpback Whale	Fish (predominantly capelin), euphausiids	Piatt et al. (1989)
Blue Whale	Euphausiids	
Fin Whale	Fish (predominantly capelin), euphausiids	Piatt et al. (1989)
Sei Whale	Copepods, euphausiids, some fish	
Minke Whale	Fish (predominantly capelin), squid, euphausiids	Piatt et al. (1989)
North Atlantic Right Whale	Euphausiids and other crustaceans	
Toothed Whales		
Sperm Whale	Cephalopods, fish	Reeves and Whitehead (1997)
Northern Bottlenose Whale	Primarily squid, also fish	
Sowerby's Beaked Whale	Squid, some fish	Pitman (2002)
Bottlenose Dolphin	Squid, fish (mackerel, butterfish)	Gaskin (1992a)
Killer Whale	Herring, squid, seals, dolphins, other whales	Lien et al. (1988)
Long-finned Pilot Whale	Short-finned squid, northern cod, amphipods	Nelson and Lien (1996)
Short-beaked (Common) Dolphin	Squid, fish	Katona et al. (1993)
Atlantic White-sided Dolphin	Schooling fish (sand lance, herring), hake, squid	Palka et al. (1997)
White-beaked Dolphin	Fish (cod, capelin, herring), squid	Hai et al. (1996)
Risso's Dolphin	Squid	Reeves et al. (2003)
Harbour Porpoise	Schooling fish (capelin, cod, herring, mackerel)	
True Seals		
Harp Seal	Fish (capelin, cod, halibut, sand lance), crustaceans	Lawson and Stenson (1995); Lawson et al. (1998); Wallace and Lawson (1997); Hammill and Stenson (2000).
Hooded Seal	Fish (Greenland halibut, redfish, Arctic and Atlantic cod, herring), squid, shrimp, molluscs	Ross (1993)
Grey Seal	Fish (herring, cod, hake, pollock), squid, shrimp	Benoit and Bowen (1990); Hammill et al. (1995)

Source: Mobil (1985) with updates where indicated.

their primary prey is capelin (Whitehead and Glass 1985). Thirteen humpbacks were sighted offshore on the Grand banks during the offshore supply vessel survey in 1999; most of these sightings were in September (Wiese and Montevecchi 1999). Humpbacks were fairly common in the Jeanne d'Arc Basin during marine mammal monitoring of Husky's seismic program to the north of the Project Area (Lang et al. 2006). There was a total of 27 sightings (35 individuals) in 237 hours of observation during the program, which was conducted during October and early November 2005. Humpback whales were also observed during the summers of 2004 and 2005 in and near the Orphan Basin (Moulton et al. 2005; 2006b).

Recent research on humpbacks suggests genetic as well as spatial segregation between feeding areas within the North Atlantic (Valsecchi et al. 1997). The entire North Atlantic population is estimated at approximately 10,600 individuals (Smith et al. 1999), the northwest Atlantic population at 5,505 individuals (Katona and Beard 1990) and the Newfoundland/Labrador population at 1,700 to 3,200 (Whitehead 1982).

Humpback whales occur relatively commonly within the Study Area, in both shallow (<400 m) and deep (>400 m) areas. In terms of the number of sighting events recorded in the DFO database (DFO 2003c), humpback whales ranked first in Divisions 3K, 3L (inside and outside the EEZ) and 3M, particularly in the portion of Division 3L inside of the EEZ.

The western North Atlantic and North Pacific populations of humpback whale were singly designated by COSEWIC as 'threatened' in April 1982. In April 1985, they were split into separate populations, at which time the western North Atlantic population was designated as 'special concern'. In May 2003, this population was re-examined and subsequently de-listed (i.e., considered 'not at risk').

Blue Whale.—This species is considered endangered by COSEWIC and is listed as such on Schedule 1 of *SARA*. More information is found in Section 4 of this report.

Fin Whale.—The fin whale is commonly found on the Grand Banks during summer months (Piatt et al. 1989). Eight fin whales, including two calves, were sighted on the Grand Banks in August 1999, during an offshore supply vessel survey (Wiese and Montevecchi 1999). This species is associated with the presence of capelin, their predominant prey item in these waters (Piatt et al. 1989; Whitehead and Carscadden 1985).

Recent genetic studies indicate that fin whale populations that summer in Nova Scotia, Newfoundland, and Iceland may be genetically distinct from each other (Arnason 1995). The number of fin whales in the northwest Atlantic was recently estimated at approximately 2,800 (Waring et al. 2004). This is lower than estimates from previous reports, but supports the idea that fin whale numbers are decreasing off Newfoundland (Whitehead and Carscadden 1985).

According to the DFO cetacean sightings database, these common visitors to the Study Area have been sighted most often inside the EEZ in both Divisions 3K and 3L, particularly 3L. Fin whale sightings have occurred in both the shallower (<400 m) and deeper (>400 m) areas of the Study Area. During Husky Energy's seismic program in the autumn of 2005 there were ten sightings of fin whales (16 individuals) in 237 observation hours in Jeanne d'Arc Basin (Figure 3; Lang et al. 2006). The fin whale was regularly observed in the deeper waters of the Orphan Basin during the summers of 2004 and 2005 (Moulton et al. 2005; 2006b).

The fin whale is considered a species of 'special concern' by COSEWIC and is being considered for addition to Schedule 1 of *SARA.*

Sei Whale.—The sei whale has a cosmopolitan distribution, and prefers temperate oceanic waters (Gambell 1985). Sei whales are known for their high mobility and unpredictable appearances (Reeves et al. 1998). Incursions into nearshore waters of the Gulf of Maine, associated with high copepod densities, are well documented (Payne et al. 1990; Schilling et al. 1992).

No reliable population estimates are available for sei whales. A 1970s estimate for the Nova Scotia stock suggested a minimum population of 870 individuals (Mitchell and Chapman 1977). This

population was, until recently, only thought to range as far as the Grand Banks. Based on the DFO cetacean sightings database, no sei whale sightings have been reported in the larger Study Area since 1980. (Fin and sei whales are often hard to distinguish; this could partially explain the low number of reported sei whale sightings.) However, their range is currently known to extend well north of the Study Area. Several sei whales were identified in the Orphan Basin during the summers of 2004 and 2005 (Moulton et al. 2005; 2006b). These observations are the first documented sightings of sei whales in the area since 1980 (Buchanan et al. 2004). In 2004, there were six confirmed sightings consisting of nine individuals which accounted for 13.0% of all baleen whale sightings (11.4% of total baleen whale individuals). In 2005, there were 15 sightings (24 individuals) of sei whales in the Orphan Basin (13.7% of total baleen whale individuals). Sei whales are still considered uncommon in the Project Area. The Atlantic population of the sei whale is considered by COSEWIC as 'data deficient' (COSEWIC 2006).

Minke Whale.—Another baleen whale commonly found on the Grand Banks in summer is the minke whale (Piatt et al. 1989). Eight individuals were sighted along the near-shore half of an offshore supply vessel survey in August and September 1999 (Wiese and Montevecchi 1999). Like the fin whale, the minke whale is associated with the presence of capelin, their predominant prey item in these waters (Piatt et al. 1989; Whitehead and Carscadden 1985). The size of the northwest Atlantic population of minke whales is not well known, but the best available estimate is ~4000 individuals (Waring et al. 2004).

Minke whales commonly occur within the Study Area. Most of the reported sightings (based on the Regional Area defined in Husky 2000) in the DFO database (DFO 2003c) have occurred in Divisions 3K and 3L, inside the EEZ in areas with water depths <400 m. The minke whale was sighted in relatively lower numbers than humpback, fin and sei whales during the 2004 and 2005 monitoring programs in the Orphan Basin (Moulton et al. 2005; 2006b). In the Orphan Basin, minke whales were sighted in water depths ranging from 2208-2452 m. During Husky's 2005 seismic program in Jeanne d'Arc Basin, four individuals of this species were sighted in ELs 1066, 1067 and 1089 in depths of 112 to 164 m (Lang et al. 2006).

North Atlantic Right Whale.—The North Atlantic right whale is a slow-moving whale prone to collisions with ships. It feeds on krill and other crustaceans. The right whale is among the most endangered whales and today it is distributed only in the northwestern Atlantic and numbers about 300 individuals. Off Atlantic Canada, right whales typically concentrate in the Bay of Fundy and off southwestern Nova Scotia. However, some right whales are known to occur off Iceland and it is possible (although highly unlikely) that it may occur in the Project Area. This species is designated endangered by COSEWIC and is listed with this designation on Schedule 1 of the *SARA*.

4.3.1.2 Toothed Whales (Odontocetes)

Eleven species of toothed whales are found in the Study Area (Table 4). These species range from the largest living toothed whale, the sperm whale (at approximately 18 m for an adult male (Reeves and

Whitehead 1997)) to one of the smallest whales, the harbour porpoise (at approximately 1.6 m for an average adult (Gaskin 1992b)). Most of these marine mammals occur seasonally in the Study Area and little is known regarding their distribution and population size in these waters. The Scotian Shelf population of the northern bottlenose whale is a priority species under *SARA* due to its 'endangered' designation. However, the Davis Strait population of northern bottlenose whales is not considered at risk by COSEWIC (2006).

Sperm Whale.—Sperm whales have an extensive worldwide distribution (Rice 1989). This species routinely dives to depths of hundreds of metres and may occasionally dive to more than 3,000 m. They apparently are capable of remaining submerged for longer than two hours, but most dives probably last a half-hour or less (Rice 1989). The diet of sperm whales is dominated by mesopelagic and benthic squids and fishes (Reeves and Whitehead 1997).

Population numbers of sperm whales are not known for the NW Atlantic. Reeves and Whitehead (1997) caution that previous population estimates for this species are suspect given their long-distance movements and lack of any clear stock structure. There is evidence that stock delineation in this species may be dependent on the time scale of the measure used, further complicating reliable population estimation (Dufault et al. 1999). The few sightings of sperm whales reported in the DFO cetacean sightings database occurred in Division 3K, beyond the 400 m isobath. Sperm whales are known to feed in deep water and it is possible that they occur regularly beyond the continental shelf. Sperm whales were observed north of the Study Area in the Orphan Basin. There were five sightings in early July 2004 in water depths of 2600-2900 m (Moulton et al. 2005) and 32 sightings in June to October 2005 in water depths of 803-2547 m (Moulton et al. 2006b). Sperm whales are considered 'not at risk' by COSEWIC.

Sperm whales have previously been reported to be associated with areas of high plankton productivity and upwelling, presumably because the squid upon which they feed are in turn feeding on the zooplankton (Cushing 1969 *in* Griffin 1999). If sperm whale occur in or near the Project Area, it is likely that they would be males because females usually do not venture north of 40 degrees latitude (Griffin 1999; Whitehead 2003). Another relevant point is that they may not be highly concentrated as males tend to be more dispersed than females (S. Dufault, LGL, pers. comm.). On the East Coast to the south of Newfoundland, warm-core rings and Gulf Stream fronts have been identified as areas of concentration for sperm whales (Griffin 1999).

Northern Bottlenose Whale. —Northern bottlenose whales are found only in the North Atlantic, with a total population that may be in the tens of thousands (Reeves et al. 1993). Only a few individuals have been sighted on the Grand Banks. Similar to sperm whales, bottlenose whales can dive for periods well in excess of one hour, and their dives can reach depths of more than 1,000 m. They live primarily in deep canyon and slope areas, where they prey on squid and deep-sea fishes. They are rarely found in waters less than 500 m deep (Gowans 2002).

The Study Area is within the known range of the northern bottlenose whale. This whale's life history is poorly known and most records from Newfoundland are based on carcasses washed ashore. Water

depths in the Study Area do not exceed 500 m, and typically range between 100-200 m. Few bottlenose whales are expected to occur on the relatively shallow Grand Banks. Several bottlenose whales were observed during seismic monitoring programs in Orphan Basin in 2004 and 2005 but all in water depths >1000 m (Moulton et al. 2005; 2006b). None were sighted during the Husky monitoring program in the relatively shallow water of Jeanne d'Arc Basin during the autumn of 2005 (Lang et al. 2006).

The northern bottlenose whale that inhabits the Scotian Shelf is considered as 'endangered' by COSEWIC whereas the Davis Strait population is considered 'not at risk' (COSEWIC 2006). This species occurs in Newfoundland and Labrador waters but is unknown to what population they belong. It is unlikely that sightings of northern bottlenose whales in the Orphan Basin would be from the Scotian Shelf population as these whales are known to spend most of their time in the Gully, Haldimand and Shortland canyons on the Scotian Slope and their home ranges are thought to be a few hundred kilometers or less (Wimmer and Whitehead 2004).

Sowerby's Beaked Whale.—This beaked whale is also known as the North Sea beaked whale because its distribution appears to be centered there, based on numbers of strandings. In the 1980s, two mass strandings were recorded on the northeast coast of Newfoundland. One involved three animals and the other involved six (Katona et al. 1993). The Study Area lies within the known range of the Sowerby's beaked whale. This beaked whale is also a deep-sea diver that occurs mainly in areas where water depth is 1,000 m or more. As is the case with the northern bottlenose whale, the life history of the Sowerby's beaked whale is not well understood and most Newfoundland records of it involve carcasses washed ashore. There was one sighting (four individuals) of Sowerby's beaked whale in the Orphan Basin in September 2005 in a water depth of 2,534 m (Moulton et. al. 2006b). Water depths in the Project Area do not exceed 500 m, and typically range between 100-200 m. Few Sowerby's beaked whales are expected to occur on the relatively shallow Grand Banks. They are considered of 'special concern' by *SARA* (Schedule 3). A single beaked whale was recorded during the Husky seismic program in 2005 in Jeanne d'Arc Basin (Lang et al. 2006). This whale lacked the prominent melon of the northern bottlenose whale suggesting that it was a Sowerby's or other species of beaked whale. It was seen north of the Project Area in the southwest corner of EL 1067 in 128 m of water (Lang et al. 2006).

Bottlenose Dolphin.—A north-south migration has been assumed to occur along the east coast of North America, with bottlenose dolphins moving into higher-latitude areas in summer and fall, then moving farther south (or possibly just offshore) for the winter (Selzer and Payne 1988; Gowans and Whitehead 1995). The northern limit of this species range in the summer is likely the Flemish Cap (Gaskin 1992a). It is considered 'not at risk' by COSEWIC. No bottlenose dolphins were identified during the Chevron monitoring program in Orphan Basin in 2004 and there was one sighting (15 individuals) in 2005 (Moulton et al. 2005; 2006b). No bottlenose dolphins were identified during the Husky monitoring program in Jeanne d'Arc Basin in October and November 2005 (Lang et al. 2006).

Risso's Dolphin.—Risso's dolphin is widely distributed in tropical and warm temperate oceans (Reeves et al. 2003). It is usually found over deep water (>300 m) where they feed almost exclusively on squid. They are abundant worldwide but are probably rare in the in and near the Project Area (Reeves et al. 2003).

Killer Whale. —The killer whale is a year-round resident that is thought to occur in relatively small numbers in the Study Area (Lien et al. 1988). Three killer whales were sighted within 20 km of the White Rose area on August 24, 1999 (Wiese and Montevecchi 1999). On a global basis, killer whales are not endangered. There are no population estimates for the northwest Atlantic. No killer whales were identified during the Chevron monitoring program in Orphan Basin in 2004 and 2005 (Moulton et al. 2005; 2006b). Similarly, no killer whales were sighted in Jeanne d'Arc Basin during Husky's seismic program in the autumn of 2005, although a group was sighted about 100 nmi northeast of the Avalon Peninsula (Lang et al. 2006).

Long-finned Pilot Whale.—The most common toothed whale in the Study Area and also one of the only year-round residents is the long-finned pilot whale (also known as the Atlantic pilot whale). This species is considered abundant in the Grand Banks area from July through December. However, none were sighted during a recent offshore supply vessel survey (Wiese and Montevecchi 1999). This species was the most abundant marine mammal encountered in the Orphan Basin during the summer of 2004 and 2005(Moulton et al. 2005; 2006b). The northwest Atlantic population probably numbers between 4,000 and 12,000 individuals (Nelson and Lien 1996).

It is a common belief that long-finned pilot whales in the northwest Atlantic prey mainly on short-finned squid in summer. However, this statement is based largely on evidence from inshore waters of Newfoundland (Sergeant 1962), and other evidence suggests that they also prey on a variety of fish species, as well as additional species of cephalopods (especially long-finned squid, *Loligo pealei*) at other times and in other areas (Waring et al. 1990; Overholtz and Waring 1991; Desportes and Mouritsen 1993; Nelson and Lien 1996; Gannon et al. 1997).

Most of the Survey Area (and adjacent areas) pilot whale sightings found in the DFO database (3K, 3L and 3M) were reported in areas where water depth <400 m. It is considered 'not at risk' by COSEWIC.

Short-beaked Common Dolphin.—The short-beaked common dolphin's western North Atlantic range extends from Venezuela and the Gulf of Mexico to Newfoundland. These dolphins occur rather commonly at sea off Newfoundland, usually in groups ranging from 50 to 200 individuals. Most of the population in US waters is located south of Georges Bank in areas where water depth ranges between 100 and 200 m although they do occur out the 2,000 isobath. Short-beaked common dolphins eat a variety of fishes and squids (Katona et al. 1993).

Considering the water depth ranges in areas where this cetacean has been sighted in US waters, short-beaked dolphins could occur in the Project Area. This species was not observed during the 2004 CCL monitoring program in the Orphan Basin (Moulton et al. 2005) but there were nine sightings (88 individuals) in and near Orphan Basin in 2005 (Moulton et al. 2006b). One group of 15 individuals was sighted in EL 1089 during the autumn 2005 Husky monitoring program in Jeanne d'Arc Basin (Lang et al. 2006).

Atlantic White-Sided Dolphin.—There are three stocks of Atlantic white-sided dolphins in the northwest Atlantic: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea. The combined northwest

Atlantic population probably numbers 27,000 individuals (Palka et al. 1997). The number of white-sided dolphins in the Study Area is unknown. There were seven sightings of 250 individuals on the Grand Banks in August to September 1999, including several sightings within approximately 30 km of the White Rose site, during an offshore supply vessel surveys (Wiese and Montevecchi 1999). The most easterly recorded sighting for individuals from the northwest Atlantic population occurred on the Flemish Cap (Gaskin 1992c).

Few sightings of this dolphin within the Study Area are recorded in the DFO cetacean sightings database. The sightings that are recorded occurred both inside and outside the 400 m isobath. There were four sightings totaling 70 individuals in the Orphan Basin during the summer of 2004 (Moulton et al. 2005) and 18 sightings (304 individuals) in 2005 (Moulton et al. 2006b). During the Husky monitoring program in October and November 2005, two groups (25 individuals) were sighted to the north of the Project Area in EL 1089 in Jeanne d'Arc Basin (Lang et al. 2006).

White-beaked Dolphin.—The white-beaked dolphin tends to be a coastal, cool-water species (Reeves et al. 1999). This species seems to remain at relatively high latitudes throughout the fall and winter (Lien et al. 1997), but the nature of their seasonal movements is uncertain. During the summer, approximately 3,500 white-beaked dolphins occur off southern Labrador (Alling and Whitehead 1987). This species was regularly sighted during the 1980-81 Hibernia surveys, primarily during summer (Mobil 1985). There was one sighting totaling five individuals in the Orphan Basin during the summer of 2004 (Moulton et al. 2005) and six sightings (52 individuals) during the summer of 2005 (Moulton et al. 2006b). One group of eight individuals was sighted in Jeanne d'Arc Basin in EL 1089 in 181 m of water during the Husky monitoring program in autumn 2005 (Lang et al. 2006). There is no reliable population estimate for the northwest Atlantic and the abundance of this species in the Study Area is unknown. The total North Atlantic population may range from high tens of thousands to low hundreds of thousands (Reeves et al. 1999). Ice entrapment is not uncommon in the bays of southern Newfoundland in years when pack ice is heavy (Hai et al. 1996).

Harbour Porpoise. —The harbour porpoise is widely distributed throughout temperate waters, but its population size in Newfoundland waters is unknown (Gaskin 1992b). Harbour porpoises that occur in Newfoundland waters are believed to belong to a separate stock from those in the Gulf of St. Lawrence and Bay of Fundy/Gulf of Maine regions. This is supported by differences in organochlorine contaminant levels, which are lower in Newfoundland animals (Westgate and Tolley 1999), and by differences in mitochondrial DNA haplotype frequencies (Wang et al. 1996). The northwest Atlantic population of harbour porpoise was designated by COSEWIC as 'threatened' in April 1990 but in May 2003, it was downlisted to 'special concern'. Harbour porpoises may occur in the Project Area. Two members of this species were observed north of the Project Area on 7 October 2005 in EL 1089 in a water depth of 165 m during the Husky monitoring program (Lang et al. 2006).

4.3.1.3 True Seals (Phocids)

Three species of true seals may occur in the waters of the Study Area (Table 4). Populations of harp, hooded, and grey seals in Canada are thought to be increasing (Waring et al. 2004). Because of their

potential to interact with commercial fisheries, reasonable population estimates for the northwest Atlantic are now available for most seal species. The main diet of seals consists of fish (including capelin, cod, halibut and sand lance) and invertebrates such as squid and shrimp (Table 6), with considerable seasonal, geographic and interannual variation in diet (Hammill et al. 1995; Lawson and Stenson 1995; Wallace and Lawson 1997). Other seal species (harbour, bearded, and ringed seals) may occur occasionally.

Harp Seal.—Harp seals whelp in the spring in the Gulf of St. Lawrence and in an area known as the 'Front' off southern Labrador and northeastern Newfoundland (Sergeant 1991; DFO 2000). The main whelping patch for the northwest Atlantic breeding stock of harp seal is well north of the Study Area. In heavy ice years, it is likely harp seal whelping herds extend into the Regional Area defined in Husky (2000). Individuals from these two areas spend the summer in the Arctic and then migrate south in the autumn. Surveys conducted during the early 1990s suggested that offshore waters on the northern edge of the Grand Banks in NAFO fishing area 3L were an important over-wintering area for some animals during those years (Stenson and Kavanagh 1994). Sighting effort from these surveys within the Regional Area was low, but harp seals were present in low numbers. Similarly, data from satellite transmitters deployed on harp seals suggest that the Grand Banks is an important wintering area for some seals (Stenson and Sjare 1997). It is possible that more harp seals are occurring south of this area in recent years because there has been an apparent change in their distribution. There has been a documented increase in the extralimital occurrences (south of normal range) of harp seals in the northern Gulf of Maine (McAlpine et al. 1999), which may also be occurring in the Grand Banks area. This southward expansion may be related to the increase in the harp seal population or the recent changes in ocean ecology that may be affecting their foraging success (McAlpine et al. 1999). The total population estimate of harp seals in the northwest Atlantic is currently 5.2 (±1.2) million (DFO 2000).

The diet of harp seals foraging off Newfoundland and Labrador appears to vary considerably with age, season, year and location. On the Grand Banks and Labrador Shelf, capelin predominates, followed by sand lance, Greenland halibut and other pleuronectids (Wallace and Lawson 1997; Lawson et al. 1998). Recent "historical" data on the diet of harp seals greater than a year old from northeast Newfoundland, indicates that there was a shift in prey from capelin in 1982 to Arctic cod in 1986 and beyond, while Atlantic cod remained relatively unimportant throughout this period. Harp seals collected from nearshore waters forage intensively on a variety of fish and invertebrate species, although most of the biomass is derived from relatively few species, particularly Arctic cod, capelin, Atlantic cod, Atlantic herring and some decapod crustaceans. A recent consumption model estimates that harp seals consume less Atlantic cod than once believed as seals apparently spend more time offshore than previously thought (Hammill and Stenson 2000).

Hooded Seal.—Like the harp seal, the hooded seal is a North Atlantic endemic species that reproduces on the spring pack ice of the Gulf of St. Lawrence and along the Labrador coast, and then migrates northward to the sub-Arctic and Arctic to feed during the summer (Lydersen and Kovacs 1999). Data collected from satellite transmitters deployed on hooded seals in the Gulf of St. Lawrence indicate that some females feed near the Flemish Cap after breeding while migrating to Greenland waters (G.B. Stenson, unpubl. data). Tagged males migrating to Greenland in early summer were recorded along the

Grand Banks shelf edge near the Flemish Pass. It appears that males spend little time foraging in this area (G.B. Stenson, unpubl. data). Little is known regarding their winter distribution, although it is believed that the majority of seals remain offshore; they have been seen feeding off the Grand Banks in February. Surveys in the early 1990s suggested that, as was the case for harp seals, the offshore waters on the northern edge of the Grand Banks also might be an important over-wintering area for hooded seals (Stenson and Kavanagh 1994). Hooded seal sightings in the Regional Area (defined in Husky 2000) during these surveys were less frequent than harp seal sightings. The number of visitors to the Study Area is unknown. However, these numbers may be increasing as hooded seals are apparently expanding their southern range of occurrence (McAlpine et al. 1999) and population numbers are increasing. Hooded seals increased from 470,000 individuals in 1990 to ~627,000 in 1996 (Hammill and Stenson 2000).

Hooded seals consume a variety of prey. In nearshore areas of Newfoundland, prey (in decreasing order of total wet weight) includes: Greenland halibut, redfish, Arctic cod, Atlantic herring and capelin. Relatively small amounts of squid (*Gonatus* spp.) and Atlantic cod were also found (Ross 1993). Data from offshore areas are limited, but suggest that similar prey species are consumed (J.W. Lawson and G.B. Stenson, unpubl. data).

Grey Seal.—Grey seals that might occur in the Study Area are likely migrants from the Sable Island and Gulf of St. Lawrence breeding populations. This species occurs in the Regional Area year-round, but most commonly in July and August (Stenson 1994). The Sable Island and Gulf of St. Lawrence breeding areas account for essentially all of the pup production in the northwest Atlantic, which increased exponentially between 1977 and 1989 (Stobo and Zwanenburg 1990). The eastern Canadian population of grey seals was estimated at 173,500 in 1996 (Hammill and Stenson 2000). The number that migrates into the Study Area is unknown, but is believed to be low.

Grey seals are less tied to coastal and island rookeries than are harbour seals. They travel long distances, one individual having been tracked over a distance of 2,100 km (McConnell et al. 1999). The food of grey seals in the western North Atlantic includes at least 40 species, some of which are commercially important (for example, Atlantic cod, herring, and capelin) (Benoit and Bowen 1990; Hammill et al. 1995; Hammill and Stenson 2000).

4.3.2 Sea Turtles

Sea turtles are probably not common in the Study Area but are important to consider because of their threatened or endangered status, both nationally and internationally. Three species of sea turtles may occur in the Study Area: (1) the leatherback, (2) the loggerhead, and (3) the Kemp's ridley (Ernst et al. 1994). However, little can be said to qualify, much less quantify, the degrees of occurrence of these three sea turtle species within the Study Area due to lack of information. No sea turtles were sighted during monitoring of seismic exploration of Jeanne d'Arc Basin to north by Husky in October and early November 2005 (Lang et al. 2006). The leatherback turtle is listed as endangered by COSEWIC (2006) and by the United States National Marine Fisheries Service (NMFS) and Fish and Wildlife Service (FWS) (Plotkin 1995). Due to its risk designation by COSEWIC, the leatherback turtle is considered a

priority species under *SARA*. The Kemp's ridley is also listed as endangered and the loggerhead turtle is listed as threatened by NMFS and FWS (Plotkin 1995).

4.3.2.1 Leatherback Turtle

This species is considered endangered by COSEWIC and is listed as such on Schedule 1 of *SARA*. More information is found in Section 4 of this report.

4.3.2.2 Loggerhead Turtle

This species is the most abundant sea turtle in North American waters (Ernst et al. 1994; Plotkin 1995). The loggerhead turtle winters in the south, but some individuals migrate north into the Canadian Atlantic with the Gulf Stream in summer (Cook 1984). An estimate of the population size in the Study Area is unavailable; however, loggerheads are thought to occur in these waters during summer and fall. Loggerheads found in Canadian waters are generally smaller than those found in coastal US waters, indicating that they are younger animals (Witzell 1999).

Loggerhead turtles apparently dwell in both coastal and offshore waters but generally associate with convergence zones, drift lines and downwellings (Carr 1986). Continental shelf waters are believed to be important because they contain known loggerhead prey like crabs, molluscs, sea pens and various gelatinous organisms (Payne et al. 1984). Loggerheads also eat algae and vascular plants (Ernst et al. 1994). Data from the US pelagic longline fishery observer program have added to the knowledge of loggerhead distribution off Newfoundland (Witzell 1999). Seventy percent of loggerheads (936 captures) caught incidentally by this fishery between 1992 and 1995 from the Caribbean to Labrador were captured in waters on and east of the 200 m isobath off the Grand Banks. Animals were caught in this region during all months from June to November, with a peak in captures during September. Within these waters, loggerhead captures corresponded closely with fishing effort, both clustered near the 200 m isobath where oceanographic features concentrate prey species for both the turtles and the swordfish and tuna that are the targets of the longline fishers.

The loggerhead turtle may achieve sexual maturity at an age of 30 to 50 years and one of the largest breeding aggregations is found on the central Atlantic coast of Florida (Magnuson et al. 1990). In fact, 90 percent of females nesting in the Atlantic do so in the southeastern US in what appear to be demographically independent groups (based on mitochondrial DNA haplotype distributions) (Encalada et al. 1998). Most females nest from three to five times in a season and average clutch sizes are between 95 to 150 eggs per nest (LeBuff 1990). It is unlikely that loggerhead sea turtles will occur in the Study Area. No loggerhead sea turtles were sighted during CCL's 2004 monitoring program in the Orphan Basin (Moulton et al. 2005).

4.3.2.3 Kemp's Ridley Turtle

Kemp's ridleys are the smallest (40 to 50 kg) and rarest of all sea turtles within the Newfoundland area (Cook 1984). These turtles apparently prefer shallow water and while adults rarely range beyond the

Gulf of Mexico, juveniles have been sighted along the southeast coast of Newfoundland near St. Mary's Bay and along southern Nova Scotia (Ernst et al. 1994). However, the number of Kemp's ridley turtles that may visit the Study Area is unknown, but likely low. They apparently prefer shallow water and feed primarily on crabs, but occasionally they eat molluscs, fish, shrimp and vegetation (Shaver 1991).

This species has a very restricted nesting range, with 95 percent of nests laid along a 60-km stretch of beach in Rancho Nuevo, Mexico. The number of females nesting there declined from as many as 40,000 over 50 years ago to approximately 700 in the late 1980s, but saw a steady increase in the 1990s as a result of conservation measures (Marquez et al. 1999). It is unknown how long this species lives or at what age it reaches sexual maturity. More than half of the adult females nest every year between April and August (NRC 1990). They lay an average of 3.1 clutches per season, with an average of 103 eggs per clutch (Rostal 1991). After a 48 to 65-day incubation period, eggs hatch and hatchlings head for the sea (Mager 1985). Both eggs and hatchlings are very vulnerable to predators like ghost crabs, coyotes and hawks (Plotkin 1995).

4.4 Sensitive Habitats and Times

Most important fishery areas are concentrated at more than 25-km distant from Terra Nova. As indicated in the following section, a number of *SARA*-listed and COSEWIC-listed species may occur in the Terra Nova area on more than a sporadic or 'stray' basis. These species are discussed in more detail below.

4.5 Species at Risk

The following subsections provide an overview of species listed on *SARA* and/or considered at risk by COSEWIC. Emphasis is given to those species listed as endangered or threatened on Schedule 1 of *SARA*. Only those species listed as threatened or endangered on Schedule I have special legal protection under *SARA* in terms of recovery strategies, penalties to be incurred for harming or killing individuals of the species, or destroying critical habitat. It is not Petro-Canada's intention to contravene the prohibitions of *SARA*. Status of species that may occur at Terra Nova, at least sporadically, are shown in Table 7.

Petro-Canada will apply adaptive management measures to deal with any changes to Schedule 1 of *SARA*. Each year prior to commencement of the drilling season, Petro-Canada will consult with DFO and Environment Canada regarding any listing changes of Schedule 1 species, releases of Recovery Strategy Plans, and possible mitigation measures as they relate to Species at Risk.

Species profiles for those species most likely to be encountered in the Terra Nova area are provided below.

Table 7. *SARA* and COSEWIC listed species potentially occurring in the Jeanne d'Arc Basin Area (updated October 2006).

Species	*SARA* Status	COSEWIC Status (date of most recent status report)	Comments
Atlantic Salmon (*Salmo salar*) (Bay of Fundy)	Schedule 1: Endangered	Endangered (April 2006)	Some strays are possible. Mostly in NB, NS but also in broader area of Atlantic Ocean.
Atlantic cod (*Gadus morhua*)	Schedule 3: Special Concern	Endangered (May 2003)	High likelihood of occurrence.
Porbeagle shark (*Lamna nasus*)	*No status; under consideration for addition to Schedule 1*	Endangered (May 2004)	Moderate likelihood of occurrence.
White shark (*Carcharodon carcharias*)	*Not on SARA website.*	Endangered (April 2006)	Low likelihood of occurrence.
Northern wolffish (*Anarhichas denticulatus*)	Schedule 1: Threatened	Threatened (May 2001)	Moderate likelihood of occurrence.
Spotted wolffish (*Anarhichas minor*)	Schedule 1: Threatened	Threatened (May 2001)	Moderate likelihood of occurrence.
Shortfin Mako Shark (*Isurus oxyrinchus*)	*Not on SARA website.*	Threatened (April 2006)	Moderate likelihood of occurrence.
Cusk (*Brosme brosme*)	*No schedule or status.*	Threatened (May 2003)	Low likelihood of occurrence.
Atlantic Wolffish (*Anarhichas lupus*)	Schedule 1: Special Concern	Special Concern (November 2000)	Moderate likelihood of occurrence.
American eel (*Anguilla rostrata*)	*Not on SARA website.*	Special Concern (April 2006)	Low likelihood of occurrence.
Blue shark (*Prionace glauca*)	*Not on SARA website.*	Special Concern (April 2006)	Moderate likelihood of occurrence.
Ivory Gull (*Pagophila eburnea*)	Schedule 1: Special Concern	Endangered (April 2006)	Extremely unlikely to occur in the Project Area during June to December as this species is associated with ice.
Blue Whale (*Balaenoptera musculus*)	Schedule 1: Endangered	Endangered (May 2002)	Very uncommon; more likely to be encountered in the Gulf of St. Lawrence and south coast of Newfoundland than the Jeanne d'Arc Basin.
North Atlantic Right Whale (*Eubalaena glacialis*)	Schedule 1: Endangered	Endangered (May 2003)	Extremely rare, highly unlikely to occur in Project Area. Predominantly occur in and near Bay of Fundy in Canadian waters.
Fin Whale (*Balaenoptera physalus*)	Schedule 1: Special Concern	Special Concern (May 2005)	Likely abundant within the Project Area.
Sowerby's Beaked Whale (*Mesoplodon bidens*)	Schedule 3: Special Concern	Special Concern (April 1989)	Unlikely to occur in the Project Area.
Harbour porpoise (*Phocena phocena*)	*No schedule or status; refered back to COSEWIC*	Special Concern (April 2006)	Likely to occur within the Project Area.
Leatherback Sea Turtle (*Dermochelys coriacea*)	Schedule 1: Endangered	Endangered (May 2001)	Likely very uncommon.

4.5.1 Wolffishes

In the northwest Atlantic, there are three wolffish species (*Anarhichus* spp.) distributed from Davis Strait to Maine. Kulka et al. (2004) examined changes in distribution and habitat associations of three species of wolffish on the Grand Banks and Labrador Shelf using data collected during DFO RV surveys in the spring and fall between 1971 and 2003. The three wolffish species are at the center of their distributions, reaching highest density and covering the largest area on the northeast Newfoundland and Labrador Shelf. On the Shelf, they distribute over a wide range of depths (25 to 1,400 m) with the northern wolffish exhibiting the widest distribution of the three species, and the Atlantic or striped wolffish exhibiting the narrowest. Kulka et al. (2004) demonstrated the importance of water temperature to wolffish habitat. All three wolffish species appear to be associated with an extremely narrow range of bottom water temperature (1.5 to 4.5 ºC). These fish appear to avoid areas where water temperature <0 ºC. Kulka et al. (2004) also discussed the relationship between the three wolffish species and sediment type. They reported that Atlantic wolffish and spotted wolffish were widely distributed on various sediment types while northern wolffish appear to prefer areas with sediments consisting of sand/shell hash, gravely sand and/or rock. Atlantic wolffish occurring in near-shore areas appear to avoid areas where there is potential for the substrate to get stirred up (e.g., mud). The distributions of both northern and spotted wolffish indicated by 1995-2003 trawl data are concentrated towards the Shelf edge. Kulka et al. (2004) did not establish a clear link to survival or the proximal causes of change in habitat but did demonstrate that thermal conditions appear to affect wolffish population abundance. Note that wolffish are solitary, territorial fish that build nests on the ocean bottom. The abundances of spotted and striped wolffish have been increasing slowly for several years.

Striped wolffish in Newfoundland waters spawn in September and the early juvenile stage remains close to the spawning location. Spotted wolffish are thought to spawn in late autumn or early winter. On the Grand Banks where the survey takes place, wolffish young-of-the-year (YOY) are more abundant in the northern part of the surveyed area (i.e., more in 3K than in 3L) (Simpson and Kulka 2002). The juvenile stages of all three wolffish species appear to be semi-pelagic.

The spotted wolffish and striped wolffish are regarded as commercial species in Newfoundland waters while the northern wolffish is not (Simpson and Kulka 2002). The spotted and northern wolffish occur in deep water (>475 m) where water temperatures normally range between 3 and 4ºC. They are thought to spawn during the late fall/early winter months. Wolffishes typically feed on a variety of benthic invertebrates and various fish.

DFO is presently preparing a 'Wolffish Recovery Strategy and Management Plan' (J. Simms, DFO biologist, pers. comm.). D. W. Kulka of DFO is the Chair of the 'Wolffish Recovery Team" and author of the "Wolffish Recovery Plan'. Both the northern wolffish and spotted wolffish are incidentally captured in fisheries directed at other commercial species, particularly Greenland halibut and snow crab. Incidental capture in the commercial fishery is considered the dominant source of human induced mortality for these two wolffish species. Permitting, education regarding live release, and gear modification have been identified as the key issues in ensuring the survival of these fish (DFO 2004a; Simpson and Kulka 2003). DFO (2004a) conducted a workshop on northern and spotted wolfish

designed to describe conditions that would allow human activity to occur without affecting recovery of the species. It was decided that recent levels of mortality (2000-2002) do not impair the ability of these two wolffish species to recover. It was noted that the commercial fishery was identified as the greatest source of human-induced mortality for these fish. Since many of the fisheries that result in incidental catches of northern and spotted wolffish are expected to decline over the next few years, mortality of these fish should also decline. DFO (2004a) also concluded that offshore oil and gas activities will result in negligible effects on wolfish.

4.5.2 Atlantic Cod

Atlantic cod has historically been distributed throughout Newfoundland and Labrador waters. It spawns both inshore and offshore in the Newfoundland-Labrador region. Both the eggs and larvae of this gadoid are planktonic. Atlantic cod fertilized eggs, larvae and early juvenile stages remain in the plankton for 10 to 12 weeks. Juvenile Atlantic cod eventually shift from a pelagic diet to a benthic diet. This occurs gradually over a standard length range of about 4 to 10 cm and seems to be related to change in fish gape size. At the smaller standard lengths, the gape size is appropriate for feeding on smaller pelagic prey only but as the fish grow, the larger gape size allows them to feed on larger benthic prey (Lomond et al. 1998). Cod larvae and pelagic juveniles are primarily zooplankton feeders but once the switch is made to the demersal lifestyle, benthic and epibenthic invertebrates become the main diet. As the fish grow, the array of prey also widens. Prey often includes various crustaceans (crab, shrimp, euphausiids) and fish (capelin, sand lance, redfish, other cod, herring). Adult cod are commonly prey for seals and toothed whales, while juvenile cod are commonly preyed upon by squid, Pollock and adult cod (Scott and Scott 1988).

The stock of Atlantic cod that occurs off northeast Newfoundland and Labrador is known as the 'northern' cod. The northern cod ecosystem historically encompassed a vast area from the northern Labrador Shelf to the Grand Bank. Declines in this stock occurred first in the northern part of its distributional area (NAFO Divisions 2GH) in the late 1950s, 1960s and 1970s, and then southward (NAFO Division 2J) in the late 1980s and early 1990s. By the mid-1990s, most of the remaining biomass was located in the southern part of the historical distributional area of this cod stock (NAFO Divisions 3KL) (Rose et al. 2000). There is one belief that adult cod shifted their distribution southward in the late 1980s and early 1990s (deYoung and Rose 1993) while others claim that this apparent distributional shift was due to local overfishing, first in the north and then proceeding southward (Hutchings 1996; Hutchings and Myers 1994).

Historically, many of the northern cod migrated between overwintering areas in deep water near the shelf break and feeding areas in the shallower waters both on the plateau of Grand Bank and along the coasts of Labrador and eastern Newfoundland. Some cod remained in the inshore deep water during the winter. For centuries, several nations harvested cod while they were in the shallower inshore waters, first with hook and line and later with nets that eventually evolved into the highly effective Newfoundland cod trap. The deep waters, both inshore and offshore, remained refugia until the 1950s when longliners and bottom trawlers joined the fishery. European bottom trawlers initially exploited the outerbanks cod in summer and autumn but eventually extended the fishing to winter and early spring

when the cod were highly aggregated. At the same time as offshore cod landings increased dramatically, the longliners fishing deep inshore waters introduced synthetic gillnets to the fishery.

The number and individual size of the fish declined through the 1960s and 1970s. Fishing effort by the expanding Canadian trawler fleet increased dramatically following Canada's extension of jurisdiction to 200 miles in 1977. The total allowable catch doubled between 1978 and 1984 due to an overestimation of stock size during this period. The stock was finally closed to Canadian fishing in July 1992 due to its decline (Lilly et al. 2001).

The northern cod has been called one of the least productive of the major cod stocks (Brander 1994). Historically, Atlantic cod spawned on the northeast Newfoundland shelf in late winter and spring, and then migrated shoreward across the shelf to the inshore feeding grounds, annually traversing distances of 500 km and more. Cross-shelf migration routes in spring followed thermal highways along deeper basins and trenches wherein warmer, deeper northwest Atlantic waters undercut the colder surface waters of the Labrador Current (e.g., an area on the northeast shelf known as the 'Bonavista Corridor') (Rose 1993). Ollerhead et al. (2004) indicated that between 1998 and 2002, the largest number of spawning cod along the northeast shelf edge of the Grand Banks occurred in June. Data from 1972 to 1997 indicated the highest number of spawning fish on the northeast shelf edge in April to June, peaking in May (Ollerhead et al. 2004).

After spawning, cod on the northeast Newfoundland shelf initially move southward with the dominant currents. Once they turn shoreward, as they do within the Bonavista Corridor, the dominant currents may flow offshore, against and across the direction of migration. But flows in the deeper, warmer waters of the Bonavista Corridor at times reverse and flow shoreward.

The offshore biomass index values from the fall research bottom trawl surveys in 2J3KL have been very low for the past 10 years. The average trawlable biomass of 28,000 mt during 1999-2002 is about 2% of the average in the 1980s (DFO 2003a). The same trend has been evident on the Flemish Cap during recent years (Vázquez 2002).

The last substantial offshore concentrations of cod were seen at approximately 49-50ºN on the outer shelf and upper slope as the stock collapsed. This is also one of few offshore areas where a very modest increase in cod density has been seen in recent years. In addition, a substantial portion of the cod stock used to overwinter on the northeastern slope of Grand Bank and the Nose of the Bank prior to the collapse of the stock. There have not been any recent winter surveys in these areas so recent cod concentrations are unknown. Nonetheless, these could be critical areas in the recovery of the offshore northern cod. Most cod are found shallower than the 900-m depth (G. Lilly, DFO, pers. comm.). Kulka et al. (2003) mapped the distributions of Atlantic cod on the Grand Banks based on spring and fall DFO research survey data collected between 1972 and 2002.

In March 2003, the FRCC released some recommendations for the Northern Cod. For the bank sub-stocks, the Council recommended a higher level of protection than has been in place since commencement of the moratorium. In order to reduce by-catch mortality and disturbance to spawning

and juvenile cod, the FRCC recommended the establishment of experimental 'cod boxes' in both the Hawke Channel and the Bonavista Corridor. The FRCC recommended that these areas be protected from all forms of commercial fishery (except snow crab trapping) and other activity such as seismic exploration (www.frcc-ccrh.ca).

In August 2003, the Government of Canada and the Government of Newfoundland and Labrador formed the Canada-Newfoundland and Labrador Action Team for Cod Rebuilding. This Cod Action Team (CAT) was to be led at the federal level by the Department of Fisheries and Oceans (DFO) and provincially by the Newfoundland and Labrador Department of Fisheries and Aquaculture (DFA), and was mandated to develop a stock rebuilding and long-term management strategy for the four major cod stocks adjacent to the province of Newfoundland and Labrador (http://www.dfo-mpo.gc.ca/cod-morue/strategy_overview_e.htm).

The Canada-NL CAT has engaged in collaborative efforts. In addition to the regular exchange of documents and information among the three CATs, there have been numerous face-to-face meetings, workshops and teleconferences where content and process issues were discussed. As well, the Cod Action Teams have provided regular updates to Deputies and Ministers through the Atlantic Council of Fisheries and Aquaculture Ministers (ACFAM) processes.

The plans of all three CATs propose advancing precautionary management decision-making frameworks that use multiple indicators of stock status and productivity, that define reference points for delimiting the "healthy", "cautious" and "critical" zones proposed by the DFO precautionary approach model, and specify the need for pre-agreed decision rules.

All plans propose using a suite of biological indicators related to stock abundance and productivity conditions in decision rules, although possibly in different ways. Of course, there are variations among the CATs related to their proposals: The Quebec plan is unique in proposing the inclusion of social and economic indicators (termed "objectives"), while the Canada-Maritimes Scotia-Fundy Strategy is unique in proposing inclusion of regulatory compliance indicators in Total Allowable Catch (TAC) decision rules.

On November 14, 2005, the Cod Rebuilding Strategy Report was presented to the ACFAM for their review. The ACFAM approved the release of the Report, noting that it represents an important step toward the rebuilding of Atlantic cod stocks, but that considerable work has yet to be done, including analysis of some of the recommendations and development of an implementation plan.

All governments recognize the need for continued multilateral cooperation and collaboration for the rebuilding of Atlantic cod stocks. As such, the ACFAM directed the Atlantic Fisheries and Aquaculture Committee (AFAC) to continue to monitor progress and implementation of the Strategies, and to report back to Deputies and Ministers, as necessary.

According to DFO's 2006 assessment of 2J3KL northern cod, mortality of cod in the offshore is exceedingly high. Spring and fall research bottom-trawl surveys in 2005 indicated that biomass of cod

remains low. The average biomass index from fall surveys between 2003 and 2005 was approximately 2% of the average during the 1980s. Fall survey data indicate that recruitment in the offshore is low and that total mortality has been extremely high since at least the mid-1990s (DFO 2006).

4.5.3 Sharks

Porbeagle sharks are large, cold-temperate pelagic fish that are known to occur over a depth range of surface to 715 m. The highly migratory porbeagle tends to be most abundant on continental offshore fishing banks but is also found far from land in ocean basins and occasionally inshore (Scott and Scott 1988; DFO 2005a,b; SAUP 2006).

Porbeagle sharks are predators of various fish species and cephalopods (Campana et al. 2001). Pelagic species are the primary prey of this shark during the spring and summer, followed by a shift to groundfish species in the winter. This prey shift reflects the seasonal change of distribution of porbeagle (i.e., migration to deeper areas in fall and winter) (Campana et al. 2001).

The great white shark is a highly migratory fish whose occurrence has been recorded over a broad depth range of surface to 1,280 m. This shark is primarily a coastal and offshore inhabitant of continental and insular shelves but it also occurs off oceanic islands far from any mainland. In Canadian waters, great white sharks occur primarily between April and November, mostly during August (Scott and Scott 1988; SAUP 2006).

The known depth range of occurrence of the migratory shortfin shark is 0 to 740 m., although it is usually found in surface waters down to about 150 m. While typically oceanic, the shortfin mako is sometimes found close inshore (Scott and Scott 1988).

The highly migratory blue shark is pelagic and has a known vertical distribution ranging from surface to 350 m. While primarily oceanic, this shark may be found close to shore where there is a narrowing of the continental shelf (Scott and Scott 1988; SAUP 2006).

4.5.4 Other Fish

Inner Bay of Fundy Atlantic salmon is included as 'endangered' on Schedule I of *SARA*. Atlantic salmon (*Salmo salar*) is an anadromous fish that lives in freshwater rivers for the first two years of life before migrating to sea. During the spring and summer, salmon migrate from northeastern North America to waters off Labrador and Greenland to feed for one or more years. While at sea, adult salmon consume euphausiids, amphipods, and fishes such as herring, capelin, small mackerel, sand lance, and small cod, and are prey of seals, sharks, pollock and tuna (Scott and Scott 1988). They return to coastal North America in the fall, possibly passing through the Grand Bank region during their migration from sea (Ritter 1989 *in* JWEL 2003). Therefore, it is possible that Atlantic salmon migrate through the proposed Study Area during movements to and from the ocean feeding grounds. There is some thought that the Inner Bay of Fundy salmon feed in the Gulf of Maine and therefore, probably do not migrate through the Project Area. However, there is still considerable uncertainty associated with the migratory

patterns of these fish. Specifics such as dimensions and location of a migratory corridor, size and timing of migration through the area, and the origins of the migrating salmon are unknown.

Cusk (*Brosme brosme*) are solitary, slow-swimming groundfish that occur on both sides of the North Atlantic. In Canadian waters, this species is most common in the Gulf of Maine, Gulf of St. Lawrence and the southwestern Scotian Shelf although its range is indicated for the entire Grand Banks (Scott and Scott 1988). Although most common within a depth range of 128 to 144-m, some have been caught as deep as 600 m. The diet of cusk is not well documented because their stomachs usually evert when they are brought to the surface. Studies have shown that in European waters, cusk feed on crab, molluscs, krill, cod, and halibut. Their diet is presumed to be the same in Canadian waters (Scott and Scott 1988). An allowable harm assessment for cusk in Atlantic Canada was recently prepared by DFO (DFO 2004b).

It is known that this catadromous fish spawns at sea but few specifics relating to the movements of adults and larvae at sea are understood (Scott and Scott 1988). It is speculated that adult American eels spawn in the Sargasso Sea, located south of Bermuda and east of the Bahamas but migration corridors between the Sargasso Sea and the Atlantic Canadian coast are not defined. Although unlikely, adult and/or larval American eels could occur on the Grand Bank, the adults in late summer/fall and the larvae in spring.

4.5.5 Ivory Gull

Ivory Gull (*Pagophila eburnea*) breeds in high Arctic Canada, Greenland and northern Eurasian. It winters among the sea ice within its breeding range and slightly farther south. The southern-most extent of its range is the northwestern Atlantic where it reaches northern Newfoundland waters (Haney and MacDonald 1995). Ivory Gull often feed from the wing over water, dip feeding for small fish and invertebrates on the surface. They occasionally plunge-dive so that the entire body may be submerged momentarily. They also swim and pick at the surface of the water and walk on ice to scavenge animal remains.

Ivory Gull is classified as a species of 'special concern' under *SARA* (www.speciesatrisk.gc.ca). This is likely to change to 'endangered' because COSEWIC upgraded the status to 'endangered' in April 2006 (P. Thomas, CWS, pers. comm.) It is rare on a global scale with fewer than 14,000 pairs. The Canadian Arctic supports a significant but declining population of Ivory Gull. The Canadian breeding population was estimated at 2,400 individuals in the early 1980s (Thomas and MacDonald 1987). Extensive surveys of historic breeding sites and adjacent breeding habitat in 2002 and 2003 and interviews with Inuit residents indicate the breeding population in Canada has declined by 80% (Gilchrist and Mallory 2005). Reasons for the apparent decline of the Canadian breeding population are uncertain.

The winter range of the Ivory Gull in the Northwest Atlantic is among sea ice from the Davis Strait south to about 50º to the Labrador Sea (Orr and Parsons, 1982 *in* Haney and MacDonald 1995), extending south in pack ice to the northeast coast of Newfoundland (Brown 1986; McLaren et al. 1983). Very little published information exists on Ivory Gull at sea off eastern Newfoundland. In 1981, an

aerial survey route of Petro-Canada's OLABS Program centered about Funk Island (N49° 45' W53°11') resulted in several Ivory Gull sightings. There were four sightings ranging from 1-5 individuals on the February survey and four sightings ranging from 1-5 individuals on the March survey (McLaren et al. 1983). These sightings are about 450 km northwest of the northern Grand Banks. Ivory Gulls have been documented on the northeast Avalon Peninsula at roughly the same latitude as the Project Area. Winter storms occurring in January to April storms very occasionally bring small numbers of Ivory Gulls to the St. John's area (B. Mactavish, unpubl. data). Ivory Gulls (21 in total) have been reported by environmental monitors from drill platforms on the northeast Grand Banks in 1999-2002; these observations should be treated with caution as most individuals were reported during ice-free periods (Baillie et al. 2005). There is a possibility that Ivory Gulls were confused with Iceland Gull (*Larus glaucoides*), which are relatively more abundant and whose presence is not necessarily correlated with the presence of ice. At a distance Ivory and Iceland Gulls can be easily confused given their similar white colouration and long wing shape.

The thirty-year median of ice concentration shows ice extending into the northern edge of the Grand Banks east to 48°W in late February to late March. The presence of sea ice does not does not imply that Ivory Gulls will be present. The overall density of Ivory Gull on the pack ice in the Northwest Atlantic is extremely low. The presence of sea ice is the condition most favourable for Ivory Gull occurrence. Ivory Gull may occasionally occur in the small numbers in the Project Area when pack ice reaches the northern Grand Banks in late winter (February to April). Ivory Gull would be extremely unlikely to occur in the Project Area during the typical period when VSP surveys will be conducted.

4.5.6 Blue Whale

The blue whale is a cosmopolitan species with separate populations (and subspecies) in the North Atlantic (*B.m. musculus*), North Pacific (*B.m. brevicauda*), and Southern Hemisphere (*B.m. intermedia*). The global population is thought to range from 5000-12,000 individuals but a recent and reliable estimate is not available. Blue whale abundance in the North Atlantic is currently thought to range from 600 to 1500 individuals, although more reliable and wide-ranging surveys are required for better estimates (Sears and Calambokis 2002). Blue whales concentrate in areas with large seasonal concentrations of euphausiids, its main prey (Yochem and Leatherwood 1985). Little is known about the distribution and abundance of blue whales in the northwest Atlantic—especially the waters off eastern Newfoundland. One area of blue whale concentration is the Gulf of St. Lawrence where 350 individuals have been catalogued photographically (Sears 2002).

There is insufficient data to determine population trends of the blue whale in the northwest Atlantic. The blue whale is considered endangered by COSEWIC (COSEWIC 2002) and is listed as such on Schedule 1 of the *SARA*. Accordingly, a Recovery Strategy is being developed under *SARA* and is likely due for release in the near future (J. Lawson, DFO, pers. comm.) On a global level, the IUCN—World Conservation Union, also considers the blue whale endangered (www.redlist.org). The original population was reduced due to whaling and now their biggest threats are thought to be from ship strikes, disturbance from increasing whale watching tours, entanglement in fishing gear, and pollution (Sears and Calambokidis 2002).

Blue whales have a coastal and pelagic distribution and they are known to frequent areas of the Gulf of St. Lawrence, the lower Estuary part of the St. Lawrence, and to a lesser extent the west and southwest coasts of Newfoundland. Most sighting effort and sightings of blue whales have been made along the Quebec North Shore from the Mingan and Anticosti islands region, off the Gaspé Peninsula, and west into the St. Lawrence Estuary to the Saguenay River (Sears and Calambokidis 2002). Little survey effort has been expended in other regions of the Gulf or elsewhere in the northwest Atlantic, especially outside of the summer period. Information on the distribution of blue whales in winter is lacking. Some blue whales become entrapped by ice (during heavy ice years) near the southwest coast of Newfoundland (Stenson et al. 2003). Records of entrapped blue whales date back to 1868 and 41 individual blue whales (23 entrapment events) have been recorded since then. All entrapments with available date information occurred during March and April and based on morphometric analyses most whales were adults and one whale was a pregnant female (Stenson et al. 2003). There have been no confirmed sightings of blue whales in or near the Petro-Canada Project Area (see Figure 4) based upon available data provided by DFO. The closest sighting was made in June 1993, approximately 250 km south of the Project Area. Based upon the DFO sighting database, most sightings of blue whales in Newfoundland have occurred near the coast, which may, in part, be related to the lack of dedicated marine mammal surveys in offshore waters. Blue whales were regularly sighted in offshore waters (~100-3000 m deep) of the Laurentian sub-basin area during a recent seismic monitoring program in June to September 2005. In fact, blue whales were the most frequently sighted baleen whale species. Sighting rate of blue whales was highest in water depths ranging from 2000-2500 m (Moulton et al. 2006a). However, no blue whales were sighted in the deep waters of the Orphan Basin during seismic monitoring programs conducted during the summers of 2004 (Moulton et al. 2005) and 2005 (Moulton et al. 2006b). No blue whales were sighted during a seismic monitoring program in the Jeanne d'Arc Basin in October and November 2005 (Lang et al. 2006); baleen whales are typically less abundant on the Grand Banks in late fall vs. summer. It is possible that blue whales may occur in the Jeanne d'Arc Basin but numbers are expected to be low.

In the Northern Hemisphere, blue whales mate and calve from late fall to mid-winter and become sexually mature at the ages of 5-15 (Yochem and Leatherwood 1985). Blue whales are thought to live for 70-80 years and potentially longer (Yochem and Leatherwood 1985).

Blue whales feed almost exclusively on euphausiids (krill) such as *Thysanoessa raschii* and *Meganyctiphanes norvegica* (Yochem and Leatherwood 1985). Blue whales also feed on copepods (e.g., *Temora longicornis*) and some fish species (Kawamura 1980; Reeves et al. 1998). Areas where blue whales are known to occur correspond to areas where their prey aggregate in great abundance (Simard and Lavoie 1999).

4.5.7 Leatherback Sea Turtle

The leatherback is the largest living turtle (2.2 m in length and over 900-kg (Morgan 1989)) and it also may be the most widely distributed reptile, as it ranges throughout the Atlantic, Pacific, and Indian oceans and into the Mediterranean Sea (Ernst et al. 1994). Adults engage in routine migrations between

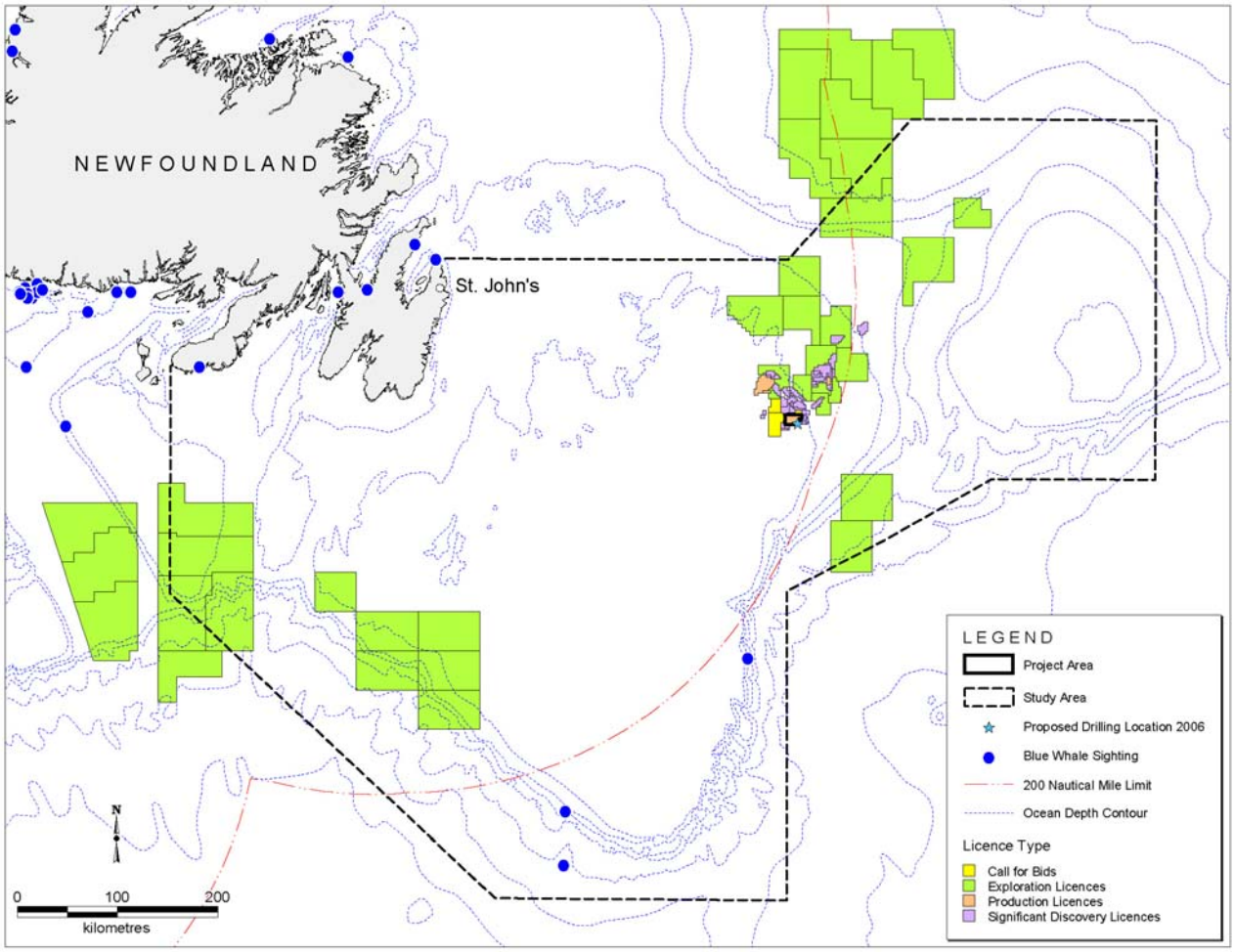


Figure 4. Location of Blue Whale Sightings Relative to Petro-Canada's Project and Study Areas (data from DFO marine mammal database).

temperate and tropical waters, presumably to optimize both foraging and nesting opportunities. Leatherbacks are less genetically diverse than other sea turtle species and may have less-rigid homing instincts (Dutton et al. 1999).

The worldwide population of leatherbacks is currently estimated at between 26,000 and 43,000 (Dutton et al. 1999). The current population is thought to be declining as major nesting colonies have declined in the last 20 years, although an increase in leatherbacks nesting in Florida has been reported in the last few years (Dutton et al. 1999). Despite its patchy worldwide distribution and in contrast to other sea turtles, adult leatherbacks are regularly sighted in the waters off Nova Scotia and Newfoundland from June to October (with peak abundance in August), where they likely come to feed on jellyfish, their primary prey (Bleakney 1965; Cook 1981; 1984). The scattered nature of the data make estimating the number of turtles in the Canadian Atlantic difficult. However, the North Atlantic Leatherback Turtle Working Group (NALTWG), created in 1997, is currently conducting research on the distribution and abundance of the leatherback. More leatherbacks visit waters near the Study Area than was once believed.

Leatherbacks, both adults and juveniles, undergo annual migrations that include areas off southern Newfoundland (James et al. 2005). The analysis of satellite telemetry, morphometric and fishing entanglement data identified areas of high-use habitat of leatherbacks in Northwest Atlantic waters. It was shown that leatherbacks do not migrate along specific routes but that they utilize broad areas of the Atlantic. Leatherback sea turtles did exhibit foraging site fidelity to shelf and slope waters off Canada and the northeastern United States (James et al. 2005). Satellite-tagged leatherbacks (caught off Cape Breton) mostly occurred well southwest of the Project Area during June to October (although some southward migrations did not begin until December; James et al. 2005). Available data are insufficient to determine if leatherbacks spend more time in slope vs. shelf waters (see ALTRT (2006) for a review). There have only been two confirmed sightings of leatherback sea turtles in the Jeanne d'Arc Basin to the best of our knowledge. Both sightings occurred during a seismic monitoring program in the Jeanne d'Arc Basin on 14 August 2006 on behalf of Husky (LGL, unpubl. data). No leatherbacks were sighted during Chevron's seismic monitoring program in the Orphan Basin in 2004 and 2005 and during Husky's seismic monitoring program in Jeanne d'Arc Basin in fall 2005 (Moulton et al. 2005, 2006b; Lang et al. 2006).

Data from the US pelagic longline fishery observer program have also added to the knowledge of leatherback distribution off Newfoundland (Witzell 1999). Nearly half of the leatherbacks (593 captures) caught incidentally by this fishery between 1992 and 1995 from the Caribbean to Labrador were captured in waters on and east of the 200 m isobath off the Grand Banks (Witzell 1999). Animals were caught in this region during all months from June to November, with the bulk of captures from July to September. Not surprisingly, leatherback captures within these waters corresponded closely with fishing effort, both clustered near the 200 m isobath.

The apparent common northerly occurrence of this species compared to other sea turtles may be attributed to an ability to maintain body temperatures of 25ºC in sea water as much as 18ºC cooler. An adult was even observed by fishermen in Trinity Bay, Newfoundland swimming amongst ice (Goff and Lien 1988). Twenty leatherbacks were reported off Newfoundland between 1976 to 1985, 14 were entangled in fishing gear (Goff and Lien 1988).

Little is known about the biology of the leatherback. It nests from April through November in the tropics along sandy beaches. Females deposit an average of five to seven nests per year, with clutch size averages varying geographically (Plotkin 1995). Nothing is known about the behaviour or survivorship of post-hatchlings. Loss of nesting habitat due to development and erosion, predation by animals, and poaching of adults and eggs for consumption inhibit the recovery of this species. Ingestion of plastic materials, which leatherbacks presumably mistake for jellyfish is common and can be fatal. The loss of individuals (primarily through net entanglement) in the Canadian Atlantic is not known to critically contribute to population decline (Cook 1981).

5.0 Effects Assessment

5.1 Assessment Methodology

The methodology of this effects assessment and definitions are consistent with all of the EAs conducted for Petro-Canada and Husky since 1996 (e.g., Petro-Canada 1996a,b; Husky 2000, 2001; LGL 2003, 2004a,b) and are provided in detail below.

5.1.1 Scoping

Extensive scoping was undertaken for the VSP EA Update; scoping was conducted by reference to the Project Description (dated March 2006), previous VSP EAs for the Grand Banks (e.g., LGL 2003, 2004b) and seismic EAs for the Grand Banks region (Buchanan et al. 2004; LGL 2005), consultation with the fishing industry and regulatory agencies, the C-NLOPB Scoping Document (dated 2 May 2006), and a scoping meeting with Ms. Kim Coady (15 May 2006).

5.1.2 Valued Ecosystem Components

The valued ecosystem components (VEC) approach was used to provide focus for the EA because it is neither feasible nor advisable to consider every species of the thousands that occur on the Grand Banks. This approach is more or less standard practice for Canadian EA. It was recognized by the authors that this approach does not capture every conceivable situation for every species but it does consider potentially important effects on those species or groups of species that are of most interest commercially, socially, culturally and aesthetically to society.

VEC selection was based upon project scoping with the following foremost considerations:

- commercial, social, cultural and aesthetic importance to society
- at least some potential sensitivity to project activities, and
- potential for interaction with project activities

The following VECs were selected:

- Commercial fish and fisheries (including fish habitat considerations) with emphasis on snow crab and the Species at Risk (e.g., Atlantic cod and wolffish)
- Seabirds with emphasis on those species most likely sensitive to VSP activities (e.g., deep divers such as murres) or vessel stranding (e.g., petrels), and Species at Risk (e.g., Ivory Gull)
- Marine Mammals with emphasis on those species (thought to be) most sensitive to low-frequency sound (e.g., baleen whales) or Species at Risk (e.g., blue whale).
- Sea Turtles with emphasis on those species most likely to occur in the Study Area and considered at risk under *SARA* (i.e., leatherback sea turtle)
- Species at Risk including those mentioned above plus several others

5.1.3 Boundaries

For the purposes of this EA, the following boundaries are defined.

Temporal—the temporal boundaries are the estimated remainder of the life of the Terra Nova Development (15-17 years) with each VSP acquisition period lasting from 8-36 hours. Within a given year, there would be a maximum of two VSP surveys.

Project Area—the 'Project Area' was defined as the Terra Nova Development area, including all of Petro-Canada's production licenses.

Affected Area—the 'Affected Area' varies according to the specific vertical and horizontal distributions and sensitivities of the VECs of interest and is defined as that area within which effects (physical or important behavioural ones) have been reported to occur.

Regional Area—the regional boundary (or Study Area) is the boundary of the Grand Banks as defined in the Hibernia, Terra Nova, White Rose, and other EAs.

Transboundary—this boundary is not relevant in the present case as neither the Project nor affected areas will extend across any international boundaries.

5.1.4 Effects Assessment Procedures

The systematic assessment of the potential effects of the Project phase involved three major steps:

1. preparation of interaction (between Project activities and the environment) matrices;
2. identification and evaluation of potential effects including description of mitigation measures and residual effects; and
3. preparation of residual effects summary tables, including evaluation of cumulative effects.

Identification and Evaluation of Effects

Interaction matrices are provided below that identify all possible Project activities that could interact with any of the VECs (e.g., Table 8). The matrices include times and places where interactions could occur. The interaction matrices are used only to identify potential interactions; they make no assumptions about the potential effects of the interactions.

Interactions were then evaluated for their potential to cause effects. In instances where the potential for an effect of an interaction was deemed impossible or extremely remote, these interactions were not considered further. In this way, the assessment could focus on key issues and the more substantive environmental effects.

An interaction was considered to be a potential effect if it could change the abundance or distribution of VECs, or change the prey species or habitats used by VECs. The potential for an effect was assessed by considering:

- the location and timing of the interaction;
- the literature on similar interactions and associated effects (including the Hibernia and Terra Nova EIS, White Rose EA; drilling EAs, other VSP EAs for offshore Newfoundland);
- when necessary, consultation with other experts; and
- results of similar effects assessments and especially, monitoring studies done in other areas.

When data were insufficient to allow certain or precise effects evaluations, predictions were made based on professional judgement. Effects were evaluated for the proposed VSP surveys, which include mitigation measures that are mandatory or have become standard operating procedure in the industry.

Note that the potential impacts from vessel wastes, air emissions, accidental events, and the physical presence of the VSP vessel and/or drill rig[1] are not assessed in detail in this report. Based on consultations for previous VSP programs[2], regulatory agencies and other stakeholders identified noise from the airgun array as the key issue for assessment. Wastes such as black and grey water, bilge water, deck drainage, discharges from machinery spaces, and garbage produced from VSP vessel and/or drill rig will be treated according to the Offshore Waste Treatment Guidelines (NEB et al. 2002). As such, impacts from waste disposal during the VSP programs would be negligible. Accidental events are captured within the Terra Nova Development EIS and are not considered here. This is valid because these activities are well within the original Project Description and EIS. It should be noted that a VSP program does not normally use streamers, which in a typical seismic program would be filled with Isopar (a kerosene-like petroleum product not that different from diesel oil, which *was* covered in the EIS).

Classifying Anticipated Environmental Effects

The concept of classifying environmental effects simply means determining whether they are negative or positive. The following includes some of the key factors that are considered for determining adverse environmental effects, as per the CEA Agency guidelines (CEAA 1994):

- negative effects on the health of biota;
- loss of rare or endangered species;
- reductions in biological diversity;
- loss or avoidance of critical/productive habitat;
- fragmentation of habitat or interruption of movement corridors and migration routes;
- transformation of natural landscapes;
- discharge of persistent and/or toxic chemicals;
- toxicity effects on human health;

[1] Discharges from drill rigs were assessed in Petro-Canada (1996a).
[2] No issues were identified during consultations for the VSP program proposed by Petro-Canada (see Section 1.3).

- loss of, or detrimental change in, current use of lands and resources for traditional purposes;
- foreclosure of future resource use or production; and
- negative effects on human health or well-being.

Mitigation

Mitigation measures appropriate for each effect predicted in the matrix were identified and the effects of various Project activities were then evaluated assuming that appropriate mitigation measures are applied. Residual effects predictions were made taking into consideration both standard and project-specific mitigations.

Application of Evaluation Criteria for Assessing Environmental Effects

Several criteria were taken into account when evaluating the nature and extent of environmental effects. These criteria include (CEAA 1994):

- magnitude;
- geographic extent;
- duration and frequency;
- reversibility; and
- ecological, socio-cultural and economic context.

Magnitude describes the nature and extent of the environmental effect for each activity. Geographic extent refers to the specific area (km^2) affected by the Project activity, which may vary depending on the activity and the relevant VEC. Duration and frequency describe how long and how often a project activity and/or environmental effect will occur. Reversibility refers to the ability of a VEC to return to an equal, or improved condition, at the end of the project. The ecological, socio-cultural and economic context describes the current status of the area affected by the project in terms of existing environmental effects. Two tables are provided for each group of VECs, indicating the results of the effects analysis and the significance of those effects.

Magnitude was defined as:

Negligible — An interaction that may create a measureable effect on individuals but would never approach the 10% value of the 'low' rating. Rating = 0.

Low — Affects > 0 to 10 percent of individuals in the affected area (e.g., geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 1.

Medium — Affects > 10 to 25 percent of individuals in the affected area (see geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 2.

High — Affects more than 25 percent of individuals in the affected area (e.g., geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 3.

Definitions of magnitude used in this EA have been used previously in numerous offshore oil-related environmental assessments under CEAA. These include assessments of exploratory drilling (LGL 2005a), development drilling (Petro-Canada 1996a; Husky 2000, 2001, 2002), 3D seismic surveys (Buchanan et al. 2004), VSP surveys (LGL 2003), and wellsite geohazard surveys (LGL 2004a).

Durations are defined as:

1	=	< 1 month
2	=	1 – 12 month
3	=	13 – 36 month
4	=	37 – 72 month
5	=	>72 month

Short duration can be considered 12 months or less and medium duration can be defined as 13 to 36 months.

Cumulative Effects

Projects and activities considered in the cumulative effects assessment included:

- Survey program within-project cumulative impacts. For the most part, and unless otherwise indicated, within-project cumulative effects are fully integrated within this assessment;
- Hibernia, Terra Nova, and White Rose oilfield developments;
- Other offshore oil exploration activity (seismic surveys and exploratory drilling);
- Commercial fisheries; and
- Marine transportation (tankers, cargo ships, supply vessels, naval vessels, fishing vessel transits, etc.).

Integrated Residual Environmental Effects

Upon completion of the evaluation of environmental effects, the residual environmental effects (effects after project-specific mitigation measures are imposed) are assigned a rating of significance for:

- each project activity or accident scenario;
- the cumulative effects of project activities within the Project; and
- the cumulative effects of combined projects on the Grand Banks.

These ratings are presented in summary tables of residual environmental effects. The last of these points considers all residual environmental effects, including project and other-project cumulative environmental effects. As such, this represents an integrated residual environmental effects evaluation.

The analysis and prediction of the significance of environmental effects, including cumulative environmental effects, encompasses the following:

- determination of the significance of residual environmental effects;
- establishment of the level of confidence for prediction; and
- evaluation of the scientific certainty and probability of occurrence of the residual impact prediction.

Ratings for level of confidence, probability of occurrence, and determination of scientific certainty associated with each prediction are presented in the tables of residual environmental effects. The guidelines used to assess these ratings are discussed in detail in the sections below.

Significance Rating

Significant environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In the VSP EA, a *significant* effect is defined as:

- *Having a high magnitude or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2*

An effect can be considered *significant*, *not significant*, or *positive*.

Level of Confidence

The significance of the residual environmental effects is based on a review of relevant literature, consultation with experts, and professional judgment. In some instances, making predictions of potential residual environmental effects is difficult due to the limitations of available data (for example, technical boundaries). Ratings are therefore provided to indicate, qualitatively, the level of confidence for each prediction.

Determination of Whether Predicted Environmental Effects are Likely to Occur

The following criteria for the evaluation the likelihood of any predicted significant effects are used.

- probability of occurrence; and
- scientific certainty.

Follow-up Monitoring

Because any effects of the Project on the environment will be short-term and transitory, and for the most part negligible, there is no need to conduct follow-up monitoring. However, there will be some level of

monitoring during the course of the Project, and if these observations indicate an accidental release of fuel or some other unforeseen occurrence, then some follow-up monitoring may be conducted under the guidance of the C-NLOPB and other appropriate agencies.

5.2 Effects of the Environment on the Project

The effects of the environment on the project are *negligible* (and thus *not significant*) for the following reasons:

- The VSP surveys are sometimes conducted from the drill rig and thus are relatively unaffected by wave conditions.

- VSP surveys are typically scheduled during the summer months when the weather and ice conditions are good for operations.

- Surveys are of short duration (8-36 h) and thus any potential effects of bad wind or wave conditions can be mitigated by judicious scheduling.

VSP surveys are less affected by surface weather noise because the receivers are in the well bore and not being towed on streamers near the surface as with large seismic surveys.

5.3 Potential Effects on Fish and Commercial Fishery

5.3.1 Fish

Research on the impact of seismic energy on fish and invertebrates has been limited to date compared to studies involving marine mammals. The existing body of information relating to the impacts of seismic on marine fish and invertebrate species can be considered in three categories: (1) pathological effects, (2) physiological effects, and (3) behavioural effects. Pathological effects include lethal and sub-lethal damage to the animals, physiological effects include changes to the levels of various constituents of the blood/haemolymph, and behavioural effects refer to changes in exhibited behaviours of the fish and invertebrate animals. These three general types of effects are certainly interrelated in complex ways. For example, some physiological and behavioural changes could potentially lead to pathological effects such as mortality.

Pathological Effects.—In water, pathological effects of organisms exposed to seismic energy might depend on at least two features of the sound source: (1) an extremely high received peak pressure, and (2) a relatively short time for the pressure to rise and decay. Considering the peak pressure and rise/decay time characteristics of seismic arrays used today, the pathological zone for fish and invertebrates would be expected to be within a few metres of the seismic source.

Laboratory and controlled field studies have revealed damage to fish ear structures from exposure to seismic pulses from air cylinders (McCauley et al. 2000a, 2000b, 2003). In these studies fish were

exposed to received sound levels that ranged from ~145 to 190 dB re 1µPa $_{[rms]}$ at distances of 5 to 800 m from the source. The total duration of exposure was 1.7 hours at six air releases per minute. The experimental fish were caged and exposed to high cumulative levels of seismic energy, much higher than levels expected for this VSP survey. In addition, the fish were caged which makes direct comparisons with free-ranging fish difficult. Atlantic salmon were exposed within 1.5 m of underwater explosions (Sverdrup et al. 1994). Compared to air cylinder sources, explosive detonations are characterized by higher peak pressures and more rapid rise and decay times, and are considered to have greater potential to damage marine biota. In spite of this, no salmon mortality was observed immediately after exposure or during the seven-day monitoring period following exposure.

Laboratory studies have indicated that exposure to intense noise can affect the auditory thresholds of fish. Temporary threshold shift (TTS) can occur in fish under certain conditions, followed by complete recovery after varying lengths of time. Smith et al. (2004) found that goldfish had significant threshold shift after only 10 minutes of exposure to white noise (160-170 dB re 1 µPa; unspecified measure type) and that these shifts increased linearly up to approximately 28 dB after 24 hours of exposure to the noise. Threshold shifts did not increase beyond the 24-hour exposure time. After 21 days of exposure to the noise, the goldfish hearing sensitivity required 14 days to recover to normal levels. The likelihood of occurrence for this degree of noise exposure under natural conditions, including the proposed geohazard survey, is low.

Studies have also been conducted to investigate the effects of seismic exposure on fish eggs and larvae (Kostyuchenko 1973; Booman et al. 1996; Dalen et al. 1996). In all cases, damage was minimal and any mortality effect was not significantly different from the experimental controls. Saetre and Ona (1996) applied a 'worst-case scenario' mathematical model to investigate the effects of seismic energy on fish eggs and larvae and concluded that mortality rates caused by exposure to seismic are so low compared to the natural mortality that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

The pathological impacts of seismic energy on marine invertebrate species have also been investigated. In their pilot study, Christian et al. (2004) exposed adult male snow crabs, egg-carrying female snow crabs and fertilized snow crab eggs to the energy from seismic air guns. Eggs were exposed to received sound levels of ~221 dB re 1µPa $_{[0\text{-peak}]}$ at 2 m from the source. The total duration of exposure was 33 minutes at six air releases per minute. Neither acute nor chronic (12 weeks after exposure) mortality was observed for the adult male and female crabs. There was a significant difference in development rate noted between the exposed and unexposed fertilized eggs. The egg mass exposed to seismic energy had a higher proportion of less-developed eggs than the unexposed mass. It should be noted that both egg masses came from a single female and any measure of natural variability was unattainable. However, a result such as this does point to the need for further study.

Pearson et al. (1994) exposed Stage II larvae of the Dungeness crab to single discharges from a seven-air cylinder seismic array and compared their mortality and development rates with those of unexposed larvae. For immediate and long-term survival and time to molt, this field experiment did not reveal any statistically significant differences between the exposed and unexposed larvae, even those exposed within 1 m of the seismic source.

Bivalves of the Adriatic Sea were also exposed to seismic energy and subsequently assessed (LaBella et al. 1996). No effects of the exposure were noted.

In 2001 and 2003, there were two incidents of multiple strandings of the giant squid (*Architeuthis dux*) on the north coast of Spain. The timing of the strandings generally coincided with the timing of geophysical seismic surveys in the Bay of Biscay. A total of nine giant squids, either stranded or moribund surface-floating, were collected at these times. Guerra et al. (2004) presented evidence of acute tissue damage in the stranded and surface-floating giant squids after conducting necropsies on seven (six females and one male) of the relatively fresh nine specimens. The authors speculated that the one female with extensive tissue damage was affected by the impact of acoustic waves. However, little is known about the impact of marine acoustic technology on cephalopods. Unfortunately, the authors did not describe the seismic sources, locations, and durations of the Bay of Biscay surveys and no conclusive link can be made between the seismic surveys and the strandings.

McCauley et al. (2000a,b) reported results from the exposure of caged cephalopods (50 squid and two cuttlefish) to sound from a single 20-in^3 air cylinder. The cephalopds were exposed to both stationary and mobile sound sources. The two-run total exposure times of the three trials ranged from 69 to 119 minutes at an air release rate of once every 10 to 15 seconds. Maximum zero-to-peak exposure levels were greater than 200 dB re 1 µPa. Statocysts were removed and preserved but at the time of the study report publication, results of the statocyst analyses were not available. Some of the squid fired their ink sacs apparently in response to the first air release of one of the trials and then moved quickly away from the air cylinder. However, the ink sac firing was not observed for similar or greater received levels if the signal was ramped up. In addition to the above-described startle responses, some squid also moved towards the water surface as the air cylinder approached. Sound shadows, areas of lower sound pressure levels, are known to occur near the surface (Richardson et al. 1995). An increase in swimming speed was also exhibited by some of the squid. No squid or cuttlefish mortalities were reported as a result of these exposures.

Physiological Effects.—Biochemical responses by marine fish and invertebrates to acoustic stress have also been studied, albeit in a limited way. Studying the variations in the biochemical parameters influenced by acoustic stress might give some indication of the extent of the stress and perhaps forecast eventual detrimental effects. Such stress could potentially affect animal populations by reducing reproductive capacity and adult abundance.

McCauley et al. (2000a,b) used various physiological measures to study the physiological effects of exposure to seismic energy on various fish species, squid and cuttlefish. No significant physiological stress increases attributable to seismic were detected. Sverdrup et al. (1994) found that Atlantic salmon subjected to acoustic stress released primary stress hormones, adrenaline and cortisol as a biochemical response although there were different patterns of delayed increases for the different indicators. Caged European sea bass were exposed to seismic energy and numerous biochemical responses were indicated. All returned to their normal physiological levels within 72 hours of exposure.

Stress indicators in the haemolymph of adult male snow crabs were monitored after exposure of the animals to seismic energy (Christian et al. 2004). No significant differences between exposed and unexposed animals in terms of the stress indicators (e.g., proteins, enzymes, cell type count) were indicated.

In December 2003, egg-bearing female snow crabs (*Chionoecetes opilio*) off Cape Breton, Nova Scotia were caught, caged and subsequently exposed to seismic energy released during a commercial seismic survey (DFO 2004e). In this study, crab were exposed to a maximum received sound level of ~190 dB re 1µPa $_{[rms]}$. The distance between the seismic source and the caged crab ranged from ~70 m to 35 km and crab were periodically exposed to seismic pulses over a 9-day period. Both acute and chronic effects on the adult female crabs, embryos and larvae hatched from the eggs were studied in this DFO study. There were two clear observations from the study.

1. The seismic survey did not cause any acute or chronic (5 months) mortality of the crab, or any changes to the feeding activity of the treated crabs being held in the laboratory.
2. Neither the survival of embryos being carried by the female crabs during exposure nor the locomotion of the larvae after hatch appeared to be affected.

The parameters that were found to be not significantly different between the treatment and control crabs include acute and chronic mortality, external damage, eye condition, heart condition, spermathecae condition, larval locomotion, embryonic survival, and certain conditional aspects of antennules, gills and statocysts. While the observed differences are not definitive, the observed similarities are.

Lagardère (1982) presented results from laboratory experimentation that suggested that behavioural and physiological reactions of brown shrimp (*Crangon crangon*) were modified by exposure to increased background noise in tanks. Shrimp were kept in two environments for about three months, one noisier than the other. The mean difference in sound level in the 80 to 400 Hz range was 30 to 40 dB (unspecified measure type). There was a significant difference in growth rate and reproduction rate between the two groups. Those shrimp in the noisier environment had lower rates of each compared to those in the quieter environment. Increased noise levels also appeared to increase aggression (cannibalism) and mortality rate, and decrease food uptake. It is unclear how tank experiments with sound relate to conditions in the wild. The likelihood of occurrence for this type of noise exposure under natural conditions, including the proposed geohazard survey, is low.

Behavioural Effects.—Because of the relative lack of indication of serious pathological and physiological effects of seismic energy on marine fish and invertebrates, most concern now centers on the possible effects of exposure to seismic on the distribution, migration patterns and catchability of fish (i.e., behavioural effects). There is a need for more information on exactly what effect such sound sources might have on the detailed behaviour patterns of fish and invertebrates at different ranges.

Fish and Invertebrate Acoustic Detection and Production

Hearing in fishes was first demonstrated in the early 1900s through studies involving cyprinids (Parker 1903; Bigelow 1904 *in* Kenyon et al. 1998). Since that time, numerous methods have been used to test auditory sensitivity in fishes, resulting in audiograms of over 50 species. These data reveal great diversity in fish hearing ability, mostly due to various peripheral modes of coupling the ear to some internal structures, including the swim bladder. However, the general auditory capabilities of less than 0.2% of fish species are known so far.

For many years, studies of fish hearing have reported that the hearing bandwidth typically extends from below 100 Hz to approximately 1 kHz in fishes without specializations for sound detection, and up to about 7 kHz in fish with specializations that enhance bandwidth and sensitivity. Recently there have been suggestions that certain fishes, including many clupeiforms (i.e., herring, shads, anchovies, etc.) may be capable of detecting ultrasonic signals with frequencies as high as 126 kHz (Dunning et al. 1992; Nestler et al. 1992). Studies on Atlantic cod, a non-clupeiform fish, suggested that this species could detect ultrasound at almost 40 kHz (Astrup and Møhl 1993).

Mann et al. (2001) showed that the clupeiform fish, the American shad, is capable of detecting sounds up to 180 kHz. They also demonstrated that the gulf menhaden is also able to detect ultrasound while other species such as the bay anchovy, scaled sardine, and Spanish sardine only detect sounds with frequencies up to about 4 kHz.

Among fishes, at least two major pathways for sound to get to the ear have been identified. The first and most primitive is the conduction of sound directly from the water to tissue and bone. The fish's body takes up the sound's acoustic particle motion and subsequent hair cell stimulation occurs due to the difference in inertia between the hair cells and their overlying otoliths. The second sound pathway to the ears is indirect. The swim bladder or other gas bubble near the ears expands and contracts in volume in response to sound pressure fluctuations, and this motion is then transmitted to the otoliths. Only some species of fish appear to be sound pressure sensitive via this indirect pathway to the ears and are called 'hearing specialists'. Hearing specialists' sound pressure sensitivity is high and their upper frequency range of detection is extended above those species that hear only by the previously described direct pathway. The species having only the direct pathway are known as 'hearing generalists' (Fay and Popper 1999). Typically, most fish detect sounds of frequencies up to 2,000 Hz but, as indicated, others have detection ranges that extend to much higher frequencies.

Fish also possess lateral lines that detect water movements. The essential stimulus for the lateral line consists of differential water movement between the body surface and the surrounding water. The lateral line is typically used in concert with other sensory information, including hearing (Coombs and Montgomery 1999).

Because they lack air filled cavities and are often the same density as water, invertebrates detect underwater acoustics differently than fish. Rather than being pressure sensitive, invertebrates appear to be most sensitive to particle displacement. However, their sensitivity to particle displacement and

hydrodynamic stimulation seem poor compared to fish. Decapods, for example, have an extensive array of hair-like receptors both within and upon the body surface that could potentially respond to water- or substrate-borne displacements. They are also equipped with an abundance of proprioceptive organs that could serve secondarily to perceive vibrations. Crustaceans appear to be most sensitive to sounds of low frequency (i.e., < 1,000 Hz) (Budelmann 1992; Popper et al. 2001).

Many fish and invertebrates are also capable of sound production. It is believed that these sounds are used for communication in a wide range of behavioural and environmental contexts. The behaviours most often associated with acoustic communication include territorial behaviour, mate finding, courtship and aggression. Sound production provides a means of long distance communication as well as communication when underwater visibility is poor (Zelick et al. 1999).

Behavioural Effects of Seismic

Studies investigating the possible effects of seismic on fish and invertebrate behaviour have been conducted on both uncaged and caged animals. Studies looking at change in catch rate regard potential effects of seismic on larger spatial and temporal scales than are typical for close range studies that often involving caged animals (Hirst and Rodhouse 2000).

Engås et al. (1996) assessed the effects of seismic surveying on cod and haddock behaviour using acoustic mapping and commercial fishing techniques. Results indicated that fish abundance decreased at the seismic survey area and the decline in abundance and catch rate lessened as one moved away from the survey area. Engås et al. (1996) found that fish abundance and catch rates had not returned to pre-shooting levels five days after cessation of shooting. Other studies that used fishing catch rate as an indicator of behavioural shift also showed reduced catch rates, particularly in the immediate vicinity of the seismic survey (Løkkeborg 1991; Skalski et al. 1992). Anecdotal information from Newfoundland, Canada indicated that snow crab catch rates showed a significant reduction immediately following a pass by a seismic survey vessel. Other anecdotal information from Newfoundland indicated that a school of shrimp showing on a fishing vessel sounder shifted downwards and away from a nearby seismic source. Effects were temporary in both the snow crab and shrimp anecdotes (G. Chidley and H. Thorne, commercial fishermen, pers. comm.).

Using telemetry techniques, Shin et al. (2003) investigated changes in the swimming behaviour of caged Israeli carp (*Cyprinus carpio*) in response to underwater explosions. The received sound levels ranged from 140 to 156 dB re 1 µPa (unspecified type of measurement). Immediately after an explosion, the fish swimming area was reduced. After one hour, the area had returned to pre-explosion size. Other behavioural reactions included downward movement and increased swimming speed but these behavioural shifts also returned to normal shortly after cessation of explosions. Considering that underwater explosions are considered worst-case scenarios compared to air cylinder discharges and that these fish exhibited minor short-term behavioural changes, reactions of these fish to air cylinder discharges should be minimal.

The influence of seismic activity on pelagic fish (i.e., herring, blue whiting and mesopelagic species) was investigated using acoustic mapping off western Norway in 1999 (Slotte et al. 2004). The distribution and abundance of pelagic fish within the survey area and in surrounding waters out to 50 km from the survey area were mapped three times and compared, and the abundance was recorded immediately prior to and after shooting along some of the survey transects. The inconclusive results indicated that the acoustic abundance of pelagic fish was higher outside than inside the survey area after exposure to seismic activity. At the same time, the abundance of pelagic fish prior to seismic activity was not significantly different than abundance immediately after shooting along some of the survey transects, indicating that no significant short-term horizontal movement occurred. However, there were indications that some of the pelagics might have moved downwards in response to the seismic activity.

Marine fish inhabiting an inshore reef off the coast of Scotland were monitored by telemetry and remote camera before, during and after air cylinder releases (Wardle et al. 2001). Although some startle responses were observed, the seismic source releases had little overall effect on the day-to-day behaviour of the resident fish.

Studies on the effects of sound on fish behaviour have also been conducted using caged or confined fish. Such experiments were conducted in Australia using fish, squid and cuttlefish as subjects (McCauley et al. (2000a,b). Common observations of fish behaviour included startle response, faster swimming, movement to the part of the cage furthest from the seismic source (i.e., avoidance), and eventual habituation. Fish behaviour appeared to return pre-seismic state 15 to 30 minutes after cessation of seismic. Squid exhibited strong startle responses to the onset of proximate air cylinder activities by releasing ink and/or jetting away from the source. The squid consistently made use of the 'sound shadow' at surface where the sound intensity was less than at 3-m depth. These Australian experiments provided more evidence that fish and invertebrate behaviour will be modified at some received sound level. Again, these behavioural changes seem to be temporary.

Other species involved in studies that have indicated fish behavioural responses to underwater sound include rockfish (Pearson et al. 1992), Pacific herring (Schwarz and Greer 1984), and Atlantic herring (Blaxter et al. 1981).

Christian et al. (2004) conducted an experimental commercial fishery for snow crab before and after the area was exposed to seismic pulses. No drastic decrease in catch rate of commercial-size snow crab was observed after seismic activity commenced. Another behavioural investigation by Christian et al. (2004) involved caging snow crabs, positioning the cage 50 m below a seven-gun array, and observing the immediate responses of the crabs to the onset of seismic activity by remote underwater camera. No obvious startle behaviours were observed.

The first field evidence for previous suggestions that underwater sound may provide an orientation cue for the pelagic stages of coastal crustaceans has recently been published (Jeffs et al. 2003). The authors' work in New Zealand involved the testing of the responses of planktonic stages of common coastal crabs to artificial sources of natural reef sound played through underwater sound projectors. The results

demonstrated that the pelagic stages of the crabs responded to underwater sounds and that they may use this cue to orient themselves towards the coast.

Potential interactions between the Project and fish VEC are shown in Table 8. The minimal spatial and temporal overlap and the relatively small nature of the proposed Project suggest that there is no potential for significant effects on the fish VEC. The proposed VSP survey is predicted to have *negligible to low* physical effects on the various life stages of the fish VEC species over a duration of *<1 month* in an area *<1 km²* (Table 9). Therefore, any physical effects of the Project on the fish VEC would be *not significant* (Table 10).

Similarly, the proposed VSP survey is predicted to have *negligible to low* disturbance (behavioural) effects on the various life stages of the fish VEC species over a duration of *<1 month* in an area *101-1,000 km²* (Table 9). Therefore, any disturbance (behavioural) effects of the Project on the fish VEC would be *not significant* (Table 10).

Table 8. Potential interactions between the Project and Fish VEC.

Valued Environmental Component: Fish						
	Feeding		**Reproduction**		**Adult Stage**	
	Plankton	**Benthos**	**Eggs/Larvae**	**Juveniles[1]**	**Pelagic Fish**	**Groundfish**
PROJECT ACTIVITIES						
Vessel Lights	x		x		x	
Sanitary/Domestic Waste	x		x		x	
Air Emissions	x		x		x	
Garbage (N/A)[2]						
Noise						
Vessel	x	x	x	x	x	x
Seismic Array	x	x	x	x	x	x
Shore Facilities (N/A)[3]						
Accidental Spills (N/A)[4]						
OTHER PROJECTS AND ACTIVITIES						
Hibernia	x	x	x	x	x	x
Terra Nova	x	x	x	x	x	x
White Rose	x	x	x	x	x	x
Exploration	x	x	x	x	x	x
Fisheries	x	x	x	x	x	x
Marine Transportation	x		x		x	x

[1] Juveniles are young fish that have left the plankton and are often found closely associated with substrates.
[2] Not applicable as garbage will be brought ashore.
[3] There will not be any new onshore facilities. Existing infrastructure will be used.
[4] Accidental spills were assessed in the original Terra Nova EIS (see Section 5.7 *in* Petro-Canada 1996a)

Table 9. Effects assessment on Fish VEC.

Valued Environmental Component: Fish								
PROJECT ACTIVITY	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Vessel Lights	Attraction (N)	-	0	1	1	1	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	-	0	1	1	1	R	2
Air Emissions	Surface Contaminants (N)	-	0	1	1	1	R	2
Noise								
Vessel	Disturbance (N)	-	0-1	1	1	1	R	2
Seismic Array	Disturbance (N) Physical Effects (N)	Ramp up	1	4	1	1	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = < 11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = > 200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible (refers to population)

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = > 72 months

Geographic Extent:
1 = < 1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1000 km^2
5 = 1001-10,000 km^2
6 = > 10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 10. Significance of predicted residual environmental effects on the fish VEC.

Valued Environmental Component: Fish				
PROJECT ACTIVITY	Significance Rating	Level of Confidence	Likelihood	
	Significance of Predicted Residual Environmental Effects		Probability of Occurrence	Scientific Certainty
Vessel Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Air Emissions	NS	3	-	-
Noise				
Vessel	NS	3	-	-
Seismic Array	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

SARA Species.—The fish VEC was defined in a previous section as including four of the five fish species presently listed under *SARA*; northern wolffish, spotted wolffish, Atlantic wolffish, and Atlantic cod. Northern and spotted wolffish are listed as 'threatened' on Schedule 1, Atlantic wolffish as 'special concern' on Schedule 1, and Atlantic cod as 'special concern' on Schedule 3. The fifth fish species referred to above is Atlantic salmon (*Salmo salar*) in the Inner Bay of Fundy. It is uncertain if this population is relevant to this update. As indicated above, the physical and disturbance (behavioural) effects of the proposed VSP survey on these *SARA* species are assessed as *not significant*.

5.3.2 Commercial Fishery

Any effect on the behaviour of fish and invertebrates could potentially affect the relevant commercial fisheries in terms of catch rate. If fish and invertebrates temporarily move out of an area or become inactive in response to underwater sound, then subsequent catches would most probably be affected. The potential of such impact could be reduced by good communications with fishers before and during the Project.

As with all vessel traffic on the Grand Banks, there is some potential for the project vessel to interfere with fixed-fishing gear while in transit. However, the potential of conflict will be reduced by good

communications with fishers before and during the Project. Any effects such as gear damage that can be attributed to the Project will be reduced to negligible by compensation for damaged or lost fishing gear.

Potential interactions between the Project and the commercial fishery VEC (includes DFO research surveys) are shown in Table 11.

Table 11. Potential interactions between the Project and Commercial Fishery VEC.

Valued Environmental Component: Commercial Fishery			
PROJECT ACTIVITIES	**Catch Success**	**Gear Conflict**	**Research Surveys**
Vessel Lights			
Sanitary/Domestic Waste	x	x	x
Air Emissions			
Garbage (N/A)			
Noise			
Vessel	x		x
Seismic Array	x		x
Vessel Activities			x
Physical presence of vessel and VSP equipment	x	x	x
Accidental Spills[1]			
OTHER PROJECTS AND ACTIVITIES			
Exploration	x	x	x
Marine Transportation	x	x	x
[1]Accidental spills were assessed in the original Terra Nova EIS (see Section 5.7 *in* Petro-Canada 1996a)			

The chief sources for potential impacts of the Project on the commercial fisheries would be related to (1) changes in catch rates resulting from sound-induced behavioural changes (scaring) of fish, (2) interference with fishing activities - particularly fixed gear - owing to gear or vessel conflicts, or (3) as a result of effects on stock assessments and DFO research, which is used, among other purposes, for setting fishing quotas or exploring new fisheries. [Impacts related to physical effects on fish and invertebrates are not discussed here as they were assessed in previous sections, and predicted to be *not significant*.]

There is typically minimal commercial harvesting within the proposed Project Area. Given the small spatial and temporal footprint of the proposed Project, there will be minimal conflict between the commercial fisheries and the Project. Mitigations such as advisories will lessen the potential for effects and a compensation program for gear loss will lessen any potential effects to *negligible*. The primary commercial fishery gear type used in the area is the fixed-gear crab pot.

The proposed VSP survey is predicted to have *negligible to low* disturbance (behavioural) effects on the commercial fishery VEC over a duration of *<1 month* in an area *101-1,000 km^2* (Table 12). Therefore, any disturbance (behavioural) effects of the Project on the commercial fishery VEC (and research surveys) would be *not significant* (Table 13).

5.4 Potential Effects on Seabirds

Typically, seabirds have not been species of concern in environmental assessments of VSP surveys, because seabirds in general do not appear to be particularly sensitive to underwater sound and they do not appear to use sound for feeding. Nonetheless, some concern has been expressed recently by Environment Canada that some species such as murres may be more sensitive to underwater sound because of the amount of time they spend underwater. Other potential issues include seabird stranding (particularly petrels) onboard vessels at night or during foggy conditions.

Potential interactions between the Project and seabird VECs are shown in Table 14. The effects assessment is shown in Table 15. Murres are potentially the most sensitive group to underwater sound because of their time spent underwater. Murres and shearwaters may be the most sensitive bird species for the Project, the former because of its feeding habits, spending large amounts on and under the water, and the latter because of their relatively large numbers in the Project Area during periods when VSP surveys are likely to be conducted (i.e., summer-early fall). Petrels also have some sensitivity to the Project if they are attracted to the survey vessel and become stranded but the numbers involved for the duration of a VSP survey would be low. It is unlikely that the Ivory Gull will occur in a Project Area and its feeding strategy would not expose it for long periods of time to underwater sound.

Most effects of the Project on seabirds will be *negligible* (Table 15) because available information (albeit limited for seismic sound) for the most part suggests that birds are not particularly sensitive to underwater sound. Some petrels could be affected if they become attracted to and then stranded on the ship, but mitigation/handling methods should reduce or eliminate mortalities. In addition, lighting on the survey ship at night and in poor weather conditions will be reduced as much as possible. Furthermore, there is no streamer flotation liquid associated with this project. Thus, the number of birds affected by the Project should be quite low and thus any effects (including those on Ivory Gulls) will be *not significant* (Table 16).

5.5 Potential Effects on Marine Mammals and Sea Turtles

Documents such as Davis et al. (1998: pages 90-99 and 142-150), Moulton et al. (2003: section 8) and Lawson et al. (2000: sections 5 and 6) provide a good overview of the effects of seismic sounds on marine mammals. Little is known about the effects of seismic sounds on sea turtles. This section contains an overview of the literature on the effects of airgun sounds (typically from large arrays used in 2-D or 3-D seismic programs) on marine mammals and sea turtles. It is important to note that the each VSP survey (maximum of two per year) proposed by Petro-Canada program will involve only 8-36 hours of data acquisition in a small area with a relatively small airgun array. The types of effects considered here are (1) masking, (2) disturbance, and (3) potential hearing impairment and physical effects.

Table 12. Effects assessment on Commercial Fishery VEC.

Valued Environmental Component: Commercial Fishery								
PROJECT ACTIVITY	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Sanitary/Domestic Waste	Increased Food (N/P)		0	1	1	1	R	2
Noise								
Seismic Array Vessel	Behavioural Response (N/P)	Avoidance, Communications	1	4	1	1	R	2
Vessel Activities								
Physical presence of vessel and VSP equipment	Gear conflict and damage (N)	Avoidance, SPOC, Compensation plan	0[1]	1-2	1	1	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = < 11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = > 200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible (refers to population)

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = > 72 months

Geographic Extent:
1 = < 1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1000 km^2
5 = 1001-10,000 km^2
6 = > 10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not affected by human activity
2 = Evidence of existing effects

[1]This is considered negligible since, if a conflict occurs, compensation will eliminate any economic impact.

Table 13. Significance of predicted residual environmental effects on the commercial fishery VEC.

Valued Environmental Component: Commercial Fishery				
PROJECT ACTIVITY	Significance Rating	Level of Confidence	Likelihood	
	Significance of Predicted Residual Environmental Effects		Probability of Occurrence	Scientific Certainty
Sanitary/Domestic Wastes	NS	3	-	-
Air Emissions	NS	3	-	-
Noise				
Seismic Array Vessel	NS	3	-	-
Vessel Activities			-	-
Physical presence of vessel and VSP equipment	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Table 14. Potential interactions between the Project and seabird, sea turtle and marine mammal VECs.

PROJECT ACTIVITY	Seabirds	Sea Turtles	Marine Mammals
Vessel Lights	x	x	
Sanitary/Domestic Waste	x	x	x
Air Emissions	x	x	x
Garbage (N/A)			
Noise			
Vessel	x	x	x
Seismic Array	x	x	x
Shore Facilities (N/A)			
Accidental Spills (N/A)[1]			
OTHER PROJECTS AND ACTIVITIES			
Hibernia	x	x	x
Terra Nova	x	x	x
White Rose	x	x	x
Exploration	x	x	x
Fisheries	x	x	x
Marine Transportation	x	x	x

[1]Accidental spills were assessed in the original Terra Nova EIS (see Section 5.7 *in* Petro-Canada 1996a)

Table 15. Effects assessment on seabird VEC.

Valued Environmental Component: Seabirds								
PROJECT ACTIVITY	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Vessel Lights	Attraction (N)	Release Program, minimize lighting	0-1	1	1	1	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	-	0-1	1	1	1	R	2
Air Emissions	Surface Contaminants (N)	-	0	1	1	1	R	2
Noise								
Vessel	Disturbance (N)	Avoid concentrations	0-1	1	1	1	R	2
Seismic Array	Disturbance (N) Physical Effects (N)	Ramp up	1	2-3	1	1	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = < 11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = > 200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = > 72 months

Geographic Extent:
1 = < 1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1000 km^2
5 = 1001-10,000 km^2
6 = > 10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 16. Significance of predicted residual environmental effects on the seabird VEC.

Valued Environmental Component: Seabirds				
PROJECT ACTIVITY	Significance Rating	Level of Confidence	Likelihood	
	Significance of Predicted Residual Environmental Effects		Probability of Occurrence	Scientific Certainty
Vessel Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Air Emissions	NS	3	-	-
Noise				
Vessel	NS	3	-	-
Seismic Array	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

(1) Masking Effects of VSP Surveys

Masking effects on marine mammal calls and other natural sounds are expected to be limited. Seismic sounds are short pulses occurring for less than 1-sec every 20 or thereabouts. Some whales are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999). Although there has been one report that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), more recent studies reported that sperm whales continued calling in the presence of seismic pulses (Madsen et al. 2002). 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 plus the fact that sounds important to them are predominantly at much higher frequencies than are airgun sounds.

Most of the energy in the sound pulses emitted by airgun arrays is at low frequencies, with strongest spectrum levels below 200 Hz and considerably lower spectrum levels above 1,000 Hz. These frequencies are mainly used by mysticetes, but not by odontocetes or pinnipeds. An industrial sound source will reduce the effective communication or echolocation distance only if its frequency is close to that of the cetacean signal. If little or no overlap occurs between the industrial noise and the frequencies used, as in the case of many marine mammals vs. airgun sounds, communication and echolocation are not expected to be disrupted. Furthermore, the discontinuous nature of seismic sounds makes significant masking effects unlikely even for mysticetes.

Little is known about sea turtle hearing or of the importance of hearing to sea turtles. Hearing may play a role in sea turtle navigation. However, recent studies suggest that visual, wave, and magnetic cues are the main navigational cues used by sea turtles, at least by hatchlings and juveniles (Lohmann et al. 1997, 2001; Lohmann and Lohmann 1998). Therefore, masking is probably not relevant to sea turtles. Even if acoustic signals were important to sea turtles, their hearing is best at frequencies slightly higher (250 to 700 Hz—see Moulton and Richardson (2000) for a review) than frequencies where most airgun sounds (<200 Hz) are produced, although their hearing extends down to the airgun frequencies. If sea turtles do rely on acoustical cues from the environment, the wide spacing between seismic pulses would permit them to receive these cues, even in the presence of seismic activities.

Thus, masking is unlikely to be a significant issue for either marine mammals or sea turtles exposed to the pulsed sounds from VSP surveys.

(2) Disturbance by VSP Surveys

Disturbance includes a variety of effects, including subtle changes in behaviour, more conspicuous dramatic changes in activities, and displacement. However, information is lacking for many species. Detailed studies have been done on humpback, gray and bowhead whales, and on ringed seals reactions to seismic pulses. Less detailed data on responses to seismic sound are available for some other species of baleen whales, sperm whales, and small toothed whales.

Baleen Whales.—Humpback, gray, and bowhead whales reacted to noise 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, 1999; Ljungblad et al. 1988; Richardson and Malme 1993; McCauley et al. 1998, 2000a; Miller et al. 1999). Fin and blue whales also show some behavioural reactions to airgun array noise (McDonald et al. 1995; Stone 2003). Prior to the late 1990s, it was thought that bowhead whales, gray whales, and humpback whales all begin to show strong avoidance reactions to seismic pulses at received levels of about 160 to 170 dB re 1 µPa rms, but that subtle behavioural changes sometimes become evident at somewhat lower received levels. Recent studies have shown that some species of baleen whales may show strong avoidance at received levels somewhat lower than 160–170 dB re 1 µPa rms (e.g., Miller et al. 1999). The observed avoidance reactions involved 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 or no biological consequence to the animals—they simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors.

Blue, sei, fin, and minke whales have been reported in areas ensonified by airgun array pulses (Moulton and Miller 2004; Moulton et al. 2005, 2006a,b; Lang et al. 2006). Sightings by observers on seismic vessels off the U.K. from 1997–2000 suggest that, at times of good sightability, numbers of rorquals seen are similar when airgun arrays are active and inactive (Stone 2003). Although individual species did not show any significant displacement in relation to seismic activity, all baleen whales combined were found to remain significantly farther from the airgun arrays during air releases compared with periods without air

releases (Stone 2003). Baleen whale pods sighted from the ship were found to be at a median distance of about 1.6 km from the array during seismic periods and 1.0 km during non-seismic periods (Stone 2003). Monitoring program results from Atlantic Canada seismic surveys have yielded variable results with sighting rates of baleen whales higher during non-seismic vs. seismic periods on the Scotian Slope and Orphan Basin (Moulton and Miller 2004; Moulton et al. 2006b), lower during non-seismic vs. seismic periods in the Jeanne d'Arc Basin (Lang et al. 2006), and similar during both periods in the Laurentian Sub-basin (Moulton et al. 2006a). Also, there was no consistent trend in the closest point of approach of baleen whales during non-seismic vs. seismic periods.

Toothed Whales.—Little systematic information is available about reactions of toothed whales to noise pulses. Dolphins and porpoises are often seen by observers on active seismic vessels (Duncan 1985; Arnold 1996; Stone 2003: Moulton et al. 2005, 2006a,b; Lang et al. 2006), occasionally at close distances (e.g., bow riding). However, some studies, especially near the U.K., show localized avoidance (Stone 2003). In contrast, recent studies show little evidence of reactions by sperm whales to airgun pulses (McCall Howard 1999; Madsen et al. 2002; Stone 2003; Jochens and Biggs 2003; Mate 2003), contrary to earlier indications (Bowles et al. 1994; Mate et al. 1994). There are no specific data on responses of beaked whales to seismic surveys; there is increasing evidence that some beaked whales may strand after exposure to strong noise from high powered military sonars. Whether they ever do so in response to seismic survey noise is unknown (but much less likely).

Pinnipeds.—Few studies of the reactions of pinnipeds to noise from open-water seismic exploration have been published (for review, see Richardson et al. 1995). Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behaviour (Harris et al. 2001; Moulton and Lawson 2002). These studies show that pinnipeds frequently do not avoid the area within a few hundred meters of an operating airgun array. However, initial telemetry work suggests that avoidance and other behavioural reactions may be stronger than evident to date from visual studies (Thompson et al. 1998).

Sea Turtles.—The limited available data indicate that sea turtles will hear airgun sounds. Based on available data, it is likely that sea turtles will exhibit behavioural changes and/or avoidance within an area of unknown size near a VSP vessel (e.g., McCauley et al. 2000b; Holst et al. 2005a). A recent seismic monitoring study off Central America (Holst et al. 2005a) indicated that sea turtles (primarily Olive ridley) were observed closer to a small airgun array when it was inactive vs. active. However, results from a monitoring program in the southern Gulf of Mexico (Holst et al. 2005b) found no difference in sea turtle sighting distances relative to the activity status of a large airgun array. Seismic operations in or near areas where turtles concentrate are likely to have the greatest impact. There are no specific data that demonstrate the consequences to sea turtles if seismic operations do occur in important areas at important times of year. The proposed project will occur outside of the peak nesting period, and in an area very distant from breeding habitat or foraging sites. Thus, it is unlikely that there will be any prolonged or significant disturbance effects on individuals or the population.

(4) Hearing Impairment and Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. The minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable Temporary Threshold Shift (TTS). The level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage. Current National Marine Fisheries Service (NMFS) policy, which has been adopted in some areas of Canada, regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds exceeding 180 and 190 dB re 1 μPa (rms), respectively (NMFS 2000). [These criteria are currently under review in the U.S.]

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds.

Very little is known about the potential for VSP survey sounds to cause auditory impairment or physical effects in marine mammals or sea turtles. Available data suggest that such effects, if they occur at all, would be limited to short distances. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals or sea turtles that might be affected in these ways. Marine mammals that show behavioural avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are unlikely to incur auditory impairment or physical effects.

Potential interactions between marine mammals, sea turtles and the Project are shown in Table 14. The VSP project proposed by Petro-Canada is of short duration (8-36 hours of data acquisition per survey) and will occur in a small area (up to 5 km from the wellhead for Walkaway VSP). Relative to a full-scale 2-D or 3-D seismic program, any effects on VECs will be minimal as source levels are lower and the duration seismic sound is emitted in the water column is much reduced.

5.5.1 Marine Mammals

Mysticetes

There is little potential for the proposed VSP program to cause hearing impairment and physical effects on mysticetes or baleen whales given that baleen whales would likely exhibit localized avoidance from the survey ship and sound source. Available evidence indicates that baleen whales are able to hear the seismic array. If some whales did experience hearing impairments, the effects would likely be "temporary" (minutes to hours to days in duration). The likelihood of baleen whales experiencing hearing impairment or other physical effects is reduced by implementing mitigation measures including ramp up of the array, delay of start up of the array for baleen whales within a 500 m safety zone, and for

the endangered blue whale shutdown of the airgun array anytime this species enters the safety zone. With mitigation measures in place, the proposed VSP program is predicted to have *negligible to low* physical impacts on baleen whales, over a duration of *<1 month*, in an area *<1 km^2* (Table 17). Therefore, hearing impairment and physical impacts of VSP surveys on baleen whales (including the endangered blue whale) would be *not significant* (Table 18).

With the implementation of the mitigation measure of ramping up the airgun array and implementation of a safety zone, disturbance effects on baleen whales (including endangered species, i.e., blue whale) are predicted to be *negligible to low*, over a duration of *<1 month*, in an area of *<1 km^2* to *101-1000 km^2* (Table 17). Therefore, impacts related to disturbance, are judged to be *not significant* for baleen whales (Table 18).

Odontocetes

There is little potential for the VSP program to cause physical effects on odontocetes (toothed whales, dolphins, porpoises) given that odontocetes would likely exhibit localized avoidance from the survey ship and sound source and toothed whales are likely most sensitive to higher frequency sound. If some odontocetes did experience hearing impairments, the effects would likely be "temporary" (minutes to hours to days in duration). The likelihood of odontocetes experiencing hearing impairment or other physical effects is reduced by implementing mitigation measures including ramp up of the array and delay of start up of the array for odontocetes within a 500 m safety zone. With mitigation measures in place, the proposed VSP program is predicted to have *negligible to low* physical impacts on odontocetes, over a duration of *<1 month*, in an area *<1 km^2* (Table 17). Therefore, hearing impairment and physical impacts of VSP surveys on odontocetes are predicted to be *not significant* (Table 18).

With the implementation of the mitigation measure of ramping up the airgun array and delaying start-up for odontocetes sighted within the 500 m safety zone, disturbance effects on odontocetes are predicted to be *negligible to low*, over a duration of *<1 month*, in an area of *<1 km^2* to *101-1000 km^2* (Table 17). Therefore, impacts related to disturbance, are judged to be *not significant* for odontocetes (Table 18).

Pinnipeds

There is little potential for the VSP program to cause hearing impairment or physical effects on seals given that few seals are expected to occur in the area during the program. Also, any seals in the area would likely exhibit localized avoidance from the survey ship and sound source. If some seals did experience hearing impairments, the effects would likely be "temporary" (minutes to hours to days in duration).

Table 17. Effects assessment on marine mammal and sea turtle VECs.

Valued Environmental Component: Marine Mammals and Sea Turtles								
PROJECT ACTIVITY	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Vessel Lights	Attraction (N)	Minimize lighting	0-1	1	1	1	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	-	0-1	1	1	1	R	2
Air Emissions	Surface Contaminants (N)	-	0	1	1	1	R	2
Noise								
Vessel	Disturbance (N)	-	0-1	1	1	1	R	2
Seismic Array	Disturbance (N) Physical Effects (N)	Ramp up, safety zone for ramp up, shutdowns for endangered MM	1	1-4	1	1	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = < 11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = > 200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible (refers to population)

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = > 72 months

Geographic Extent:
1 = < 1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1000 km^2
5 = 1001-10,000 km^2
6 = > 10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 18. Significance of predicted residual environmental effects on the marine mammal and sea turtle VECs.

Valued Environmental Component: Marine Mammals, Sea Turtles				
PROJECT ACTIVITY	Significance Rating	Level of Confidence	Likelihood	
	Significance of Predicted Residual Environmental Effects		Probability of Occurrence	Scientific Certainty
Vessel Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Air Emissions	NS	3	-	-
Noise				
Vessel	NS	3	-	-
Seismic Array	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

The likelihood of seals experiencing hearing impairment or other physical effects is reduced by implementing mitigation measures including ramp up of the array and delay of start up of the array for seals within a 500 m safety zone. With mitigation measures in place, the proposed VSP program is predicted to have *negligible to low* physical impacts on seals, over a duration of *<1 month*, in an area *<1 km^2* (Table 17). Therefore, hearing impairment and physical impacts of VSP surveys on seals would be *not significant* (Table 18).

With the implementation of the mitigation measure of ramping up the airgun array and delaying start-up for seals sighted within the 500 m safety zone, disturbance effects on seals are predicted to be *negligible to low,* over a duration of *<1 month*, in an area of *<1 km^2* to *101-1000 km^2* (Table 17). Therefore, impacts related to disturbance, are judged to be *not significant* for seals (Table 18).

5.5.2 Sea Turtles

There is little potential for the proposed VSP program to cause hearing impairment or physical effects on sea turtles given that few sea turtles are expected to occur in the area during the program. Also, any sea turtles in the area would likely exhibit localized avoidance from the survey ship and sound sources. If some sea turtles did experience hearing impairments, the effects would likely be "temporary". The likelihood of sea turtles experiencing hearing impairment or other physical effects is reduced by

implementing mitigation measures including ramp up of the array, delay of start up of the array for sea turtles within a 500 m safety zone, and for the endangered leatherback sea turtle shutdown of the airgun array anytime this species enters the safety zone. With mitigation measures in place, the proposed VSP program is predicted to have *negligible to low* physical impacts on sea turtles (including leatherback turtles), over a duration of *<1 month*, in an area *<1 km^2* (Table 17). Therefore, hearing impairment and physical impacts of VSP surveys on sea turtles would be *not significant* (Table 18).

With the implementation of the mitigation measure of ramping up the airgun array and implementation of a safety zone, disturbance effects on sea turtles (including endangered species, i.e., leatherback sea turtle) are predicted to be *negligible to low*, over a duration of *<1 month*, in an area of *<1 km^2 to 101-1000 km^2* (Table 17). Also, the survey site is not located in an important habitat area for turtles (i.e., breeding or feeding). Therefore, impacts related to disturbance, are judged to be *not significant* for sea turtles (Table 18).

5.6 Potential Effects on Species at Risk

Species considered as threatened or endangered under Schedule 1 of *SARA* were assessed under their specific VEC categories. To summarize, northern and spotted wolffish normally occur in much deeper water than the Project Area and thus there is little or no chance of interaction and thus *no effect* of the Project on these species of wolffish.

Leatherback sea turtles may occur occasionally in the Project Area, and few turtles are expected in the Project Area. The Project Area is not considered an important feeding (or breeding) area for this species. Available evidence (albeit limited) suggests that sea turtles exhibit at least localized avoidance of seismic arrays. There are no published reports of VSP activities significantly affecting leatherbacks; *no significant effect* of the VSP program is predicted.

As previously stated, there are no seabirds on *SARA* Schedule I that are likely to occur in the Project Area. Ivory Gull will likely become listed in the future but this species is highly associated with sea ice and would naturally be extremely rare in the Project Area.

Blue whale can be considered uncommon in the Project Area and thus potential for interaction with the Project is small. The blue whale is a baleen whale and it is anticipated that any disturbance effects on this species would be similar to those predicted for other baleen whales, namely *no significant effects*.

5.7 Potential Cumulative Effects

Cumulative effects are addressed for activities within the Project and for activities from other oil and gas projects offshore Newfoundland and Labrador.

5.7.1 Cumulative Effects within the Project

Any potential effects from a VSP program are related to underwater noise, presence of a supply boat (if one is in fact used), and accidental events. The presence of a supply boat and accidental events are captured within the Terra Nova Development EIS and are not considered here. This is valid because these activities are well within the original Project Description and EIS. It should be noted that a VSP program does not normally use streamers, which in a typical seismic program would be filled with Isopar (a kerosene-like petroleum product not that different from diesel oil, which *was* covered in the EIS). Thus, underwater noise becomes the primary issue associated with a VSP program.

The sound from a VSP airgun array will be additive to other underwater sounds produced by the Terra Nova Project from supply vessel and tanker propulsion systems, drill rig machinery, and FPSO station-holding thrusters. To our knowledge there are no baseline data on the ambient underwater sounds (natural and anthropogenic) in the Terra Nova Development area. However, it should be noted that the temporal and spatial boundaries for a VSP survey are very limited relative to the Project as a whole. For example, the time frame of a VSP survey is short (eight to 36 hours), and there are a limited number of surveys (normally one per well; thus there may be on the order of another six surveys, depending upon the number of additional wells, over the life of the Terra Nova Development). In addition, the potentially affected area from any particular survey is likewise relatively small compared to a typical exploratory seismic survey because the array is normally smaller and less powerful. Thus, no significant cumulative effects will result from the VSP surveys. The confidence level in the prediction is high as confirmed by similar predictions of non-significant cumulative effects for much larger area seismic programs using much larger and more powerful arrays over a much longer period of time (e.g., Orphan Basin 3-D 2004-2005 surveys, Laurentian Sub-basin 2004 2D and 2005 3D surveys).

5.7.2 Cumulative Effects with Other Oil and Gas Activities

In addition to cumulative effects within a project, it is necessary to assess cumulative effects with other projects in the region. Based upon an examination of the C-NLOPB website registry of projects undergoing, or recently completed, and Petro-Canada's general knowledge of the availability of seismic vessels and drill rigs, the following levels of activity in eastern Newfoundland and Labrador waters can be expected over the next several years.

- Labrador Shelf – one 2D or 3D seismic survey per year
- Orphan Basin –one 3D or CSEM survey and one exploratory well per year
- NE Grand Banks—one 3D survey and three VSP surveys (one each for Hibernia, Terra Nova, and White Rose); White Rose glory hole excavation; two or three wells drilled per year using a semi-submersible and a jack-up
- SW Grand Banks/Laurentian Sub-basin—one 3D program and one drilling program per year

The above programs will have support vessels, typically offshore supply tugs.

As discussed above, there are no broad-scale, broadband underwater sound measurements available for the regional area and thus one can only provide qualitative predictions of cumulative effects of an additional sound source from the VSP. The proposed Terra Nova VSP program will add some additional sound to the background sound from larger scale seismic programs, drill rig machinery, a dredge operating at White Rose, and seismic and support vessels. Other noise sources include those from marine transportation, fishing vessels, military ships, and private yachts. Again, because the VSP surveys are low magnitude (relative to large seismic), short duration (up to 36 h), low frequency (perhaps one or two per year), little cumulative effects are predicted from this source. Thus, there will be no significant cumulative effects between the Terra Nova VSP and other oil and gas activities (or other general marine activities).

6.0 Mitigations and Follow-up

Project mitigations have been detailed in the various individual sections of the EA and are summarized below and in Table 19. Petro-Canada and its contractors will adhere to mitigations detailed in Appendix II of the C-NLOPB *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (April 2004).

Table 19. Summary of mitigation measures for the proposed VSP Program in the Terra Nova Development.

Potential Effects	Primary Mitigations
Interference with fishing vessels	Use of Terra Nova Precautionary and Safety Zones as described in the "Vessel Traffic Management Plan" (Document No. TN-PE-MR04-X00-005).
Fishing gear damage	Use of Terra Nova Precautionary and Safety Zones as described in the "Vessel Traffic Management Plan" (Document No. TN-PE-MR04-X00-005). A compensation program as per the "Fisheries Liaison and Compensation Program" (Document No. TN-IM-EV03-X00-010).
Interference with shipping	Use of Terra Nova Precautionary and Safety Zones as described in the "Vessel Traffic Management Plan" (Document No. TN-PE-MR04-X00-005).
Interference with DFO research vessels	Use of Terra Nova Safety Zone as described in the "Vessel Traffic Management Plan" (Document No. TN-PE-MR04-X00-005). Good communication and planning.
Temporary or permanent hearing damage to marine animals	Delay start-up if marine mammals or sea turtles are within 500 m; ramp-up of airguns; use of environmental observer
Disturbance to Species at Risk or other key habitats	Geographic and temporal avoidance, if possible; shut-down if blue whale or North Atlantic right whale or leatherback turtle sighted within 500-m safety zone
Injury to stranded seabirds	Handling and release protocols (as per Chardine and Williams n.d.)

Petro-Canada's monitoring and mitigation approach for marine mammals and sea turtles involves the shutdown of any active airguns if a threatened or endangered marine mammal or turtle (as listed by *SARA*) is sighted within or about to enter the 500 m safety zone. In addition, Petro-Canada will employ ramp up of the airgun array and this procedure will be delayed if any marine mammal or sea turtle is sighted within the 500 m safety zone during the 30 min prior to ramp up. More specifically, for marine mammals and sea turtles:

For 30 minutes prior to the commencement of ramping up of the seismic array

- an Environmental Observer (EO) will maintain a watch for marine mammals and sea turtles

- if any marine mammal or sea turtle species comes within the 500 meter zone[3] during this period ramp up will not commence until the animal has left the zone (or the EO has not seen the marine mammal or sea turtle for 20 minutes)

During the ramp up of the array

- the EO will maintain a watch for marine mammals and sea turtles and if an endangered species (blue whale, North Atlantic right whale, or leatherback sea turtle) enters the 500 meter zone, ramp up will be halted until the animal leaves the zone (or the EO has not seen the marine mammal or sea turtle for 20 minutes)

- ramp up will take a minimum of 30 minutes starting with the smallest airgun and gradually adding airguns at evenly spaced intervals, increasing the volume over a 30-minute period until all airguns are active.

- these ramp up procedures will be followed at night and in periods of negligible visibility (i.e., fog) with the exception that the EO will not be able to perform the 30 minute watch prior to ramp up at night

- note that ramp up procedures should be implemented when the airguns have been off for 20 or more minutes

During periods of data acquisition (i.e., line shooting) of the array

- during data acquisition (or periods of seismic testing), if the EO sights a blue whale, North Atlantic right whale, or leatherback turtle within the 500 meter zone the airgun array will be shut down until the animal has left the zone or the EO has not seen the blue or right whale, or leatherback turtle for 20 minutes

Any dead or distressed marine mammal or turtle will be reported immediately to the C-NLOPB and DFO. A follow-up program will not be implemented for the VSP surveys but a monitoring report will be submitted to the C-NLOPB which details the numbers, species, and behavioural observations of marine mammals and sea turtles recorded during the monitoring program.

Any seabirds (most likely Leach's Storm-Petrel) that become stranded on the vessel will be released using the mitigation methods consistent with *The Leach's Storm-Petrel: General Information and Handling Instructions* by U. Williams (Petro-Canada) and J. Chardine (CWS) (n.d.). Stranded birds will be handled by a designated crew member. Lighting aboard the survey vessel will be reduced (only when it is safe to do so) at night to minimize the likelihood of seabirds stranding.

[3] Observers will consider the safety zone to be 500 m from the bridge (location of the observer) not the center of the array.

7.0 Conclusions

Given the present state of knowledge, the following conclusions can be drawn:

- There are no recorded unusually large concentrations of species sensitive to sound, or 'species at risk' under *SARA*, in the Terra Nova Development and surrounding area.
- The geographic extent, magnitude, and duration of the VSP activities will all be much less than standard 2-D or 3-D seismic surveys.
- Mitigation measures will be employed.

Considering the above three points, VSP activities at the Terra Nova Development will not result in any significant effects on VECs assessed in this EA.

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Personal Communication

Canning, S.	Canning and Pitt, St. John's, NL
Chidley, G.	Commercial fisherman
Dufault, S.	LGL Ltd., Halifax, NS
Dugal, R.	Petro-Canada, St. John's, NL
Evans, J.	Petro-Canada, St. John's, NL
Kaderali, A.	Husky Oil Operations, St. John's, NL
Lawson, J.	DFO, St. John's, NL
Lilly, G.	DFO, St. John's, NL
Simms, J.	DFO, St. John's, NL
Thomas, P.	CWS, St. John's, NL
Tillman, J.	DFO, St. John's, NL
Thorne, H.	Commercial fisherman

Appendix A: Physical Environment Report