ORPHAN BASIN CONTROLLED SOURCE ELECTROMAGNETIC SURVEY PROGRAM ENVIRONMENTAL ASSESSMENT

Prepared by

LGL LIMITED
environmental research associates

for

ExxonMobil Canada Ltd.

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6 June 2006

Orphan Basin Controlled Source Electromagnetic Survey Program, Environmental Assessment

by

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1.0 Introduction

This document is an environmental assessment (EA) of a proposed controlled source electromagnetic survey to be conducted during 2006 or 2007 (and possibly in later years to the term of the exploration licences (ELs)) in the Orphan Basin on behalf of ExxonMobil Canada Ltd., (hereafter referred to as ExxonMobil) and partners (collectively referred to as "the Proponents"). This EA has been prepared for the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), under the *Atlantic Accord* acts.

Previous environmental assessments for Orphan Basin include a strategic environmental assessment (SEA) of offshore exploration activities conducted for the C-NLOPB (LGL 2003), a 3D seismic program EA, and associated update and monitoring reports (Buchanan et al. 2004; Moulton et al. 2005a, b), and a drilling EA (LGL 2005) and addendum (LGL 2006).

Controlled source electromagnetic surveys (CSEM) or resistivity mapping is a relatively new technology. ExxonMobil is a world leader in developing the CSEM technology which has been used with success in West Africa, Brazil, Columbia and Norway. The technique is used supplemental to 3D seismic data to discriminate petroleum from water if the reservoir structure is known, and thus increase drilling success rates. It involves the following steps:

- Identification of potential reservoir structures suitable for hydrocarbon accumulation using 3D seismic,
- Placement of anchored dipole receivers in a fine grid pattern,
- Towing of very low frequency electromagnetic source alternating current (AC), about 50 m above the bottom,
- Measurement and mapping of electrical resistance encountered,
- Retrieval of receivers using acoustic releases, and
- Data analyses.

At present the technique is only used in deep (>500 m) water where the signal to noise ratio is low. The technique, the proposed survey program and potential environmental effects are described in the following sections.

2.0 The Operator ExxonMobil

ExxonMobil is the industry leader in each of its core businesses and has an unmatched array of proprietary technologies aimed at increasing the productivity of its assets and employees. The company conducts business in almost 200 countries and territories around the globe in the areas of technology development, downstream refining and marketing, chemical production and upstream exploration and production.

ExxonMobil's upstream exploration and production portfolio spans more than 40 countries and includes a resource base totaling 72 billion oil-equivalent barrels, 4.2 million oil-equivalent barrels per day of production in 25 countries, more than 100 major new development projects, and global gas and power marketing.

ExxonMobil is the largest crude oil producer in Canada, a significant natural gas producer, and holds the leading proved reserve position through its wholly owned affiliate, ExxonMobil Canada Ltd. and its majority-owned affiliate, Imperial Oil Limited.

The company’s objective is to prevent all accidents, injuries, and occupational illness through the active participation of all employees. ExxonMobil is pleased that our contractors have joined us in an all-out effort to see that "Nobody Gets Hurt".

The successful management for safety starts with the involvement of everyone from the CEO to hourly workers in a systematic and continual focus on hazard recognition and mitigation. Production and profits are never more important than safety--NEVER.

ExxonMobil is committed to conducting business in a manner that is compatible with the environmental and economic needs of all communities in which it operates and that protects the safety, health and security of its’ employees, those involved in our operations, our customers and the public. These commitments are documented in its’ safety, health, environmental, product safety and security policies. These policies are put into practice through a disciplined management framework called Operations Integrity Management system (OIMS).

The OIMS framework includes 11 elements. Each element contains an underlying principle and a set of expectations. The OIMS framework also includes the characteristics of and processes for evaluating and implementing, 27 operations integrity management systems.

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3.0 Project Description

It is proposed to conduct controlled source electromagnetic surveys of the Proponents' jointly-licenced offshore acreage in Orphan Basin in 2006 or 2007 and possibly from time to time until the ELs expire. For the purposes of this EA, and to maintain consistency with previous 3D seismic EAs for the area, a 'Project Area' has been defined as the ELs leased by the Co-venturers in Orphan Basin plus a 20-km area surrounding the ELs in order to include possible program extension and vessel turnaround zones (Figure 3.1). Within the Project Area, the specific area for survey operations in 2006 or 2007 is called the '2006-7 CSEM Program Area' (Figure 3.1). In 2006 or 2007, it is proposed that a survey vessel will operate within the Project Area (Figure 3.2) for a period within a July through September/October timeframe but commencing in May in future years.

3.1 Location of Proposed Project

The Proponents may conduct electromagnetic survey operations in portions of ELs 1073, 1074, 1076, 1077, 1078, 1079, and 1080. For 2006-7 surveys, three targets have been identified: (1) Great Barasway, (2) Chapel Arm, and (3) Sunnyside (Figure 3.1). Water depths in the 2006-7 Program Area range from about 1,500 m to 2,750 m. The 2006-7 Program Area, at its closest point, is about 300 km northeast of St. John's, Newfoundland and Labrador.

3.2 Acquisition Duration and Timing

The total duration of the 2006-7 program is anticipated to be 64 days. There will be ~49 days of field data acquisition and the remaining days would include transit, equipment deployment and retrieval, weather and technical downtime. The 2006-7 program will occur during the 1 July to 30 September period. Subsequent surveys, if they occur, could be conducted within a 1 May to 31 October time window.

3.3 Electrical Source Parameters

The electrical source (Figure 3.3) will be towed approximately 50 m above the sea bottom. Current (about 1,000 A) will be alternating and very low frequency (on the order of 0.25 Hz, to be determined on site after initial testing).

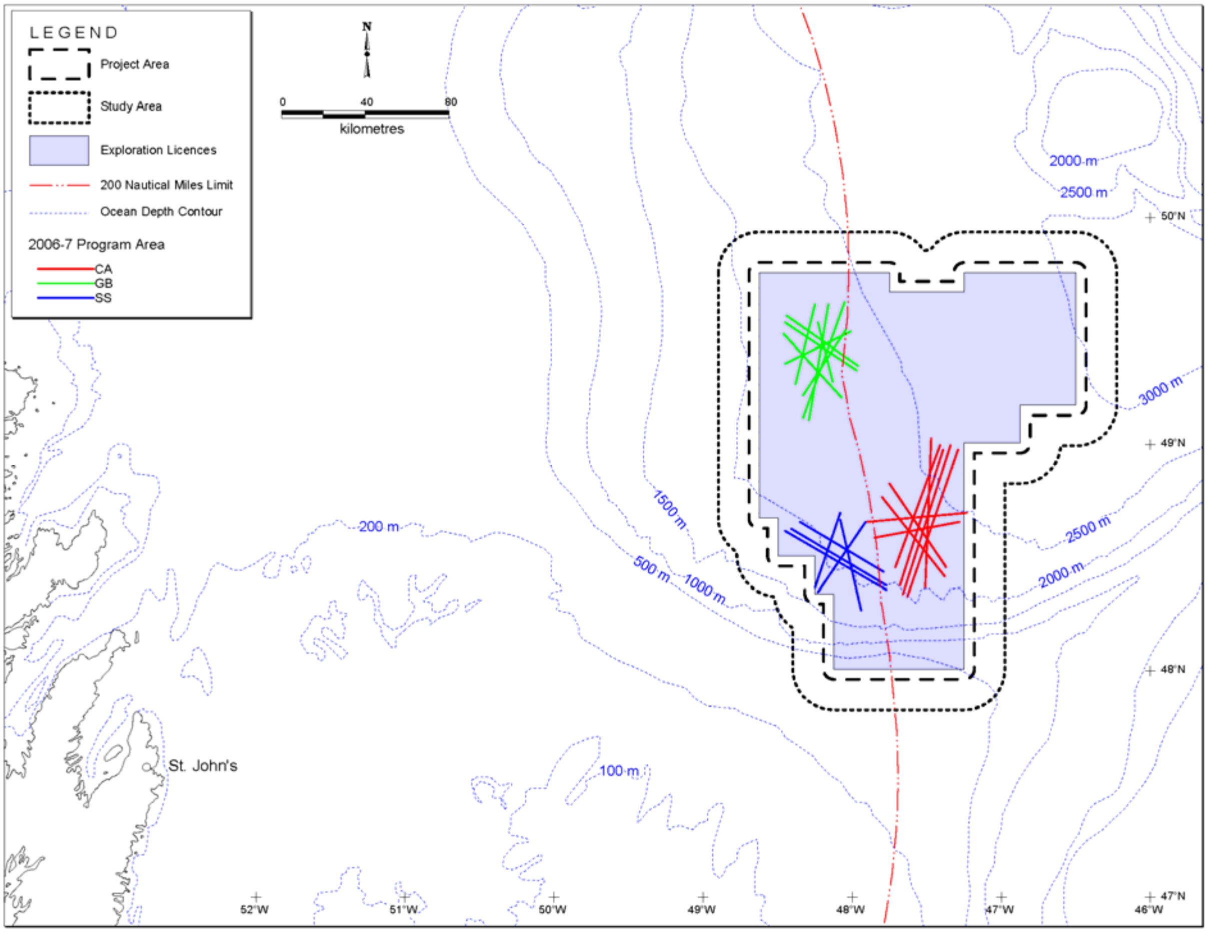

Figure 3.1. Locations of the Study Area, Project Area and Proposed CSEM Program for 2006.

3.4 Field Survey Vessel

The field survey vessel, similar to many large offshore vessels (e.g., supply vessels, cable laying vessels, etc.) presently in use in Canadian waters, will be chartered for the duration of the survey and will meet all international and Canadian requirements for a vessel of its class and size (see Figure 3.2 for example). The vessel will be large enough to accommodate ship's officers and crew and scientific and technical personnel for a total of about 30-40 personnel. It will have dynamic positioning capabilities and a large aft deck to accommodate and deploy the equipment safely and efficiently by crane.

The receivers are dipole antennas that are placed on the bottom with concrete blocks (about 1 m x 1 m x 10-15 cm) (Figure 3.4). Receivers are released remotely by acoustic releases and retrieved. Blocks are left on the bottom.

Figure 3.2. Typical CSEM Survey Vessel.

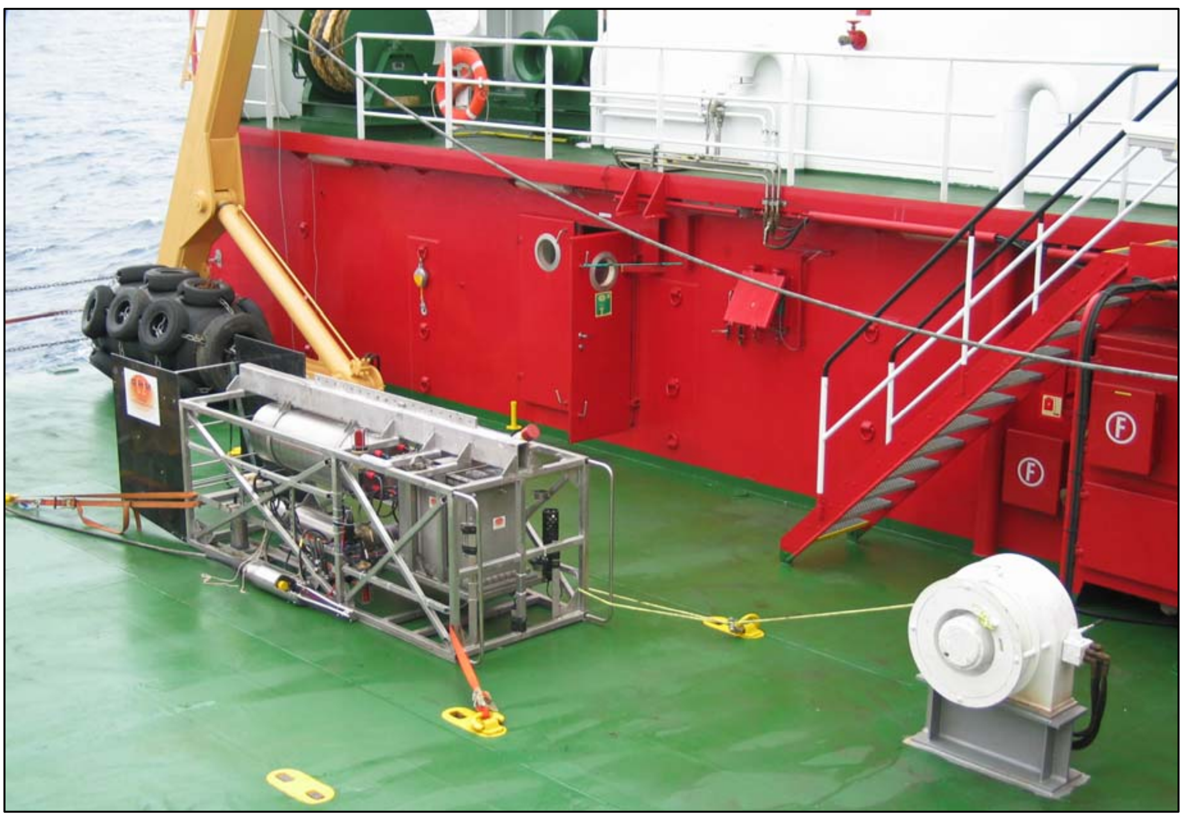

Figure 3.3. CSEM Towed Gear.

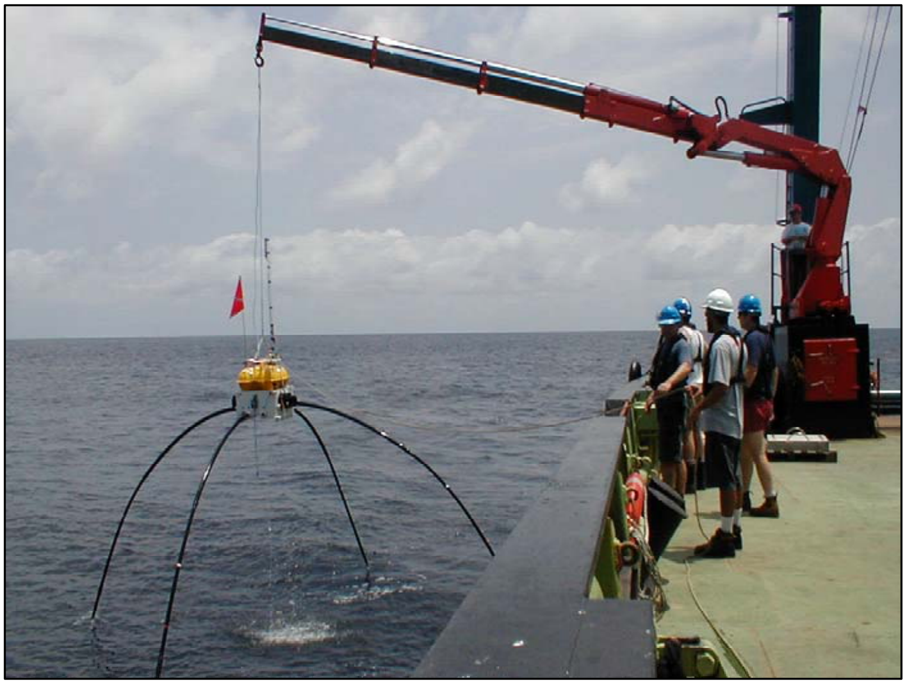

Figure 3.4. Dipole Antenna with Anchor.

3.5 Survey Design

The 2006 survey design, including active source lines is shown in Figure 3.5. Great Barasway will have about 46 receiver locations over 387 km of active source lines for about 19 days. Chapel Arm with 54 receiver locations and 555 km of active source lines over about 18 days is shown in Figure 3.6. Sunnyside will have 39 receiver locations with 289 km of active source lines over 12 days (Figure 3.7).

3.6 Logistical Support

Helicopters may be used to ferry personnel and lightweight supplies to the vessel if it is equipped with a heli-deck. Helicopter logistic support would be based in St. John's. For 2006-7, it is anticipated that re-supply and some crew change could occur in St. John's about half-way through the program.

3.7 Mitigations

CSEM surveys are not analogous to seismic surveys and thus the same type of mitigations are not warranted. No significant effects from the proposed deepwater survey on the biota of Orphan Basin are predicted, as detailed in the following EA. Nonetheless, the Proponents will institute mitigations to lessen any potential effects on biota, however small they might be, and to reduce or eliminate any effects on seabirds or the fishery. Mitigations during the proposed 2006-7 survey program in Orphan Basin will include:

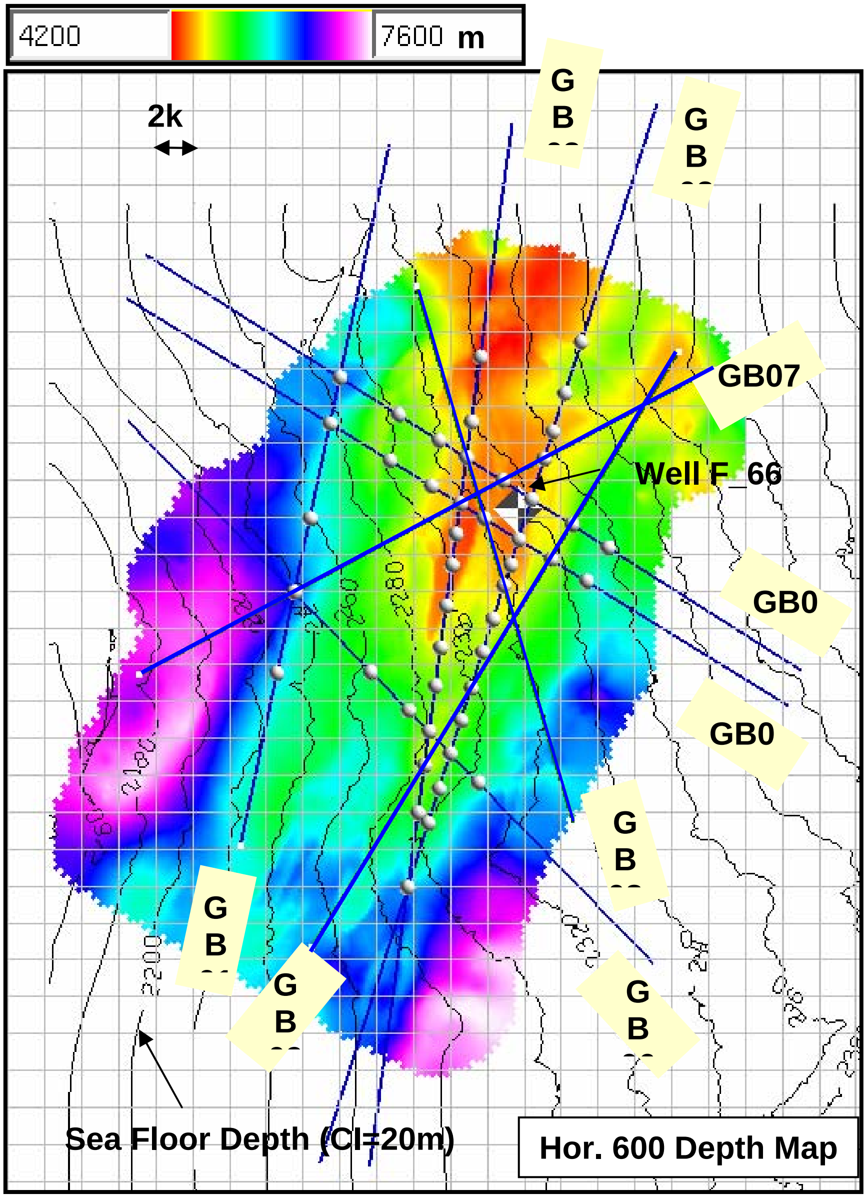

Figure 3.5. Great Barasway Survey Design.

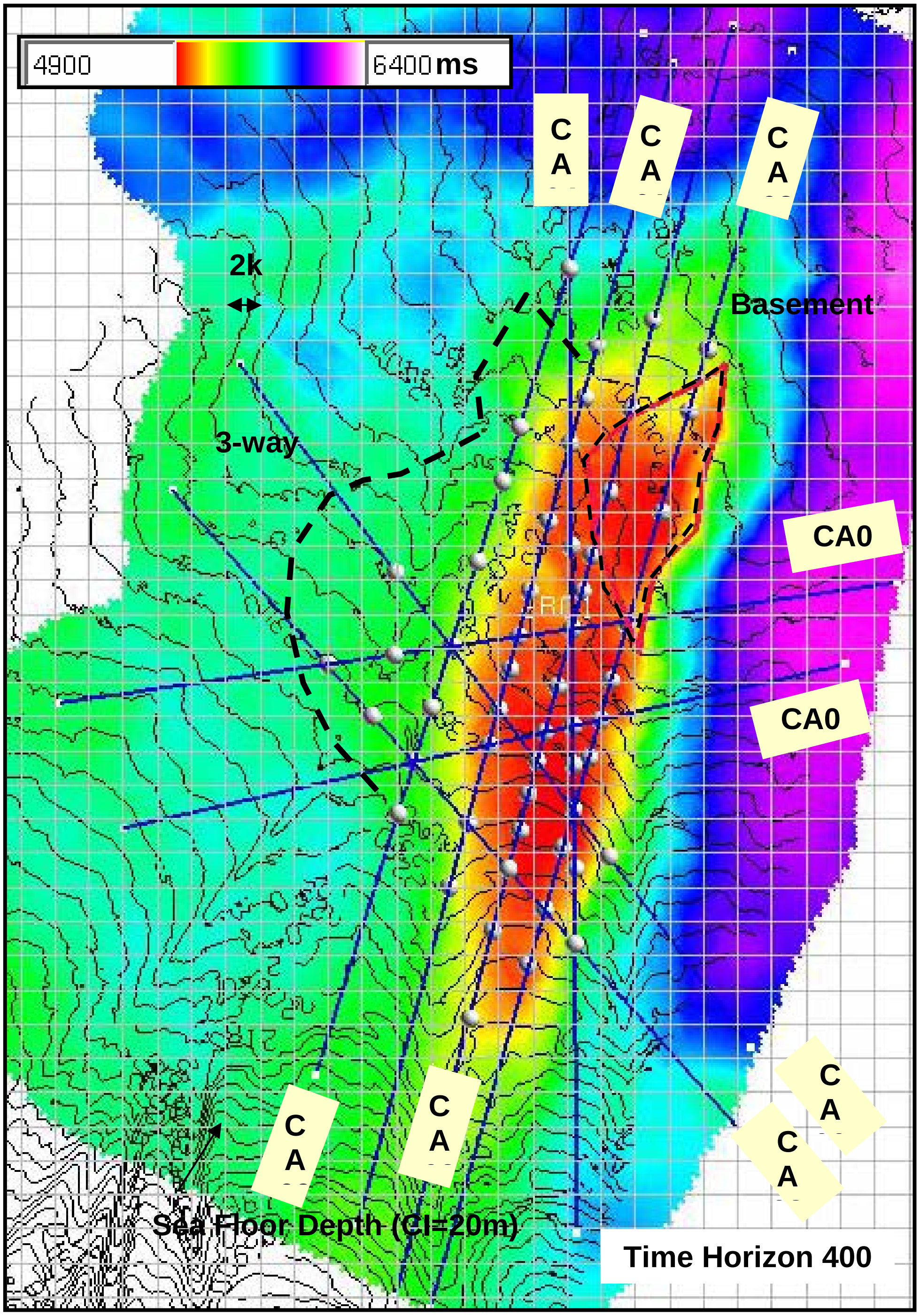

Figure 3.6. Chapel Arm Survey Design.

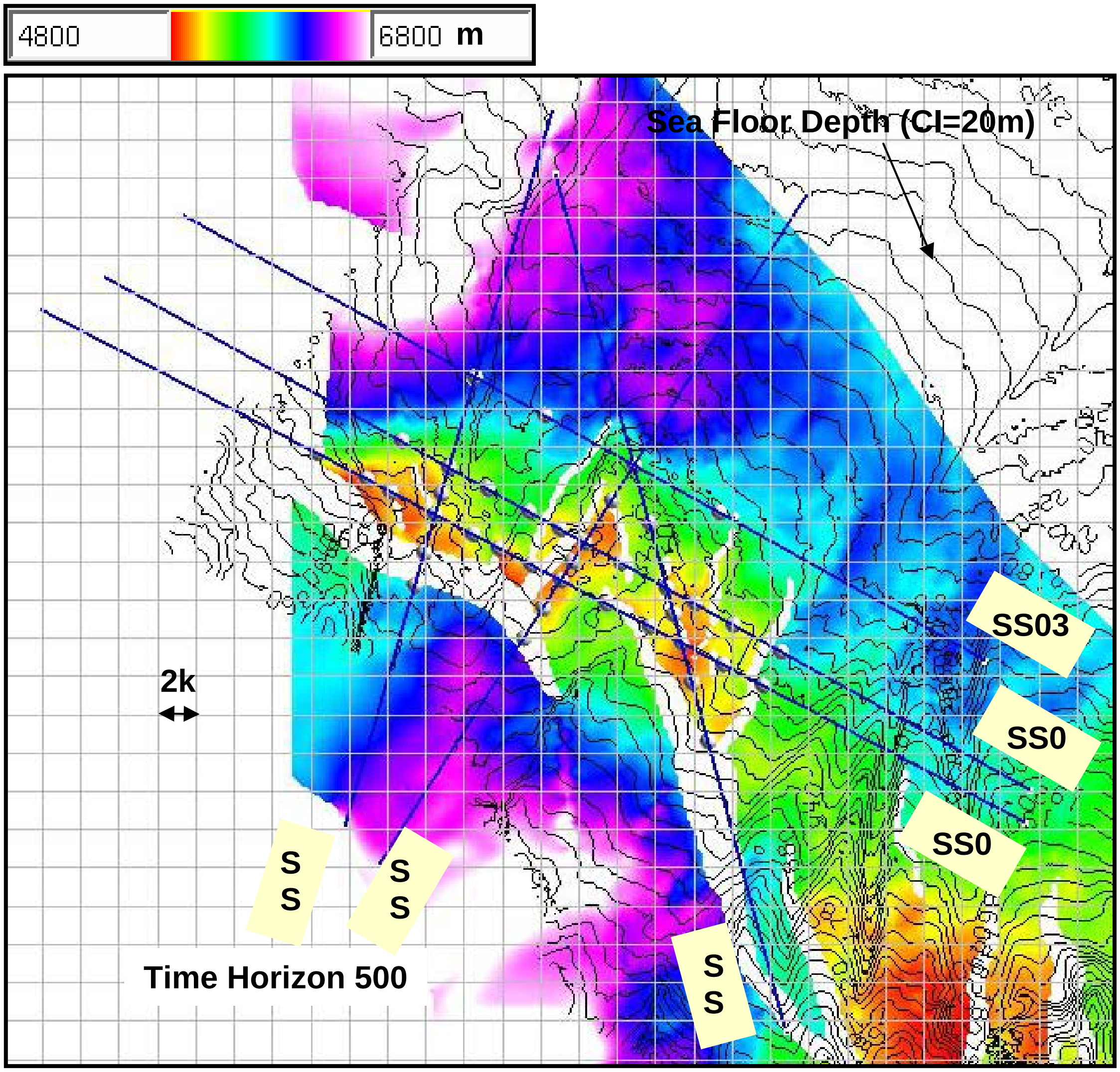

Figure 3.7. Sunnyside Survey Design.

- Ramp-up of the electromagnetic source over a 20 to 40 minute period.
- Will not operate the electromagnetic source in shallow water (<500 m) and during turns.
- Reducing lighting on board the survey ship to minimum safe levels.
- Retrieving and releasing stranded seabirds according to appropriate guidelines.
- Notification to fishers of the timing and location of planned survey activities via "Notice to Mariners" and "Notice to Fishers" as well as consultations with appropriate fishing groups.
- Use of a FLO to monitor and communicate with fishing vessels in the area.
- Compensation program for fishers for any gear loss attributable to the CSEM program.

3.8 Monitoring

Qualified Environmental Observer (s) (EO) will be on board the ship to monitor marine mammals, sea turtles and to release stranded seabirds. Seabird and marine mammal data will be collected on an opportunistic basis and safe handling and release of any seabirds (typically petrels) that may become stranded on the vessel will be managed in accordance with guidelines from the Canadian Wildlife Service. The EO will be assisted by a Fisheries Liaison Officer (FLO) trained in marine mammal identification and data recording procedures. This monitoring program will provide additional assurance on the EA predictions although the primary purpose will be to collect additional data from the Orphan Basin for potential future use in drilling and production EAs and monitoring programs.

For seismic surveys, monitoring of marine mammals and seabirds during operations is conducted as a mitigation strategy in conjunction with a 500 m exclusion zone. In the case of CSEM, the electromagnetic source is located in deep water (~ 1,500 – 2,750 m) approximately 50 m of sea bottom therefore risk to animals at/near the surface is considered negligible. However, given this is the first CSEM survey in the Newfoundland and Labrador offshore area, data will be collected during operations to verify EA predictions.

The EO personnel qualifications will be consistent with the expectations of the Canadian Wildlife Service (CWS) and Fisheries and Oceans (DFO) (Moulton and Mactavish 2004).

4.0 Existing Environment

The existing physical and biological environment of Orphan Basin has been detailed in the previous EAs and addenda based on the most recent available information. Lower trophic levels (e.g., plankton) in the Orphan Basin are not unique and are similar to those found on the Grand Banks and associated slopes, and deepwater of the NW Atlantic. Because of the extensive documentation within current EAs for the Orphan Basin 3D seismic and drilling programs and because there is no evidence to suggest adverse effects on lower trophic levels the following sections are focused on the valued ecosystem components (VECs) that have at least some potential to be affected by the program.

4.1 Species at Risk

Canada's *Species at Risk Act* (*SARA*) was designed to aid in the protection and recovery of species whose populations are considered endangered, threatened or of special concern. It should be noted that there is also provincial legislation concerning threatened and endangered species but, for the most part, it is not relevant to the offshore. Species are nominated to the federal Minister of Environment for inclusion on the *SARA* lists (Schedules 1 to 3) by the Committee for the Status of Endangered Wildlife in Canada (COSEWIC). Schedule 1 of the *SARA* is the official legal list of wildlife species at risk in Canada. Once listed, the measures to protect and promote the recovery of a listed species are implemented.

Status of species that may occur in Orphan Basin, at least sporadically are shown in Table 4.1. *SARA* Schedule 1 endangered or threatened species have special legal protection under *SARA* and there are potential obligations in regard to management and recovery plans.

Schedules 2 and 3 of *SARA* identify species that were designated "at risk" by COSEWIC but not yet added to Schedule 1 by ministerial recommendation and Governor in Council. Species considered at risk which may occur in the CSEM Study Area but which have not received special legal protection under *SARA* Schedule 1 include Sowerby's beaked whale (*Mesoplodon bidens*). Various populations of Atlantic cod (*Gadus morhua*) have been assessed by COSEWIC as special concern, threatened or endangered but no stocks have received legal protection under *SARA*.

Under *SARA* Schedule 1, a 'recovery strategy' and corresponding 'action plan' must be prepared for endangered, threatened, and extirpated species. A management plan must be prepared for species listed as special concern. Currently, there are no Recovery Strategies, action plans, or management plans in place for species listed as either endangered or threatened under Schedule 1, and which are known to occur in the Study Area. A Recovery Strategy should be in place for blue whales soon (J. Lawson, DFO, pers. comm.). Recovery Strategies for wolffishes and leatherback sea turtles are presently in draft form.

Table 4.1. *SARA* and COSEWIC Listed Species that could Occur in Orphan Basin, as of May 2006.

Species	**SARA Status**	**COSEWIC Status**	**Comments**
Blue Whale (*Balaenoptera musculus*)	Schedule 1 endangered		Very uncommon; more likely to be encountered in the Gulf of St. Lawrence than the Grand Banks
North Atlantic Right Whale (*Eubalaena glacialis*)	Schedule 1 endangered		Unlikely north of Nova Scotia
Ivory Gull (*Pagophila eburnea*)		Endangered (April 2006)	Associated with ice
Leatherback Turtle	Schedule 1 endangered		Potentially associated more with the slope of the banks than the shelf
Atlantic Salmon (*Salmo salar*) (Bay of Fundy)	Schedule 1 endangered		Some strays are possible
Atlantic cod (*Gadus morhua*) (NL)		Endangered	Not placed on *SARA* legal list after public consultations
Porbeagle shark (*Lamna nasus*)		Endangered (April 2004)	
White shark (*Carcharodon carcharias*)		Endangered (April 2006)	
Northern wolffish (*Anarhichas denticulatus*)	Schedule 1 Threatened		
Spotted wolffish (*Anarhichas minor*)	Schedule 1 Threatened		
Cusk (*Brosme brosme*)		Threatened (April 2006)	
Shortfin Mako (*Isurus oxyrinchus*)		Threatened (April 2006)	
Fin Whale (*Balaenoptera physalus*)		Special Concern (May 2005)	
Sowerby's Beaked Whale (*Mesoplodon bidens*)	Schedule 3 Special Concern		
American eel (*Anguilla rostrata*)		Special Concern (April 2006)	
Blue shark (*Prionace glauca*)		Special Concern (April 2006)	
Harbour porpoise (*Phocena phocena*)		Special Concern (April 2006)	

ExxonMobil will apply adaptive management measures to deal with any changes to Schedule 1 of *SARA* during the program. Each year prior to commencement of the survey season, ExxonMobil will consult with DFO and Environment Canada regarding any listing changes of Schedule 1 species, releases of Recovery Strategy Plans, and possible mitigative measures as they relate to Species at Risk. The Proponents will continue to monitor the listings through the Canadian Association of Petroleum Producers (CAPP), the law gazettes, and the Internet, and to assess their activities relative to any future relevant *SARA* listings, Recovery Strategies and Action Plans.

It is the Proponents' intent not to contravene any of the prohibitions of *SARA*. Project effects are not expected to contravene the prohibitions of *SARA* for any of the listed species which could be found in the Orphan Basin.

Profiles for *SARA*-listed species potentially occurring in the CSEM Study Area are provided later in this chapter.

4.2 Benthos

Benthos is not strictly speaking a VEC although it may contain and/or support VECs such as certain benthic commercial species. Benthic invertebrates living on the seafloor form an important link to higher trophic levels such as fish, seabirds and marine mammals. There do not appear to be any published studies on benthic communities in Orphan Basin; it is assumed that they are similar to other areas of the northwest Atlantic for equivalent depths and substrates (see LGL 2003, 2005, 2006 for review).

Previous EA studies have mostly focused on the Grand Banks continental shelf with specific interest in the Hibernia region where benthic samples range in depth from 51 to 183 m. Published studies from Memorial University include epibenthic megafauna collected also from the outer Grand Banks Hibernia region (Schneider et al. 1987) and macrobenthic data collected from deeper regions in the Carson Canyon at depths of 76 to 1,129 m (Houston and Haedrich 1984). A functional study of benthic polychaete communities was also conducted in the Hermitage Channel to the south of Newfoundland in depths ranging from 305 to 375 m (Gagnon and Haedrich 1991). DFO has conducted a number of surveys to assess impacts of commercial bottom trawling on the Grand Banks which provide additional information on macrofaunal communities in un-trawled areas (Gilkinson et al. 1998; Gordon et al. 1998; Prena et al. 1999; Kenchington et al. 2001). Allen (1965) and Nesis (1965) list benthic organisms recorded in the outer Grand Banks. These authors reported on mollusc species and descriptive benthic species assemblages based on grab samples and incidental trawl catches collected during Fisheries Research Board cruises but the data are qualitative or else localized in scope and dated.

In summary, much of the benthic fauna of Newfoundland and Labrador remains to be inventoried (Gilkinson 1986) and there are considerable data gaps for certain geographic regions and deep-sea environments such as the continental margin and slope environments and deep sea abyssal habitats. Surveys that assess benthic community composition rather than species-specific studies are limited for this region. At present, no existing published studies of benthic community composition specifically for the CSEM Study Area could be identified. The Study Area encompasses continental slope environments as well as abyssal habitats with depths that range from 500 to 3,000+ m. This area is influenced by cold arctic and subarctic waters as well as by warmer North Atlantic waters that also influence the eastern and southern edges of the Grand Banks.

Box core samples were collected by LGL on behalf of the Orphan Basin exploration licence holders at four locations within the Project Area (Figure 4.1) during June and July 2004 as part of a scientific cruise on the CCGS *Hudson*: (1) OB-1 in EL1079, (2) OB-2 in EL1076, (3) OB-3 in EL1077, and (4) OB-4 in EL1078. All samples were collected in very deep (>2,000 m) water (Table 4.2). The four box core samples were opportunistically collected during the scientific cruise organized by Natural Resources Canada and intended to study geohazards on the continental margin off Newfoundland. The cruise did not devote time to areas in the Study Area where commercial fishing is prosecuted. The surface area sampled by the box corer is 0.25 m2 (0.5 m x 0.5 m) (D. Piper, Scientist, NRCan, pers. comm.). The maximum volume of sediment sampled by the box corer is 0.15 m3 (Piper 2005).

Species diversity was slightly higher in sediments collected at OB-1 and OB-2 mostly due to higher numbers of polychaete worms (Table 4.2). The number of individual specimens found in OB-1 sediment was considerably higher than the numbers found in the sediments from the other three sampling sites mostly due to protozoans, polychaetes and crustaceans including cumaceans, isopods, and amphipods (Table 4.2). Analysis of the sediments indicated that samples from OB-1 had a substantially larger sand component than those from the other three sampling sites. No corals were collected in the four samples. Echinoderms are typically another important, diverse and highly visible component of deep-sea megafauna and undoubtedly occur in the CSEM Study Area.

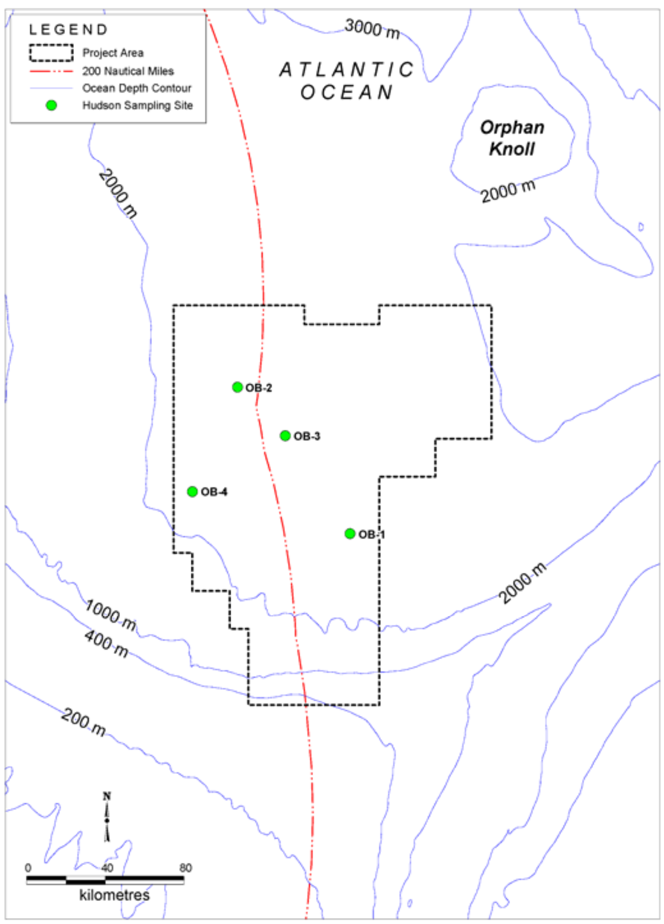

Figure 4.1. Sampling in the Project Area by LGL on the RV *Hudson*.

Table 4.2. Infauna in Sediment Cores Collected from RV *Hudson* in Orphan Basin, June and July 2004.

PHYLUM	**CLASS**	**SAMPLING LOCATIONS (Water Depth)**			
		OB-1 (2,423 m)	**OB-2 (2,277 m)**	**OB-3 (2,363 m)**	**OB-4 (2,123 m)**
Sarcodina	Rhizopodea (protozoa)	Various species **35**	Various species **3**	Various species **20**	Various species **13**
Cnidaria	Anthozoa (sea anemones)	1 species **4**	1 species **8**		
Annelida	Polychaeta	15 species **29**	15 species **23**	8 species **11**	13 species **20**
Sipuncula	(sipunculids)		**3**		
Nematoda	(nematodes)	**3**	**2**	**6**	**23**
Nemertinia		**1**	**1**	**1**	**1**
Arthropoda	Brachyopoda		**3**		
Arthropoda	Malacostraca[1]	6 species **17**	4 species **5**	8 species **19**	3 species **3**
Arthropoda	Ostracoda		1 species **1**		
Arthropoda	Pycnogonida			1 species **1**	1 species **1**
Mollusca	Aplacophora	1 species **1**			
Mollusca	Gastropoda	1 species **1**			
Mollusca	Pelecypoda	1 species **1**			1 species **1**
Echinodermata	Stelleroidea	1 species **1**	1 species **1**	1 species **1**	
Total Number of Species		**29+**	**27+**	**21+**	**21+**
Total Number of Individuals		**93**	**50**	**59**	**62**

Bold numbers indicate number of individuals
[1] includes cumaceans, isopods and amphipods
Source: (JWEL/EMC unpubl. data).

4.2.1 Deep-Water Corals

Deep-water corals are reviewed in detail in LGL (2005, 2006). There has been increasing interest in deep-water corals in recent years because of their likely sensitivity to disturbance, their long generation times, scientific interest, and other factors. These benthic invertebrates generally occur on the ocean bottom at depths exceeding 150 m (often >200 m in Atlantic Canada). Some of these filter-feeding animals form reefs while others are much smaller and remain solitary. Corals add structural complexity to ocean bottom habitats that may otherwise be relatively featureless. It is generally accepted that coral habitats are areas of high biological diversity (Breeze et al. 1997; MacIssac et al. 2001). The most widely accepted theory for the formation of deep-water reefs is that corals establish themselves at locations on the seafloor where there is a continuous and regular supply of concentrated food and/or nutrients, in the form of zooplankton, caused by the flow of a relatively strong current over special topographical formations which cause eddies to form. There is also belief that nutrient seepage from the sub-stratum might also promote a location for settlement (Hovland et al. 2002). Four major groups of deep-water corals occur in eastern Canadian waters: (1) Alcyonacea (soft corals), (2) Gorgonacea (horny corals), (3) Scleractinia (stony corals), and (4) Antipatharia (black corals). Most deep-water corals are found in areas where water depths exceed 200 m (i.e., edge of continental slope, canyons, channels between fishing banks). Some soft corals do occur in shallower waters on the continental shelf (Mortensen et al., *in press*).

Of seventeen deep water stations (1,000-1,500 m to 2,500-3,000 m) off the Scotian Shelf that were characterized during an environmental assessment of exploration drilling for Marathon, corals were observed at six of them (Marathon Canada 2003). Primary coral habitat was observed at stations where depths were ≤ 1,500 m. Deep-water corals are known to occur in regions off the west coast of Ireland (e.g., Rockall Trough, Porcupine Seabight). Water depths where corals occur in this region typically range from 150 to 1,000 m.

Between 1999 and 2001, DFO research trawl surveys conducted off Nova Scotia, Newfoundland and Labrador, and in the Arctic region collected 57 deep-water coral specimens (Gass 2002). There were seven species comprising this collection:

1. *Acanella arbuscula*
2. *Acanthogorgia armata*
3. *Flabellum* spp.
4. *Keratoisis ornate*
5. *Paragorgia arborea*
6. *Paramuricea* spp.
7. *Primnoa resedaeformis*

The corals were generally distributed along the edge of the continental shelf. All but *Flabellum* spp. and *K. ornate* were collected during trawl surveys in waters off Newfoundland and Labrador. Table 4.3 presents information relating to those coral specimens (all gorgonian) collected in Newfoundland and Labrador waters.

Table 4.3. Depth Ranges of Corals Based on DFO Groundfish Trawl Surveys and the Fisheries Observer Program.

Species[1]	**Average Depth (m)**	**Minimum Depth (m)**	**Maximum Depth (m)**	**Standard Deviation**
Acanella arbuscula	622	281	1,400	365
Acanthogorgia armata	551	164	1,400	579
Paragorgia arborea (Bubblegum coral)	361	249	720	107
Paramuricea spp. (Black coral)	598	154	1,159	411
Primnoa resedaeformis (Sea corn)	319	166	467	75

[1] Only species found to date in Newfoundland and Labrador waters are considered.

Edinger et al. (DRAFT 2005) mapped coral distributions in Newfoundland and Labrador waters using coral samples and records from DFO research vessel survey trawls between fall 2003 and winter 2005, and fisheries observers aboard commercial fishing vessels during the April 2004 to March 2005 period. A total of nineteen species of corals were recorded, including seven horny corals (gorgonians), three soft corals (alcyonareans), six seapens (pennatulaceans), two cup corals (scleractinians), and one black coral (antipathians). The corals were broadly distributed along the edge of the continental shelf, mostly at depths exceeding 300 m. Only soft corals were found at depths less than 170 m and temperatures less than 1.1ºC. Locations of multi-coral species assemblages (a.k.a. "coral hotspots") in Newfoundland waters included the northeast and eastern edges of the Northeast Newfoundland Shelf (west of the Study Area, with several "hotspots" of multiple species of *Bathypathes* south of the Project Area.

Local ecological knowledge (LEK) of fishers is also an important source of information on corals occurring in Newfoundland waters (Gass 2002). Some of the coral occurrence locations indicated by fishers include the following:

- Slope at southern Laurentian Channel
- Slope at southern St. Pierre Bank and Halibut Channel
- Slope near South Whale
- Slope on southeastern 'Tail' of Grand Bank
- Slope on eastern side of northern Flemish Pass (near southern limit of Orphan Basin Project Area)
- Shallow slope area of northeastern Newfoundland shelf (northern 3L and southern 3K)
- Slope off southern Labrador
- Slope off Cape Chidley

Based on interviews with fishers, shrimp trawls caught at least 49 coral specimens off Newfoundland between 2000 and 2001.

4.2.1.1 Coral Species Found off Newfoundland and Labrador

Brief profiles of corals found off Newfoundland and Labrador are provided below.

Acanella arbuscula

Colonies of this coral are characterized by small branches and an anchor-like, branched base structure which anchors the colony in soft substrates. Colonies are stiff but delicate and are usually less than 15 cm high. This coral typically occurs on muddy or sandy-muddy bottom. During trawl surveys conducted between 1999 and 2001, there was only one record of this species in waters off Newfoundland and Labrador. It occurred at a location on the 'Tail' of the Grand Bank at a water depth of 1,400 m. The Atlantic Canadian depth range of collected specimens is 281 to 1,400 m (see Table 4.3).

Acanthogorgia armata

This coral occurs in branched colonies which are flexible and resemble a small bush. Most colonies of this coral stand less than 20 cm high although there are reports of colonies as high as 50 cm. *A. armata* typically occurs on muddy or sandy-muddy substrate. Mortensen and Buhl-Mortensen (2004) described the study of the distribution and abundance of deep-water gorgonian corals along 52 transects at a depth range of 183 to 498 m in the Northeast Channel between Georges Bank and Browns Bank. Underwater camera/ROV work was used to run these transects. One of the coral species observed was *A. armata*. These corals were more common in the outer part of the channel along the shelf break and slope than on the inner shelf. Transects with highest abundances of coral were characterized by depths >400 m, maximum water temperatures <9.2ºC, and a relatively high percentage of coverage of cobble and boulder (i.e., more than 19% and 6%, respectively). Observations also indicated that the coral abundance is also controlled by such factors as larger-scaled topographic features governing current regimes (i.e., supply of food and larvae). During trawl surveys conducted between 1999 and 2001, there was only one record of this species in waters off Newfoundland and Labrador. It occurred at a location on the 'Tail' of the Grand Bank with a water depth of 1,400 m. The Atlantic Canadian depth range of collected specimens is 164 to 1,400 m (see Table 4.3).

***Paramuricea* spp.**

Also known as 'black coral', the two species of this genus are difficult to distinguish without microscopy. Colonies are fan-like and the branches are arranged in loose and irregular patterns in one plane. The skeleton of this coral is flexible. The colonies, which stand as high as 50 cm, are typically attached to gravel and bedrock. Three Newfoundland region DFO survey sets conducted between 1999 and 2001 collected specimens of this coral. All catches were made on the continental slope east of Newfoundland in water as deep as 1,159 m. The Atlantic Canadian depth range of collected specimens is 154 to 1,159 m (see Table 4.3).

Primnoa resedaeformis

Also known as 'sea corn', this coral is characterized by densely branched colonies that give the appearance of small trees or bushes. The 'trees/bushes' can be as high as one metre. *P. resedaeformis* is typically attached to gravel and bedrock, especially in channels and canyons. Mortensen and Buhl-Mortensen (2004) described the study of the distribution and abundance of deep-water gorgonian corals along 52 transects at a depth range of 183 to 498 m in the Northeast Channel between Georges Bank and Browns Bank. Underwater camera/ROV work was used to run these transects. One of the coral species observed was *P. resedaeformis*. The highest abundance of colonies for *Primnoa* was found along transects with average temperatures between 5.3 and 6.5ºC. *Primnoa* occurred over a wider temperature range (maximum temperature = 12.1ºC) than co-occurring *Paragorgia* (maximum temperature = 9.7ºC). Salinities ranged from 33 to 35‰. Various fauna were observed in association with *P. arborea* samples collected in the Northeast Channel off Nova Scotia. These fauna included amphipods (dominant crustacean), isopods, cirripeds, copepods, ostracods, decapods (e.g., shrimp), euphausiids and hydroids (Buhl-Mortensen and Mortensen 2004). Manned submersible observations of *Primnoa* spp. were also made in the Gulf of Alaska (Krieger and Wing 2002). *Primnoa* colonies were attached to boulders or bedrock, although less than 1% of the boulders had *Primnoa* colonies. Predators on the *Primnoa* polyps included sea stars, nudibranchs, and snails. Suspension-feeders occurring on the coral included crinoids, basket stars, anemones, and sponges. Various protection seekers, including rockfish, crab and shrimp were also observed in apparent association with the coral colonies. Mating king crabs were observed.

Specimens of this coral species were collected during three survey sets conducted between 1999 and 2001 in waters off Newfoundland and Labrador. There were 33 records off Cape Chidley, Labrador, and one further south on the edge of the Labrador Shelf. Almost 70% of the records off the northern tip of Labrador were collected in water depths ranging from 381 to 463 m. The remaining specimens were collected from locations with water depths ranging from 324 to 380 m. The Atlantic Canadian depth range of collected specimens is 166 to 467 m (see Table 4.3).

Paragorgia arborea

Also known as bubblegum coral, the colonies of this coral are tree-like, fan-shaped, brittle and easily broken. Colonies are known to grow as high as three metres, with unconfirmed reports of even greater heights. *P. arborea* typically grows on gravel, particularly in canyons and channels. Mortensen and Buhl-Mortensen (2004) described the study of the distribution and abundance of deep-water gorgonian corals along 52 transects at a depth range of 183 to 498 m in the Northeast Channel between Georges Bank and Browns Bank. Underwater camera/ROV work was used to run these transects. One of the coral species observed was *P. arborea*. The highest abundance of colonies for Paragorgia was found along transects with average temperatures between 5.3 and 6.5ºC. The co-occurring Primnoa occurred over a wider temperature range (maximum temperature = 12.1ºC) than Paragorgia (maximum temperature = 9.7ºC). Salinities ranged from 33 to 35‰. Various fauna were observed in association with *P. arborea* samples collected in the Northeast Channel off Nova Scotia. These fauna included amphipods (dominant crustacean), isopods, cirripeds, copepods, ostracods, decapods (e.g., shrimp), euphausiids and hydroids (Buhl-Mortensen and Mortensen 2004). Two Newfoundland trawl survey sets have collected *P. arborea*. There has also been one observer record from the southwestern Grand Banks (720 m) and 15 observer records from areas off Labrador. Eleven of the 13 records off Cape Chidley, Labrador were taken at depths ranging between 391 and 463 m. The other two records occurred at locations with water depths ranging between 353 and 390 m. The Atlantic Canadian depth range of collected specimens is 249 to 720 m (see Table 4.3). This species has been reported frequently on the fishing banks off Newfoundland over the past number of years.

Azooxanthellate corals have been dredged from a depth of 1,700 m at Orphan Knoll, located north-northeast of the CSEM Study Area (Smith et al. 1999).

4.2.1.2 Coral Associations

In Atlantic Canada, *P. resedaeformis* and *P. arborea* are commonly found on *Lophelia pertusa* ‘forests’ or ‘fields’ (Mortensen 2000 *in* Gass 2002). However, these species do not always occur together. Consideration of habitat requirements for *L. pertusa* (scleractinian) could possibly shed some light on the habitat requirements of the two gorgonian corals. *L. pertusa* requires hard substrate, strong currents, depths of 200-1,000 m, water temperatures ranging from 4 to 12ºC, and salinities ranging from 35 to 37‰.

4.2.1.3 Deep Sea Corals and Fish Habitat

There is some thought that deep-water corals provide habitat for some commercially fished species (Gass 1999 *in* Gass 2002). Recent studies have assessed this idea and determined that these corals are important habitat for several commercial species including redfish (Furevik et al. 2000, Fosså and Mortensen 1998 *in* Gass 2002). Some fishers in Nova Scotia have described areas with deep-water corals as important Atlantic halibut grounds (Gass 2002). Deep-water corals have been caught during Nova Scotia and Newfoundland fisheries for Greenland halibut, Atlantic cod, redfish, pollock and grey sole (Gass 2002).

The video imagery data discussed in MacIsaac et al. (2001) are spatially limited and lacking a time series. Their video imagery did not provide any evidence to suggest that the densities and types of corals that were viewed functioned as locally important feeding and/or nursery areas for fish. The authors concluded that more detailed analyses on benthic habitat are required for closer examination of the direct and indirect links between fish, habitat and corals. Edinger et al. (DRAFT 2005) also performed some preliminary examinations of relationships between corals and fish using data collected in Newfoundland and Labrador waters. They found some co-occurrences of fish diversity hotspots and coral hotspots but did indicate the requirement for more detailed investigation of these relationships.

Historically, corals were not generally caught during the cod fishery in waters off Newfoundland. With the onset of the moratorium in 1992, fishers began to target other species that occurred at different, often deeper areas, with different gear. Both of these changes in the fishery would likely increase the probability of interaction with deep-water corals. During recent years (i.e., since 2000), there have been relatively high coral catches east of Cape Chidley, Labrador. These catches have been reported in the northern shrimp fishery that employs shrimp trawls (Gass 2002). Bottom trawling has long been suspected of causing considerable damage to marine benthic habitat. Considering the vulnerability of deep-water corals, as described in earlier species profiles, fishing probably remains the primary threat to corals.

4.3 Commercial Fish and Invertebrates

Profiles of the three principal commercial fishery target species (northern shrimp, snow crab, Greenland halibut), the four *SARA*-listed species (spotted wolffish, northern wolfish, striped wolfish, Newfoundland and Labrador population of Atlantic cod), and the three additional species listed by COSEWIC (porbeagle shark, cusk and winter skate) are included in this section. Additional notable invertebrate and fish species are also discussed.

4.3.1 Northern Shrimp

Northern shrimp (*Pandalus borealis*) occur in the northwest Atlantic from Davis Strait to the Gulf of Maine, primarily in areas where the substrate is soft mud and bottom water temperatures range from 2 to 6ºC (DFO 2004a). These environmental conditions occur in waters offshore of Newfoundland and Labrador where depths range between 150 and 600 m.

Colbourne and Orr (2004) investigated the spatial distributions and abundance of northern shrimp in relation to their thermal habitat for North Atlantic Fisheries Organization (NAFO) Divisions 3LNO during spring surveys between 1998 and 2004, and fall surveys between 1995 and 2003. [The reader is referred to the maps in Section 4.4 for the location of NAFO boundaries.] The highest numbers of shrimp were found within the 2 to 4ºC temperature range during the spring surveys, and within the 1 to 3ºC temperature range during the fall surveys. Less than 5% of the spring catches were associated with water temperatures <1ºC while up to 30% of the fall catches were associated with water temperatures <1ºC. Approximately 80 to 90% of the shrimp caught during spring surveys were taken from waters with temperatures ranging between 2 and 4ºC while about half of that was taken at the same temperature range during fall surveys. Between 1998 and 2004, the bottom water temperatures in the slope region associated with the southern part of the Project Area have consistently exceeded 2ºC during both the spring and fall surveys. In terms of available thermal habitat, about 30% and 40% of the area surveyed in spring and fall, respectively, was covered with water in the 2 to 4ºC temperature range. In 2004, the average spring bottom temperature increased significantly from that in 2003 to >2ºC, the highest since the early 1980s (Colbourne and Orr 2004). In fall 2004, there was an apparent shift of shrimp distribution toward low temperatures further up the Grand Banks and toward inshore regions. As a result of this distributional change, a greater proportion (~30%) of the fall survey catch shifted into waters with temperatures ranging from 0 to 1ºC. Few shrimp were caught in waters with temperatures <0ºC and >4ºC during both spring and fall surveys.

To summarize the work by Colbourne and Orr (2004), most of the large spring survey catches between 1995 and 2003 occurred in the warm water along the slopes of Divisions 3LN, while in the fall, the largest catches occurred in most areas of 3L, including the inshore areas of the bays along the east coast of Newfoundland. It is not clear whether the changes in shrimp distribution observed in 2004 are environmentally driven or due to other factors (e.g., change in trawl catchability due to vertical migration, feeding behaviour).

Northern shrimp typically exhibit diel vertical migration, remaining relatively deep in the water column during the day, followed by upward movement in the water column during the night in order to feed on zooplankton. Common predators of northern shrimp include Atlantic cod, Greenland halibut, Atlantic halibut, skates, wolffishes and harp seals (DFO 2003a).

Northern shrimp spawn once a year, typically in late summer/early fall (Table 4.4). In eastern Canadian waters, shrimp eggs are extruded during late summer and fall and they remain attached to the female until larval hatch the following spring/summer. Females may move into shallower areas to maximize the rate of embryonic development. The larvae remain planktonic in the upper water column for a few months after which time they move downward through the water column and metamorphose to adulthood (DFO 1993).

Table 4.4. Temporal and Spatial Aspects of the Eggs and Larvae of Important Fish and Invertebrate Species Known to Spawn in or near Orphan Basin.

Species	Occurrence of Planktonic Eggs/Larvae	Timing of Eggs/Larvae in Plankton	Depth Distribution of Eggs/Larvae	References
Northern shrimp	Eggs: Yes (attached to female) Larvae: Yes	• Spawning typically occurs in late - June/early July. • Eggs remain attached to females from late summer/fall until larval hatch the following spring/summer. • Larvae remain planktonic in upper water column for a few months.	• Egg depth distribution depends on location of females in the water column. • Larvae are in upper water column.	DFO (2004a) DFO (1993)
Snow crab	Eggs: No Larvae: Yes	• Larval hatch generally occurs in late spring/summer. • Larvae remain planktonic for 3 to 4 months.	• Larvae occur in upper water column.	DFO (2004b)
Atlantic cod	Eggs: Yes Larvae: Yes	• Spawning primarily between April and June.	• Fertilized eggs and larvae may occur anywhere within the upper 100 m of the water column, eggs generally most concentrated in the upper 10 m.	Ollerhead et al. (2004) DFO (2004c) DFO (2003b) Scott and Scott (1988)
Wolffishes	Eggs: No Larvae: Yes	• Spawning from early fall to early winter.	• N/A	DFO (2004d) DFO (2004e) Scott and Scott (1988)
American plaice	Eggs: Yes Larvae: Yes	• Spawning between April and June.	• Fertilized eggs and larvae both occur in the surface waters.	Ollerhead et al. (2004) Dwyer and Morgan (2004) Scott and Scott (1988)
Witch flounder	Eggs: Yes Larvae: Yes	• Spawning between April and August at depth range of 60 to 160 m	• Fertilized eggs and larvae are concentrated in the upper 10 to 50 m of the water column	Ollerhead et al. (2004) Maddock Parsons (2004) Scott and Scott (1988)

Research vessel survey biomass and abundance indices for Shrimp Fishing Area (SFA) 6 (includes NAFO Division 3K) indicated an increase between 1997 and 2001. These indices remained constant into 2002. Despite an apparent decline in the mean size of female northern shrimp since 1992 and, therefore, reduced individual fecundity, there has been a minimal impact upon total egg production given the current historically high biomass/abundance indices (Orr et al. 2002; DFO 2003a). Biomass and abundance indices from spring and fall DFO research vessel surveys in NAFO Division 3K (part of SFA 6) since 2001 have remained high (DFO 2004a). The strong year class observed in 1999 was expected to be mostly female by 2004 and should remain so for 2005.

Since fall of 2002, fall and spring research surveys in NAFO Divisions 3LNO indicated the greatest concentrations of northern shrimp occur along the 3L slope region between 185 m and 550 m. Results from fall 2002, spring 2003 and fall 2003 were quite similar but the distribution map for the spring 2004 research survey indicated slightly smaller catches in this region. During recent years, 90.5 to 99.9% of the total Divisions 3LNO northern shrimp biomass has been found within 3L. Between 2000 and 2003, 21% of the fall biomass and 26% of the spring biomass was found outside the 200 nautical miles limit (Orr et al. 2004a). Analyses from the fall 2003 survey indicated that the Divisions 3LNO trawlable biomass remained stable at 224,000 tons (47 billion animals) (Orr et al. 2004b).

4.3.2 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. While commercial-sized snow crabs (≥95 mm carapace width (CW)) typically occur on mud or mud/sand substrate, smaller snow crabs are often found on harder substrates as well as on the softer ones (DFO 2004b). 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 2004b). 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 2004b).

Based on the DFO multispecies bottom trawl survey conducted in the fall 2003, 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 2004b). Other recent trends for snow crab in Division 3L are discussed in the Orphan Basin SEA (LGL 2003). The 2005 DFO stock status report that will include 2004 assessment is not yet available. There appears to be relatively little snow crab in the Project Area.

4.3.3 Greenland Halibut

Greenland halibut (turbot) (*Reinhardtius hippoglossoides*) is a deepwater flatfish that occurs in water temperatures ranging between –0.5 to 6ºC but appears to have a preference for temperatures of 0 to 4.5ºC. In the northwest Atlantic off northeastern Newfoundland and southern Labrador, Greenland halibut are typically caught at depths exceeding 450 m. Reported depths of capture range from 90 to 1,600 m. Larger individuals tend to occur in the deeper parts of the vertical distribution of this species. Unlike many flatfishes, Greenland halibut spend considerable time off bottom in a pelagic mode (Scott and Scott 1988). Vollen and Albert (2004) conducted a recent study off Norway to investigate whether pelagic occurrence of Greenland halibut is evenly distributed among sexes and size-classes, and between sampling periods. They did not find any size-related catch differences between pelagic (up to 420 m off bottom) and demersal longlines. Male Greenland halibut dominated the pelagic longline catches whereas females dominated the demersal catches. Pelagic catches were higher in August and December than in March, however, stomach contents from fish taken during bottom trawl catches at all sampling times included pelagic prey (herring). It should be noted that >98% of all catches during this study were taken on demersal longline.

Greenland halibut are thought to spawn in Davis Strait during the winter and early spring at water depths ranging from 650 to 1,000 m. There are also indications that these flatfish spawn in the Laurentian Channel and the Gulf of St. Lawrence during the winter. The large fertilized eggs of this species (4 to 5 mm diameter) are benthic and the newly- hatched larvae move upward in the water column and remain at about 30 m below surface until they attain an approximate length of 70 mm. As they grow, the young fish move downward in the water column and are transported by the currents in the Davis Strait southward to the continental shelf and slopes of Labrador and Newfoundland (Scott and Scott 1988).

Greenland halibut are voracious bathypelagic predators that feed on a wide variety of prey. Summer and fall appear to be the seasons of most intense feeding. Typical Greenland halibut prey includes capelin, Atlantic cod, polar cod, young Greenland halibut, grenadier, redfishes, sand lance, barracudinas, crustaceans (e.g., northern shrimp), cephalopods and various benthic invertebrates (Scott and Scott 1988; Román et al. 2004). Major predators of Greenland halibut include the Greenland shark, various whales, hooded seals, cod, salmon and Greenland halibut themselves (Scott and Scott 1988).

This flatfish species is widely distributed throughout the Labrador-eastern Newfoundland area (Bowering 2002; Dwyer et al. 2004). During the late 1970s and most of the 1980s, they were plentiful along the deep slopes of the continental shelf and in the deep channels running between fishing banks, particularly in NAFO Divisions 2G, 2H, 2J and 3K. By 1991, the Greenland halibut distribution in the northern areas was greatly reduced and most of these fish were located in Division 3K and along the northern slope of Division 3L. Kulka et al. (2003) produced catch distribution maps based on spring and fall research surveys conducted between 1980 and 2000. Maps for the 1992-2000 period indicate that Greenland halibut were more abundant in the vicinity of the southern part of the Project Area during spring compared to fall. Based on annual Canadian research vessel survey data, by 1996-2001, the Greenland halibut distribution to some of the more northern areas of historical high abundance began to reoccur (Bowering 2002). However, the Greenland halibut stock size has been declining since 1999, showing a significant drop between 2001 and 2002. The highest abundances observed during the 2003 research vessel surveys were in traditional areas of the deep channels running between the fishing banks, particularly in Divisions 2J and 3K. However, abundance in the Flemish Pass (Divisions 3LM deepwater) was low, despite the concentration of fishing effort in this area (Dwyer et al. 2004).

Between 1995 and 2001, the DFO stratified random fall surveys in Division 3K were conducted primarily over a depth range of 100 to 1,500 m with a Campelen 1800 shrimp trawl. In Division 3L, surveys conducted between 1996 and 2001 extended to at least 730 m in the spring and to 1,500 m in the fall using the Campelen 1800 shrimp trawl (Bowering 2002). Division 3K is surveyed only in the fall, to depths of 1,500 m. The surveys in 1999 reported large catches in 3K and along the northern slope of 3L. Catches have remained relatively low along the eastern slope of 3L and in 3M. In 2000, survey results showed improved catches along the northeast slope of 3L while results in 3K were similar to 1999 (Bowering 2002). European Union (EU) July trawl surveys conducted at the Flemish Cap since 1988 reported increasing Greenland halibut biomass up to 1998 after which time the biomass has decreased. These surveys have been conducted over a depth range of 200 to 730 m (Vázquez 2002). Underwater video evidence of Greenland halibut lying on bottom are discussed by Zaferman and Tarasova (2004) in relation to their reactions to fishing trawls. They reported that the trawls, on average, missed capturing about 36% of the Greenland halibut observed, either due to active or passive escapism. Low trawl efficiency can obviously affect accuracy of assessment indices.

The Canadian fishery for Greenland halibut in Divisions 3KLMNO, with emphasis on 2003, was described by Brodie and Power (2004). In 2001 and 2002, Canadian Greenland halibut catches were reported along the slope regions on the western side of Orphan Basin and to the south within EL 1080. However, in 2003, Canadian catches only occurred on the western Orphan Basin slope area, not along the southern slope area. In 2004, there were relatively small domestic catches on the SW slope in Unit Area 3Le (DFO 2004 catch data) (see Section 4.4 for more detail).

4.3.4 SARA-*COSEWIC Species*

4.3.4.1 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, including areas that occur within the CSEM Study Area. 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 (Table 4.4).

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.

The Department of Fisheries and Oceans is presently preparing a 'Wolffish Recovery Plan' but this document has not yet been published (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 2004d; Simpson and Kulka 2003). DFO (2004e) conducted a workshop on northern and spotted wolffish 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 greatest threat to these fish is the commercial fishery. 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 (2004e) also concluded that offshore oil and gas activities will result in negligible effects on wolffish.

4.3.4.2 Atlantic Cod (Newfoundland and Labrador population)

Atlantic cod have historically been distributed throughout Newfoundland and Labrador waters. This fish spawns both inshore and offshore in the Newfoundland-Labrador region. Atlantic cod eggs and larvae are planktonic, followed by an eventual shift by juvenile Atlantic cod from a pelagic diet to a benthic diet. This occurs gradually over a standard length range of about 4 to 10 cm and appears to be related to change in 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 primary 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).

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). Some believe that the 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, initially 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 shallow 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 shallow inshore waters, first with hook and line and later with nets that eventually evolved into the highly effective Newfoundland cod traps. 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 outer banks cod in summer and autumn and then extended the fishery 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 throughout 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 abundance of spawning fish at this same shelf edge location 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.

Kulka et al. (2003) produced catch distribution maps based on spring and fall research surveys conducted between 1980 and 2000. Maps for the 1992-2000 period indicate that Atlantic cod were more abundant in the vicinity of the southern part of the Project Area during spring compared to fall.

The offshore biomass index values from the fall research bottom trawl surveys in 2J3KL have been very low during recent years. The average trawlable biomass of 28,000 mt during the 1999 to 2002 period is about 2% of the average observed in the 1980s (DFO 2003b). The same trend has been evident on the

Flemish Cap during recent years (Vázquez 2002). The most recent assessment of the status of the northern (2J+3KL) cod stock was conducted in February 2003. The 2003 research bottom-trawl surveys during both spring and fall indicated that the biomass of cod in the offshore remains extremely low (1% of the average during the 1980s) (DFO 2003b). At approximately 49-50ºN on the outer shelf and upper slope is where the last substantial offshore concentrations of cod were seen 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 once typically overwintered 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 present day 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.). While most of the Project Area is too deep for cod, there is always the possibility that materials can be advected into cod habitat (J. Meade, DFO Habitat Evaluation Biologist, pers. comm.). In addition, cod eggs and larvae released in shallow water may be advected into the Orphan Basin as the western part of the Project Area may be in a frontal zone (see SEA, LGL 2003).

As noted previously, Newfoundland populations of Atlantic cod have been classified as endangered by COSEWIC but after public consultations, the Minister of Fisheries and Oceans decided not to place the species on the *SARA* legal list.

4.3.4.3 Other Listed Species

Other listed species are discussed in following sections where relevant to the discussion of potential effects.

4.3.5 Other Notable Fish Species

Other than the species discussed above, there are other ones that are of potential ecological or economic importance that may occur in the Study Area. Stratified-random surveys have been conducted on the Grand Bank by Canadian research vessels in the spring (April to June) of each year from 1971-2004, and in the fall (October to November) of each year from 1981-2004. In 3L, sampling depths have ranged from 30 to 1,463 m. Less than 10% of the Project Area has water depths <1,500 m, and less than 15% of the CSEM Study Area has water depths <1,500 m.

Analyses of the data collected by DFO during the 2002-2004 spring and fall multispecies trawl surveys within and proximate to the Study Area identified fish species other than those already profiled that made up substantial proportions of the survey catches. These species include the following:

- Capelin (*Mallotus villosus*)
- American plaice (*Hippoglossoides platessoides*)
- Deepwater redfish (*Sebastes mentella*)
- Roughhead grenadier (*Macrourus berglax*)
- Blue hake (*Antimora rostrata*)

- Thorny skate (*Raja radiata*)
- Sand lance (*Ammodytes* spp.)

All but two of the above seven species were caught in the southern part of the Project Area and Study Area. The nearest RV survey catches of capelin and sand lance occurred outside of the Study Area. Catches of the other five species were made within 20-25 km of the two CSEM survey areas proposed for the southern part of the project Area.

A recent paper (Devine et al. 2006) provides evidence that the roughhead grenadier population in the northwest Atlantic is exhibiting severe declines.

4.3.6 Experimental Fisheries

According to the FFAWU (K. Sullivan, Biologist, FFAWU, pers. comm.), they are not presently conducting any exploratory/experimental fisheries in the CSEM Study Area. However, there will be an exploratory/experimental fishery for hagfish conducted in late summer/early fall 2006 in the northern two-thirds of NAFO Division 3L (E. Way, Emerging Fisheries, DFO, pers. comm.). This could potentially overlap with a substantial portion of the CSEM Study Area (i.e., NAFO Unit Areas 3Le). The survey will be conducted by DFO using a 65' vessel.

4.4 Commercial Fisheries

4.4.1 Fisheries Study Area and Data

The Study Area for this assessment is identical to that used for two recent Orphan Basin environmental reports (Buchanan et al. 2004; Moulton et al. 2005), and the relevant commercial fisheries are described therein to 2003 for the current Study Area (identified as the "Project Area" in those reports). Buchanan et al. (2004) also provides a historical overview of the fisheries in the general area (for Unit Areas 3Kg, 3Le and 3Li). Consequently, this assessment focuses on Study Area fisheries for 2004 and 2005, and expected fisheries for 2006.

The description of fishing activities within and near the Study Area is based in part on data derived from the Department of Fisheries and Ocean's (DFO) Newfoundland Region (Newfoundland and Labrador) and Maritimes Region (mainly southern and eastern Nova Scotia) catch and effort datasets.[1]

[1] The data used in the report represent all catch landed within the Scotia-Fundy section of DFO Maritimes Region and for all Newfoundland and Labrador landed catch. Foreign catches landed outside these areas are not included. The data for these years are still classified by DFO as preliminary though the species data shown in this report are not likely to change to any significant extent when the data are finalized. The Maritimes Region data were accessed in May 2004 (for 2003), February 2005 (2004) and February 2006 (2005), and the Newfoundland Region data in April 2004 (2003), February 2005 (2004) and February 2006 (2005).

Most of the catch data for the Study Area is georeferenced,[2] which allows plotting of past harvesting locations. Areas farther from shore, fished generally by larger boats, tend to have a greater proportion of their catch georeferenced, while those closer to shore have less. For instance, > 99% of the catch from offshore Unit Area 3Le was georeferenced in 2005.

The fish harvesting maps in the following sections show harvesting locations as dark points. The points are not "weighted" by quantity of harvest, but show where fishing effort was recorded.

The information used to characterize the fisheries reports quantities of harvest rather than harvest values. Quantities are directly comparable from year to year, while values (for the same quantity of harvest) may vary annually with negotiated prices, changes in exchange rates and fluctuating market conditions. For instance, in 2006, snow crab prices are expected to be atypically low. Although some species vary greatly in landed value, in terms of potential interference with fisheries, it is the level of fishing effort and gear utilized (better represented by quantities of harvest) that is more important. Value is important, and is carefully evaluated, in case of a compensation incident, as described in the mitigations sections of Section 3.7.

Other sources used include DFO species management plans, stock assessments, other research reports and studies, and consultations with scientists, managers and fishing interests.

4.4.2 Domestic Fisheries

The principal domestic fishery (by quantity of harvest) within the Study Area throughout the year is for shrimp (>97% over the 2 year period), with much smaller harvests (in 2004) of turbot, roughhead grenadier and snow crab (Table 4.5). This is very similar to the situation reported for the same area in Moulton et al. (2005), for 2001 to 2003, when northern shrimp constituted 92.3% of the three-year average, turbot 5.8%, snow crab 1.5% and roughhead grenadier less than 1%. Over this period both turbot and snow crab have declined while shrimp has increased in relative numbers, so that in 2005 it made up nearly all the total catch (Table 4.5).

4.4.3 2004-2005 Domestic Harvesting Locations

Most of the domestic fish harvesting within and near the Study Area is concentrated on the Shelf slope in the southwestern portion of fisheries Unit Area 3Le, and the northern part of 3Li, a small part of the southwestern quadrant of the Study Area (Figures 4.2 and 4.3). This is mostly in depths between 200 m and 500 m. As these maps illustrate, there was no recorded fishing activity on the proposed CSEM survey lines in these years, and very little to none in their general vicinity.

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[2] The location given is that recorded in the vessel's fishing log, and is reported in the database by degree and minute of latitude and longitude; thus the position is accurate within approximately .5 nautical mile of the reported co-ordinates. It should be noted that for some gear, such as mobile gear towed over an extensive area, or for extended gear, such as longlines, the reference point does not represent the full distribution of the gear or activity on the water. However, over many data entries, the reported locations create a fairly accurate indication of where such fishing activities occur.

Table 4.5. Quantity of Harvest by Species, Study Area, 2004-2005.

Species	**Tonnes**	**% of Total**
2004		
Turbot (Greenland halibut)	107.2	2.4%
Roughhead Grenadier	17.9	0.4%
Northern Shrimp	4,330.6	97.0%
Snow Crab	11.1	0.2%
Total	4,466.7	100.0%
2005		
Northern Shrimp	4,227.7	100.0%
Snow Crab	1.8	0.0%
Total	4,229.6	100.0%

Source: DFO Maritimes and Newfoundland Regions. All data tables and graphs include both Newfoundland and Maritimes Region DFO catch and effort data.

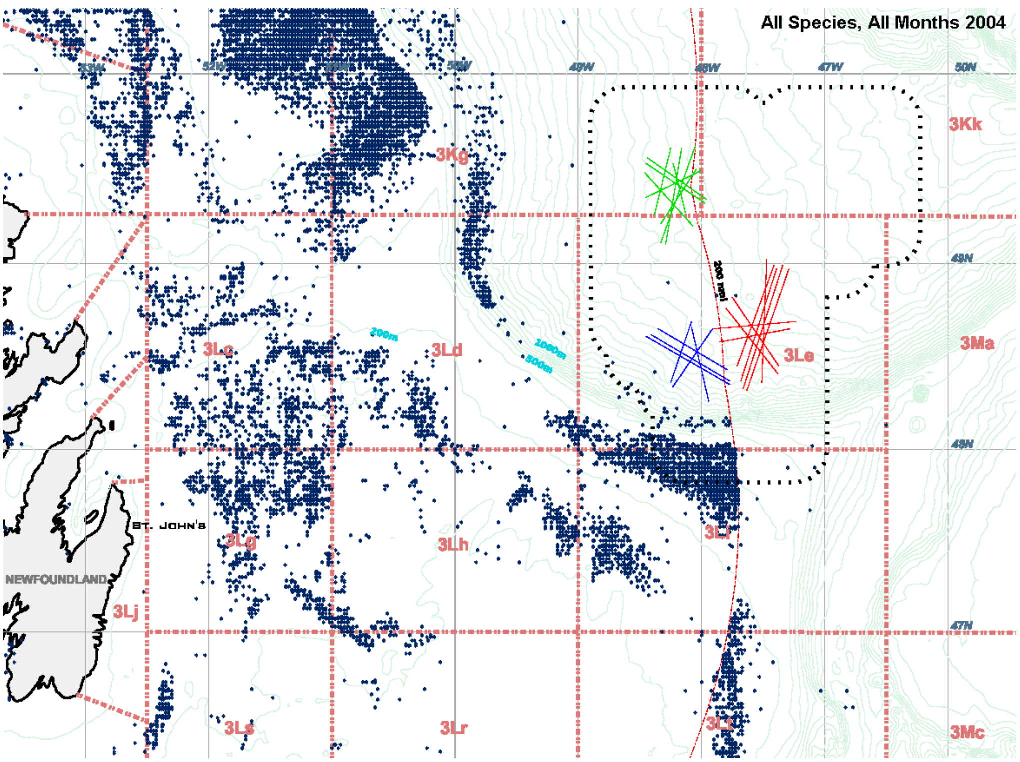


Figure 4.2. 2004 Fish Harvesting Locations.

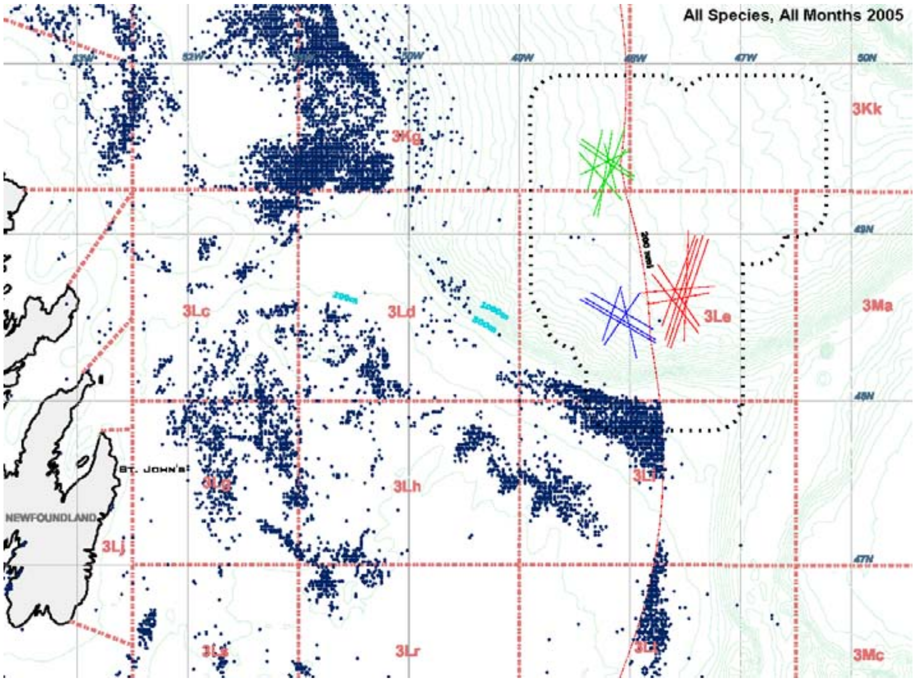


Figure 4.3. 2005 Fish Harvesting Locations.

4.4.4 Timing of the Study Area Harvest

The timing of the harvest can vary fairly widely, depending on such factors as resource availability, fisheries management plans – open and closed seasons – and enterprise harvesting strategies. Although variable (see Moulton et al. 2005), the harvest within the small southwestern portion of the Study Area has been most consistently concentrated in the June – August period in recent years, and lowest in the latter quarter of the year (Figure 4.4).

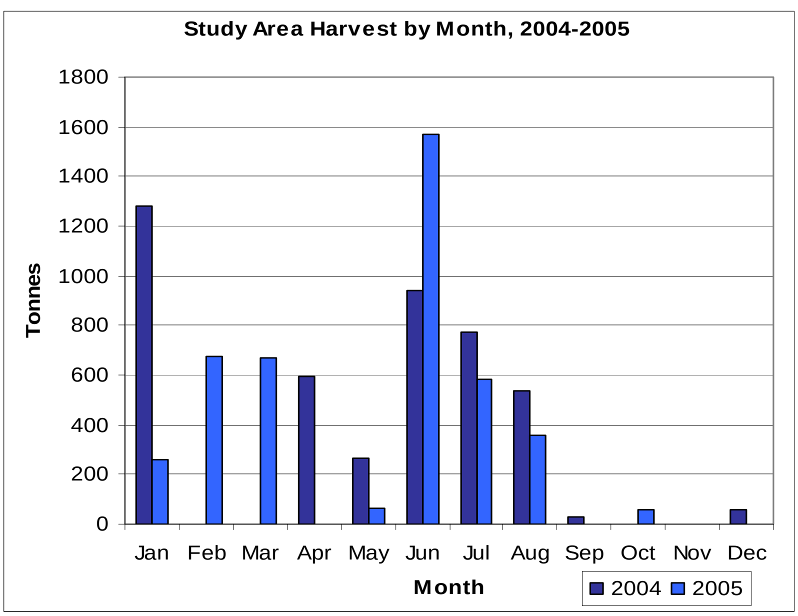


Figure 4.4. Study Area Quantity of Harvest by Month, 2004-2005.

The following maps (Figures 4.5 to 4.11) show the location of domestic harvesting activities in relation to the Study Area and survey lines, by month (May to November), for 2004 and 2005.

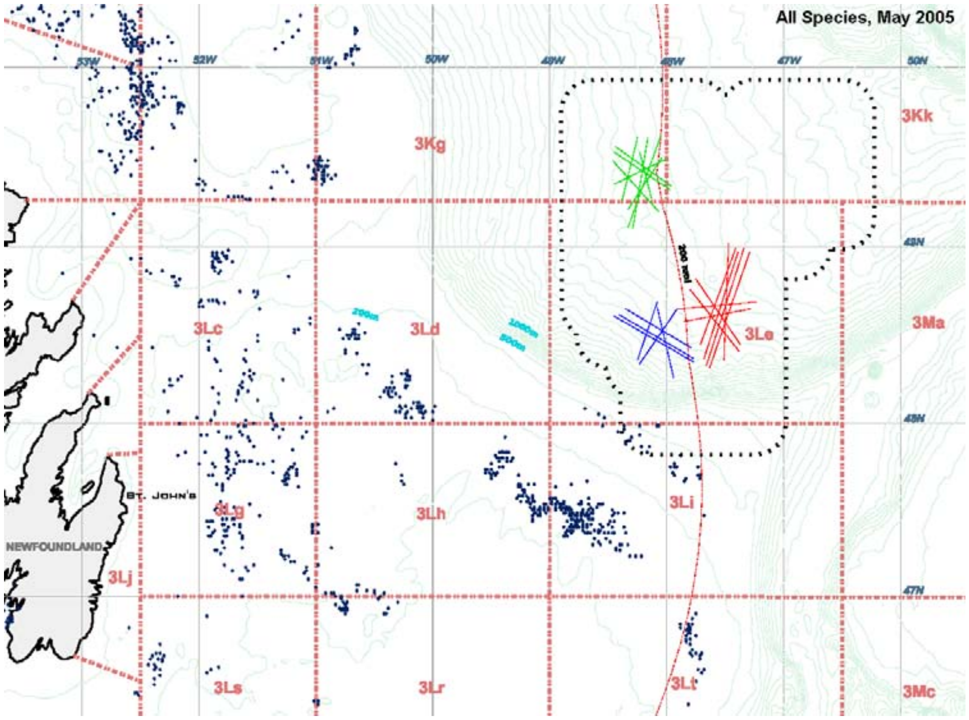


Figure 4.5. May 2005 Harvesting Locations.

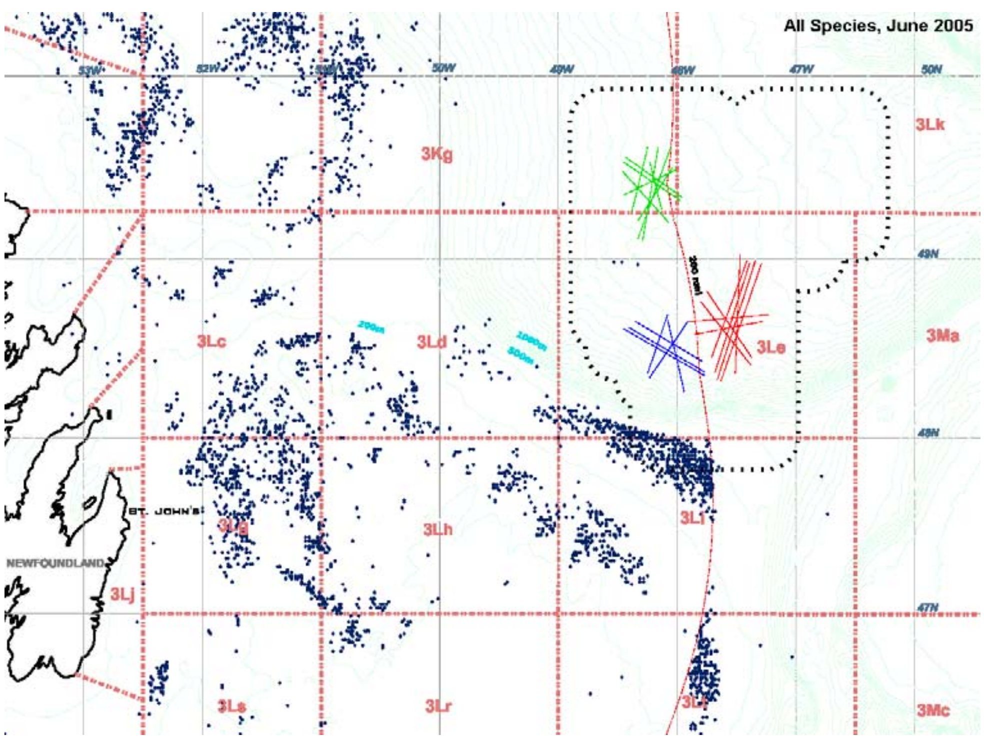


Figure 4.6. June 2005 Harvesting Locations.

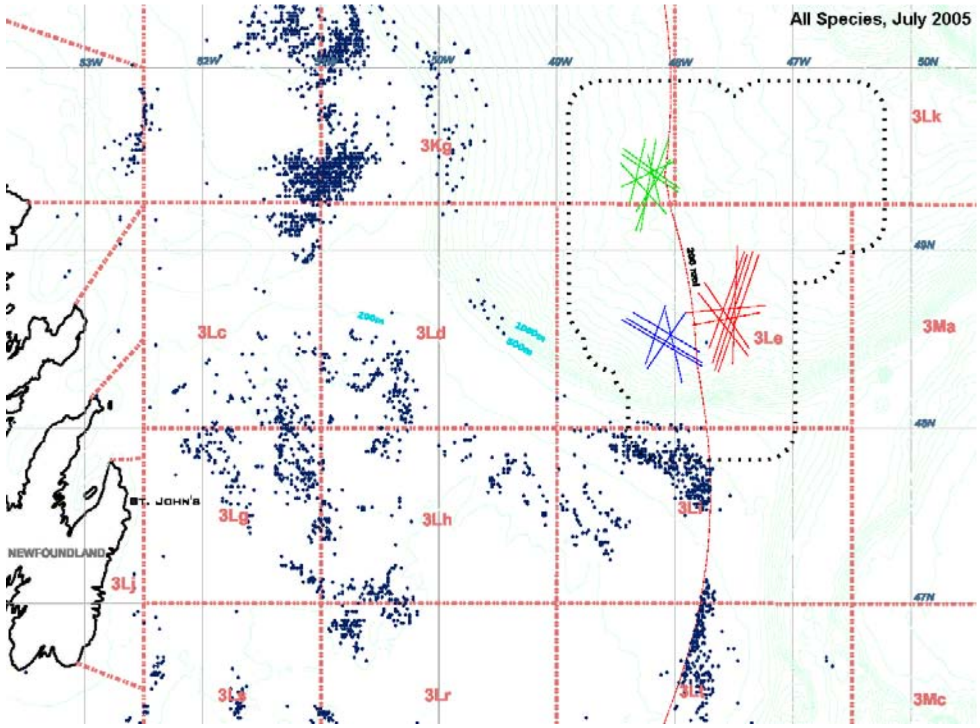


Figure 4.7. July 2005 Harvesting Locations.

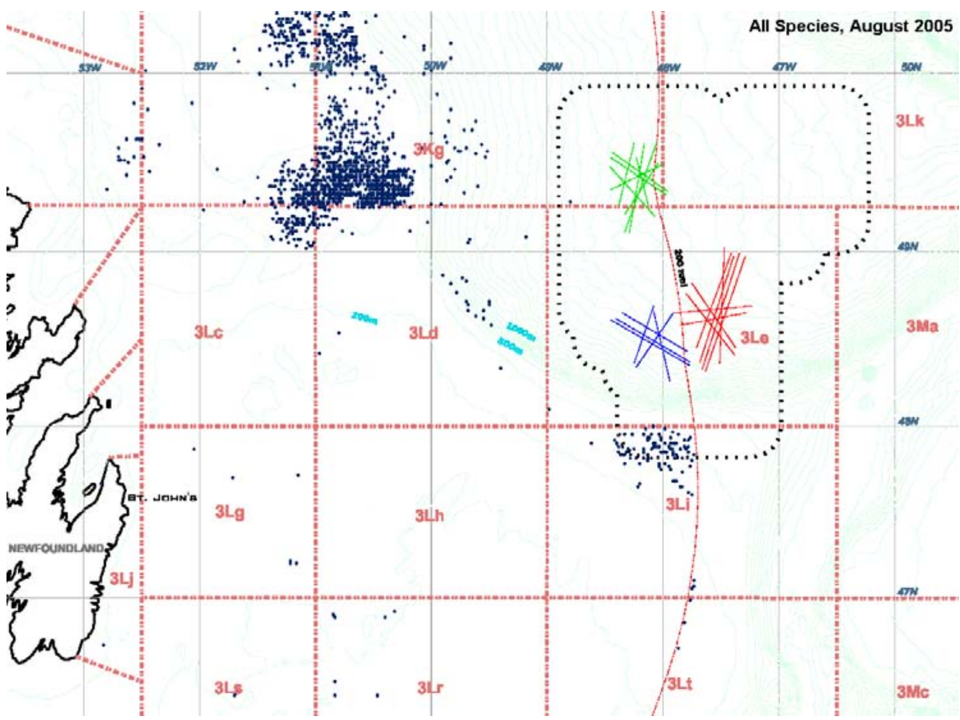


Figure 4.8. August 2005 Harvesting Locations.

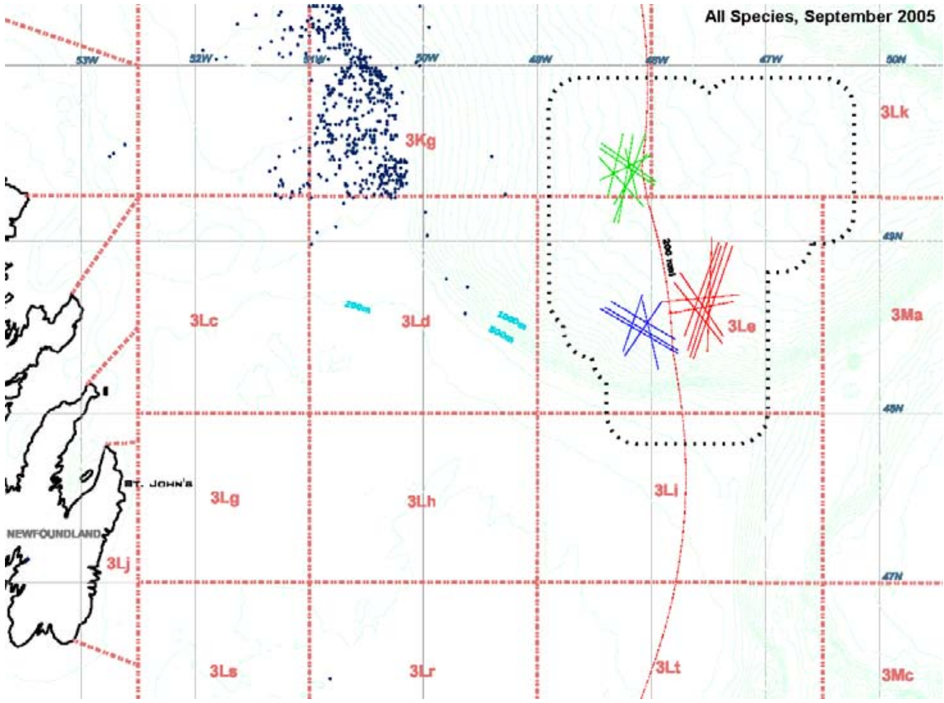


Figure 4.9. September 2005 Harvesting Locations.

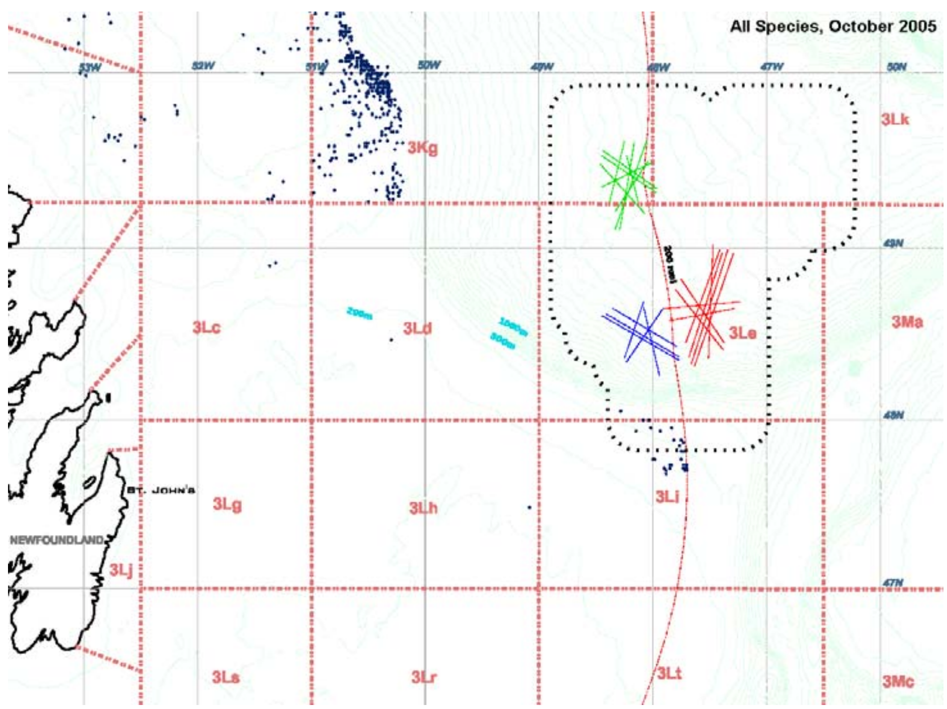


Figure 4.10. October 2005 Harvesting Locations.

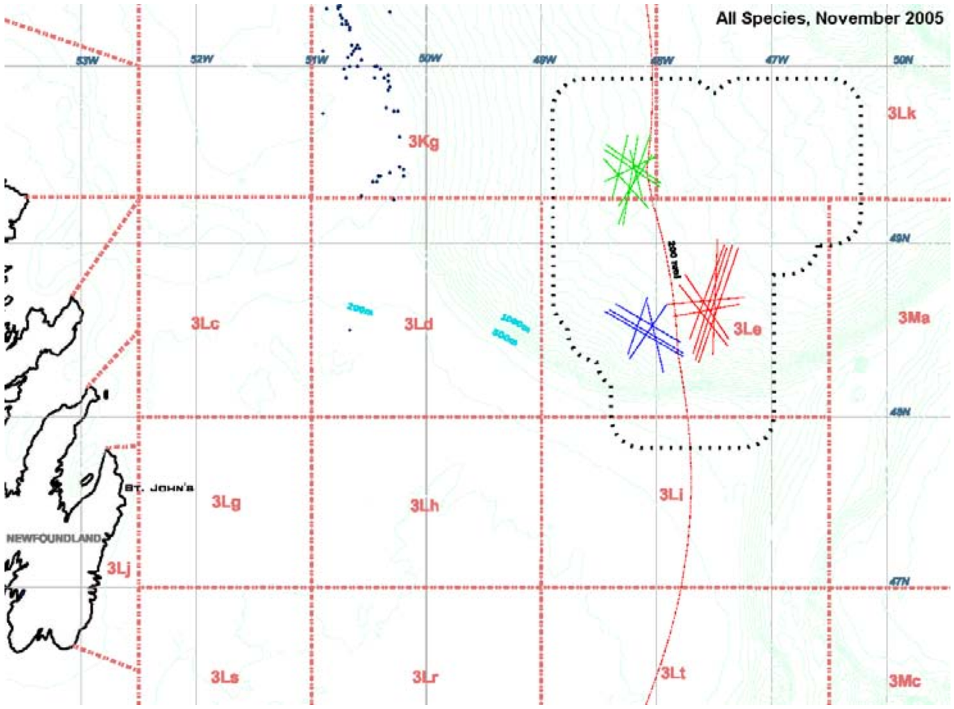


Figure 4.11. November 2005 Harvesting Locations.

4.4.5 Principal Fisheries

The following sections describe the three principal fisheries in the general area, though, as described above, the harvest within the Study Area is very predominantly northern shrimp.

Northern Shrimp. As described above, this species has made up the great majority of the harvest (>90% by weight) in the Study Area over the last five years. The following map shows the location of domestic shrimp harvesting in relation to the Study Area and the CSEM survey lines for the May – November period in 2005. As the map indicates, the effort nearest the Study Area tends to be focused on a very specific area between the 200 m -500 m contours in the southern most part of the Study Area. All catches in the area are taken using mobile shrimp trawls.

The Study Area overlaps portions of shrimp fishing areas (SFA) 6 and 7 (see Figures 4.12 and 4.13), although the relevant fishing activity is in SFA 7.

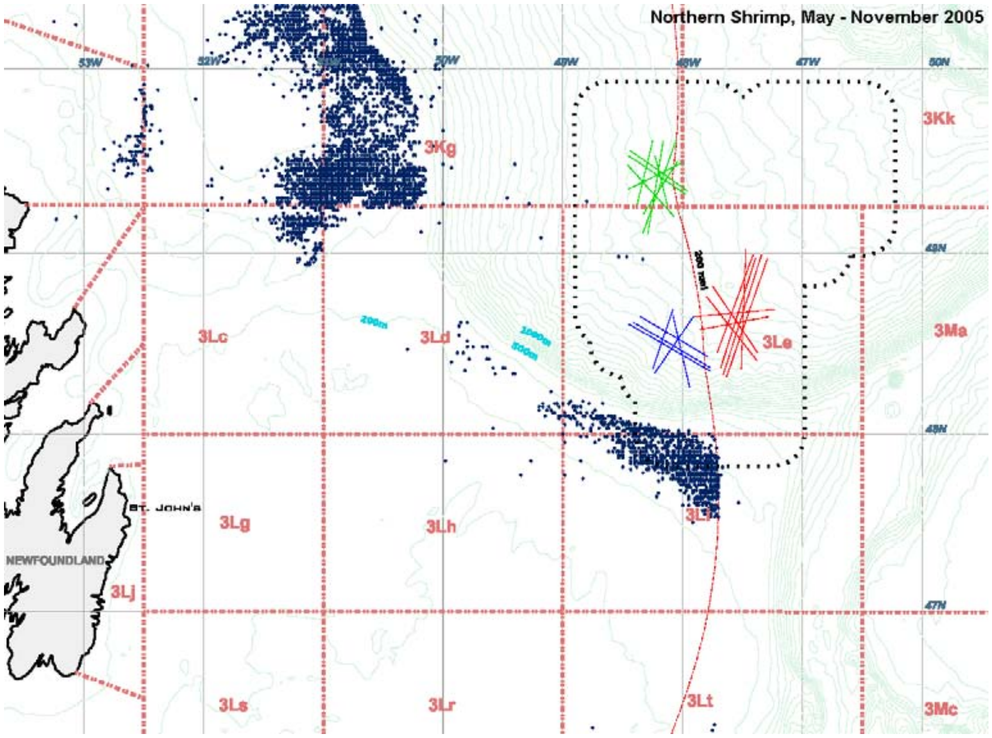


Figure 4.12. Northern Shrimp Harvesting Locations, May-November 2005.

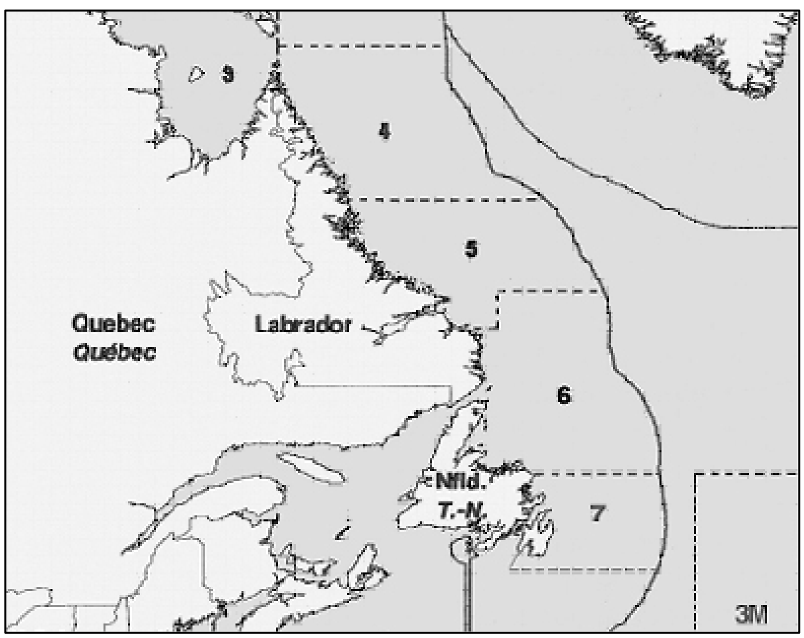


Figure 4.13. Shrimp Fishing Areas.

The most recent DFO Integrated Fisheries Management Plan for northern shrimp, northeast Newfoundland, Labrador Coast and Davis Strait notes that this fishery is based primarily on a single species, *Pandalus borealis* (northern or pink shrimp), though a second species, *Pandalus montagui* (striped shrimp) may occur as by-catch in the northern shrimp fishery (DFO 2003).

DFO (2003) states, "The offshore fishery is a year-round one which begins in SFAs 5 and 6 in January and moves north as the ice permits throughout the year. During mid-summer, the offshore fleet concentrates its fishing in the northern areas (SFAs 1 and 2) and finishes the year in SFA 4. This year-round fishing pattern was essential in order to maintain a financially viable operation and to provide a continuous supply of shrimp to the fiercely competitive international market.

In 2003, the Northern Shrimp Advisory Committee recommended a change in seasons that would run from April 1 to March 31st. Generally, the inshore shrimp-fishing season runs from April to October with the exception of 2001 and 2002, where industry-imposed closures took place in July and August. Prior to 2001, the bulk of the inshore fishing effort took place in July and August. In 1999 and 2000, over 50% of the landings from the inshore fleet occurred during this period."

The current shrimp Management Plan notes that "The current offshore fleet is comprised of twelve to thirteen factory freezer trawlers. All are purpose-built for shrimp trawling and processing; though some are also able to process and freeze groundfish. They range in length from 49m to 75 m, with hold capacities ranging from 400 to 1,960 m^3. These vessels operate out of ports in Newfoundland and Nova Scotia, with occasional landings in Greenland when fishing in far northern waters (SFA 1). Fishing trips generally last until the hold is full, a period ranging from 20 to 75 days, depending on catch rates and hold capacity. The larger, more modern vessels may make more than six to eight fishing trips per year, averaging 270-320 days annually. The smaller offshore vessels fish for 200-250 days, making eight to ten trips per year.

The inshore fleet is mainly composed of vessels less that 65 ft. operated by either adjacent fishers or core fishers who geared up to fish in SFA 6. Vessels fish using otter trawls, with a few using beam trawls. Some experimental work is ongoing with shrimp pots in Nunavut. The inshore fishery is conducted on a competitive basis with trip limits and harvesting caps determined and enforced by the industry itself" (DFO 2003).

The 17 traditional offshore licence holders are represented by four organizations: the Canadian Association of Prawn Producers (CAPP) (9 licence holders), the Northern Coalition and the Labrador Inuit Development Corporation (6 licence holders). The other two licence holders (Harbour Grace Shrimp Company Ltd. and Pikalujak Fisheries Ltd.) are not members of either of these organizations (DFO 2003).

In areas outside 200 miles, foreign vessels also have allocations and may be active in these waters near the survey during the survey window, though they usually focus on the Flemish Cap area to the south of the project. Relevant quotas for 2006 are shown in Table 4.6.

Table 4.6. 3K and 3L 2006 Northern Shrimp Quotas and Harvest-to-Date*.

Licence Category / Quota Definition	Quota (Tonnes)	Taken (Tonnes)	% Taken	Remain. (Tonnes)
3K				
Area 6 - 3K Fishers North of 50'30	4950	67	1%	4883
Area 6 - 3K Fishers South of 50'30	16420	754	5%	15666
Area 6 - 3L Fishers	11369	61	1%	11308
Area 6 - Inshore (Northern Peninsula)	3000	0	0%	3000
Area 6 - Quebec Fishers	1000	0	0%	1000
Total	36739	882	2%	35857
3L				
Area 7 - Offshore > 100' and Special	6028	2532	42%	3496
Area 7 - 2J Fishers	395	0	0%	395
Area 7 - 3K Fishers North of 50'30	395	21	5%	374
Area 7 - 3K Fishers South of 50'30	2886	204	7%	2682
Area 7 - 3L Fishers	8621	1476	17%	7145
Total	18325	4233	23%	14092

*As of 21 May 2006. See http://www.nfl.dfo-mpo.gc.ca/publications/reports_rapports/Shrimp_2006.htm for current data.

4.4.6 Snow Crab

Snow crab represents a very small part of the Study Area catch, making up less than 2 t in 2005, though somewhat larger quantities were taken in previous years. Overall, it has declined in both absolute and relative quantity within the area during the past few years, dropping from 57 t in 2001. As the most recent DFO status report notes, landings for 2J,3KLNOP,4R snow crab increased steadily from about 10,000 t annually during the late 1980s to 69,000 t in 1999 largely because of the expansion of the fishery in offshore areas. In 2000, landings decreased by 20% to 55,400 t, increased slightly to 59,400 t in 2002 and 2003 and declined to 55,700 t in 2004 with changes in TACs. In 2005, the harvest decreased by 21% to 43,900 t, primarily as the result of a drop in Division 3K landings where the TAC was not taken that year (historically, most of the snow crab landings have been from Divisions 3KL) (DFO 2006c).

DFO (2006c) also observes that, "Negative relationships between bottom temperature and snow crab CPUE have been demonstrated at lags of 6-10 years suggesting that cold conditions early in the life history are associated with the production of strong year classes. A warm oceanographic regime has persisted over the past decade implying poor long-term recruitment prospects."

As Figure 4.14 indicates, snow crab harvesting is concentrated well to the west and south of the Study Area.

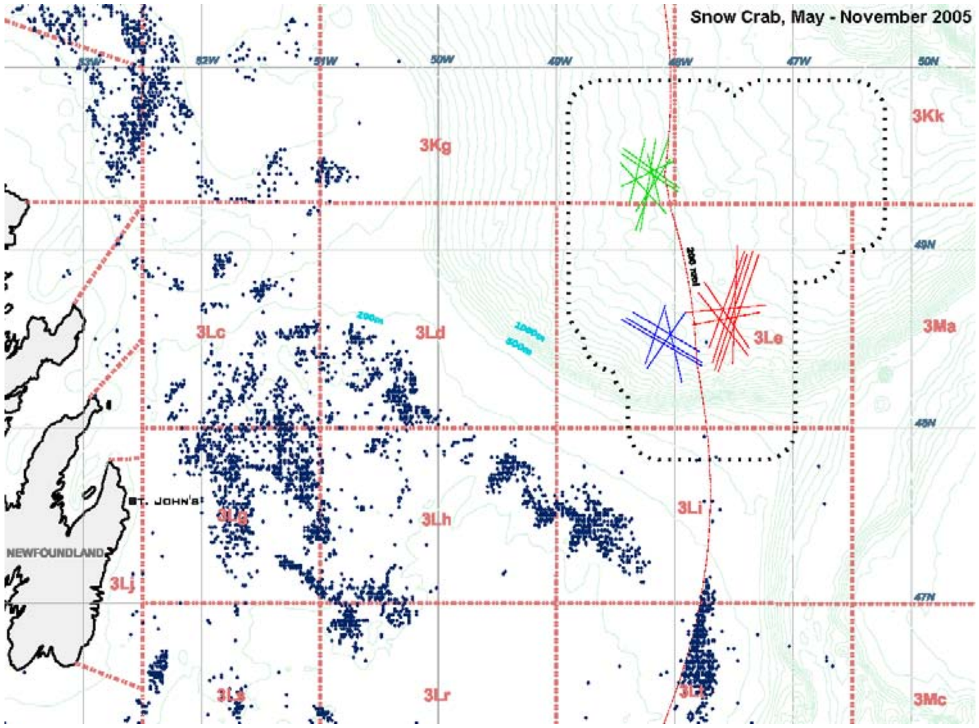


Figure 4.14. Snow Crab Harvesting Locations, May-November 2005.

DFO (2006c) reports that in Divisions 2J3KLNOP4R the fishery is prosecuted by several fleet sectors under multiple quota-controlled management areas, with more than 3300 licence holders under enterprise allocation in 2005. Stock status is assessed at the NAFO Division scale, and a vessel monitoring system (VMS) was fully implemented in the offshore fleets in 2004.

The FRCC's recent *Strategic Conservation Framework for Atlantic Snow Crab* (FRCC 2005) describes the general conduct of the offshore sector: "Vessels fishing up to and beyond 200 miles from the coast conduct voyages up to four and five days and greater depending on the vessel's holding system. Typically these vessels leave the traps for shorter periods, sometimes only a few hours, prior to retrieving the catch. Given that snow crab must be live at the time of landing and processing, the duration of fishing trips is limited, although some vessels are now able to keep crab live on board in tanks permitting them to extend the length of their trips. Upon landing the live catch, it is weighted at dockside and transferred to shore-based processing facilities where the catch is processed into market ready products on a timely basis. All snow crab catches are independently monitored."

In June 2005, the FRCC's Strategic Conservation Framework recommended to the Minister of Fisheries and Oceans a variety of conservation measures as well as changes to the fishery's management structure. In March 2006, the Minister announced that new management measures would be introduced and others continued for the Newfoundland and Labrador snow crab fishery owing to the uncertainty about future recruitment and the amount of exploitable biomass, as well as concerns about soft-shelled crab (DFO, BG-NL-06-01 and BG-NL-06-02, March 30, 2006). General measures include:

- Shortened fishing seasons in areas to provide additional protection during periods when the incidence of soft-shell crab is high;
- There will be no season extensions; Individual Quotas (IQs) are not a guarantee that the fisher will land that amount of crab;
- Enhanced soft-shell protocols;
- When areas are closed because of a high incidence of soft-shell crab, those areas will remain closed for the remainder of the year;
- Continue with increased observer coverage from 2005;
- In an effort to decrease the levels of wastage of soft-shell and undersized crabs being returned to the water, DFO will shorten fishing seasons and continue education programs with fishers on handling and discard practices;
- The Total Allowable Catch (TAC) for 2006 is 46,233t, reduced from 49,943t in 2005.

For 3LNO specifically, "The discard rate … remains at a lower level and no significant amount of soft shell has been encountered during the recent fisheries which end on July 31. The majority of quotas in these areas, both inside and outside the 200 mile limit, will be rolled over for 2006. In St. Mary's Bay the quota will be increased by 50 t." (DFO, BG-NL-06-02, March 30, 2006). The 2005 and 2006 quotas and seasons are shown in the Table 4.7.

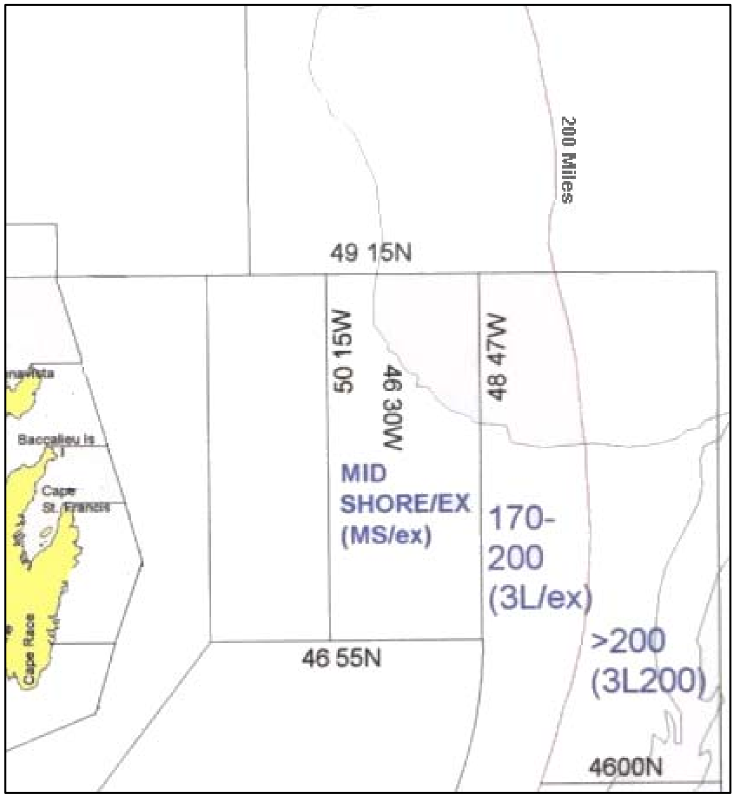
Table 4.7. The 3LNO Snow Crab Quotas and Seasons, 2005-2006.

Year	Quota (Tonnes)	Season
2005	29,748	April 9 –July 31
2006	29,798	April 5 –July 31

Table 4.8 shows the quotas for the 2006 snow crab fishery in relevant portions of 3L.

Table 4.8. Relevant 3L 2006 Snow Crab Quotas and Harvest-to-Date*.

Licence Category / Quota Definition	Quota (Tonnes)	Taken (Tonnes)	% Taken	Remain. (Tonnes)
Full-Time				
Midshore Extended (MSX)	1540	1143	74%	397
Outside 170 and Inside 200NM (3LX)	1110	748	67%	362
Outside 200NM (3L200)	950	361	38%	589
SL-Supplementary Large				
Midshore Extended (MSX)	1585	807	51%	778
Outside 170 and Inside 200NM (3LX)	1585	731	46%	854
Outside 200 NM (3L200)	1990	617	31%	1373



*As of 21 May 2006. See http://www.nfl.dfo-mpo.gc.ca/publications/reports_rapports/Crab_2006.htm for current data.

Figure 4.15. Relevant Snow Crab Areas.

4.4.7 Turbot (Greenland halibut)

Turbot has made up a relatively small proportion of the 2001-2005 Study Area harvest and has been generally declining over this period, ranging from 243 t in 2001 to 0 t in 2005 (see Table 4.5 and Moulton et al. 2005). The decline reflects a deep cut in TAC for the turbot fishery after 2003, as indicated in the following Table 4.9.

Table 4.9. The 3K, 3LG Turbot Quotas, 2003 – 2006.

Area	2003	2004	2005	2006
3K	10,105	5,024	4,777	4,647
3L	4,307	2,223	2,112	2,080
Total	14,412	7,247	6,889	6,727

Source: http://www.nfl.dfo-mpo.gc.ca/publications/reports_rapports2.asp, accessed 20 May 2006.

Although the concentration of turbot harvesting activity within the Study Area (Figure 4.16), in the southwest corner, this activity is actually turbot caught by shrimp trawls and discarded. Thus it is not counted in the landings data. The closest directed harvest is in 3Ld to the west of the Study Area and in 3Kg to the northwest, where it tends to be taken in relatively deep water between the 200 m and 1000 m contours on the shelf slope.

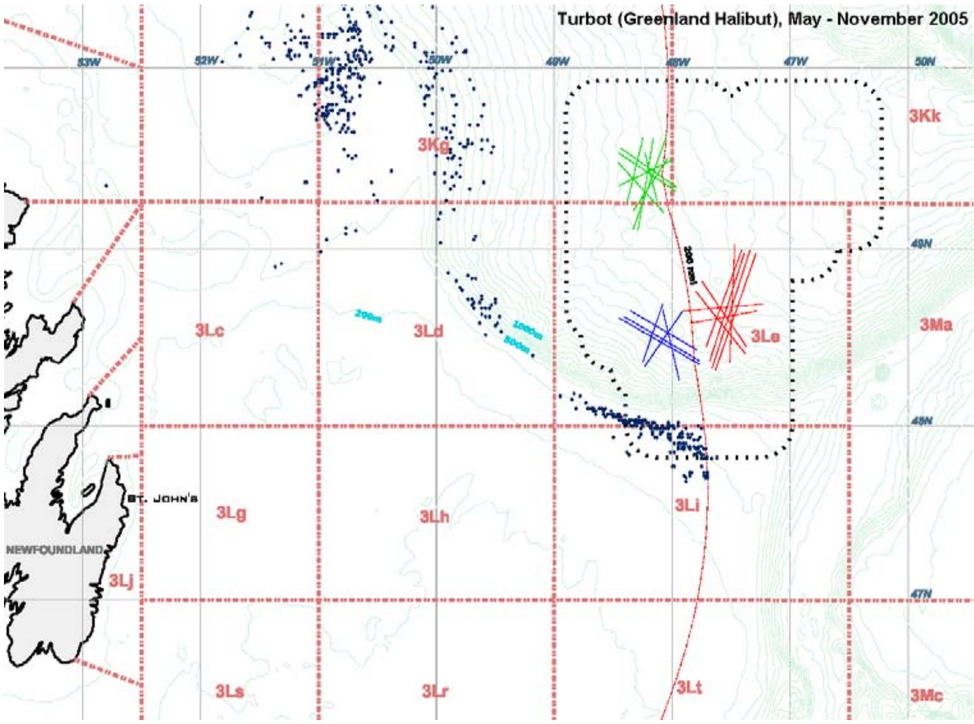


Figure 4.16. Turbot Harvesting Locations, May-November 2005.

Table 4.10 shows the current (as of 21 May 2006) harvest status in the relevant quota areas.

Table 4.10. The 3K and 3L 2006 Turbot Quotas and Harvest-to-Date*.

Licence Category / Quota Definition	Quota (Tonnes)	Taken (Tonnes)	% Taken	Remain. (Tonnes)
3K				
2+3K - Fixed Gear <65'	2501	322	13%	2179
2+3K - Mobile Gear <65'	88	0	0%	88
2+3K - Fixed Gear 65'-100'	237	0	0%	237
2+3K - Mobile Gear 65'-100'	8	0	0%	8
2+3K - Vessels >100'	1576	1877	119%	-301
2+3K - Scandinavian L/Ls >100'	237	0	0%	237
2+3K - Shrimp Fishery (discards)	0	19	0%	-19
Total	4647	2218	48%	2429
3L				
3LMNO - Fixed Gear <65'	1264	0	0%	1264
3LMNO - Mobile Gear <65'	33	0	0%	33
3LMNO - Fixed Gear 65'-100'	56	4	7%	52
3LMNO - Mobile Gear 65'-100'	6	0	0%	6
3LMNO - Vessels >100'	649	0	0%	649
3LMNO - Scandinavian L/Ls >100'	72	7	9%	65
3LMNO - Shrimp Fishery (discards)	0	0	0%	0
Total	2080	11	1%	2069

*As of 21 May 2006. See http://www.nfl.dfo-mpo.gc.ca/publications/reports_rapports/Halibut_2006.htm for current data.

4.4.8 Fixed Gear

In general, fixed gear, primarily crab pots in the general areas, poses a much greater potential for conflicts with marine activities than mobile gear since it is hard to detect when there is no fishing vessel near by, and it may be set out over long distances in the water.

Crab Pots. Because it is a fixed gear, crab pots pose a significant potential for conflict if a vessel encounters them. FRCC (2005) reports, “Snow crab fishing is conducted with single conical shaped traps (pots) although some harvesters use rectangular shaped traps. Traps are attached to a retrieval rope and marker buoy. In some areas, harvesters deploy several traps attached in series to a main fishing line otherwise known as a fleet of gear. Twine mesh is used to enclose the traps that have an open cone at the top to provide an entrance for the snow crab. … Snow crab harvesters are licenced to deploy a specific maximum number of traps to harvest their allocations. These trap limits vary by area and by the size and nature of the fishing enterprise”.

Pots set in fleets may consist of 50-60 pots buoyed at the surface. Crab gear generally has a highflyer (radar reflector) at one end and a large buoy at the other. Some fishers use highflyers at both ends. Depending on weather, they may be left unattended several days at a time. Fishers in the area generally try to leave about 20 fathoms (120 feet) on the seabed between each pot. Thus, allowing slack for the anchor ropes on either end of the string to extend upwards at an angle, the distance between the typical highflyer and end-buoy of a 50-60 pot string of crab gear would be 6,000 feet to 7,500 feet, or approximately 1.8 km to 2.3 km.

Shrimp Trawls. The traditional shrimp gear in Newfoundland and Labrador is shrimp trawl, a modified stern otter trawl, for both inshore and offshore vessels, though some use beam trawls. Since 1997, it has been mandatory to use a device called a Nordmore grate in shrimp trawls to reduce by-catch of other species The Nordmore grate is now required in shrimp trawls in all SFAs at all times (DFO 2003).

Past consultations with the Canadian Association of Prawn Producers have indicated that, for the larger ships, tows are typically about 3 hours at speeds of 3-4 kts, but the length of the tow will depend on the rate of the on-board processing plant. In general, the aim is to catch just enough at a time to keep the ship’s factory supplied.

4.5 Fisheries Research

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 3K,L this year. Table 4.11 provides the relevant 2006 DFO research survey schedule plan for Newfoundland and Labrador Region (B. Brodie, pers. comm. March 2006). Effects on DFO research are unlikely but the Proponents will communicate with DFO on this issue.

Table 4.11. DFO Science Survey Schedule, Labrador 2006.

Scientist	Survey	Start	End	Days
B. Brodie	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

4.6 Seabirds

Prior to the 2004 and 2005 surveys by LGL for the exploration licence holders (Lang and Moulton 2004; Moulton et al. 2005, 2006), seabirds had not been well studied within the Study Area. Most of the past shipboard surveys of marine birds conducted by the Canadian Wildlife Service and others in Atlantic Canada have been on shelf waters (Brown 1986; Lock et al. 1994; Baillie et al. 2005). However, the Study Area is roughly 350-400 km from shore and all but one exploration licence is beyond the continental shelf in water 2,000-2,500 m in depth. EL 1080 is situated on the continental shelf edge where water depths range from 400-2,000 m. Comprehensive seabird surveys were conducted during the 3-D seismic survey programs in the Orphan Basin within blocks EL 1073-1080 during the summer of 2004 (26 June-17 September) (Moulton et al. 2005) and 2005 (14 May-24 September) (Moulton et al. 2006). Surveys consisted of ten-minute counts using the ‘Tasker’ method (Moulton and Mactavish 2004). A total of 968 ten-minute counts were conducted in 2004 and 521 in 2005 over this time period resulting in some of the most intensive seabird surveying of any area of equal size in Newfoundland and Labrador waters. In addition, a second survey program was conducted from the RV Hudson which was also working in the Orphan Basin, 24 June-7 July (Lang and Moulton 2004). An LGL biologist conducted a total of 12.8 hours of surveying along 74.5 km of survey route in the time period.

The avifauna community of the Orphan Basin is composed mainly of true pelagic species. A large portion of the Study Area lies beyond two hundred nautical miles from the coast. This is beyond the range of most species not fully adapted for prolonged periods on the open sea. Coastal water bird groups such as Gaviidae (loons) Podicipedidae (grebes), Phalacrocoracidae (cormorants) and Anatidae (geese and ducks) do not normally range at sea beyond the sight of land. Even most members of the Laridae family (gulls) do not range as far off shore as the Orphan Basin. The main species groups that occur in the Study Area are Procellariidae (fulmars and shearwaters), Hydrobatidae (storm-petrels), Sulidae (gannets), Phalaropodinae (phalaropes), Laridae (skuas, jaegers, gulls and terns) and Alcidae (auks) (Table 4.12).

Table 4.12. Species Occurring in 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	*Sula bassanus*				S	S	S	S	S	S	S		
Phalaropodinae													
Red Phalarope	*Phalaropus fulicaria*					S	S	S	S	S	S		
Red-necked Phalarope	*Phalaropus lobatus*					S	S	S	S	S			
Laridae													
Great Skua	*Catharacta skua*					S	S	S	S	S	S		
South Polar Skua	*Catharacta 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 Gull	*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
Razorbill	*Alca torda*				VS	VS	VS	VS	VS	VS	VS		
Atlantic Puffin	*Fratercula arctica*					S	S	S	S	S	S	S	

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

The avifaunal richness of the Grand Banks and Funk Island Bank 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 4.13). These birds plus their young and non-breeding sub-adults use the Grand Banks and/or Funk Island Bank 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.

Table 4.13. Number 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[1]	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* (Species of Concern on Schedule 1; assessed as endangered by COSEWIC in April 2006) that might occur in the Study Area albeit in winter or early spring (January-April). The Ivory Gull lives among the pack ice and thus may occur in the Project 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 Study Area. Interaction between the survey work and Ivory Gull is further reduced in that surveys would not occur in the winter months when the weather is roughest.

4.6.1 Seasonal Occurrence and Abundance in Orphan Basin

The world range and seasonal occurrence and abundance of seabirds occurring regularly in the Study Area are summarized in Brown (1986), Lock et al. (1994), Lang and Moulton (2004), (Baillie et al. 2005), Moulton et al. (2005) and Moulton et al. (2006) (see Table 4.12). The following sections are focused on shearwaters and petrels because the former contain magnetite and the latter because they have a tendency to strand on lighted vessels. Some attention is also paid to the alcids (e.g., murres) as they spend time the most time underwater.

4.6.1.1 Procellariidae (fulmars and shearwaters)

Northern Fulmar and Greater Shearwater were two of the most abundant species on the Orphan Basin during the 2004 and 2005 seismic monitoring seasons. Northern Fulmar remains in the cool north Atlantic waters throughout the year. Fulmar may be most numerous on the Orphan Basin in the winter months. Greater and Sooty Shearwater breed in the Southern Hemisphere and come to Newfoundland waters in the summer during their non-breeding season to moult. Greater Shearwater was the most abundant species recorded on the Orphan Basin during the 2004 and 2005 seismic monitoring seasons. Sooty Shearwater was greatly outnumbered by the Greater Shearwater during the 2004 and 2005 seismic monitoring seasons. Manx Shearwater is a European species with a small population in Atlantic Canada. It was relatively rare on the Orphan Basin.

4.6.1.1.1 Greater Shearwater

Greater Shearwater breeds in the south Atlantic Ocean, mainly on the Tristan da Cunha Island and Gough Island. The adults occur at breeding sites from October to April. They spend the non-breeding season (April to October) in the north Atlantic. A significant percentage of the total world population migrates to eastern Newfoundland, particularly the Grand Banks for the annual moult in June and July (Lock et al. 1994).

During the 2004 and 2005 seismic acquisition periods, Greater Shearwater was the most abundant species in mid summer with July densities of 10.0 to 99.0 per km^2 (Moulton et al. 2005; Moulton et al. 2006). Flocks of Greater Shearwaters were frequently observed resting on the water in July. These birds were in obvious heavy wing moult as indicated by extremely ragged wings in flight. Greater Shearwater was the most numerous bird observed from drill platforms on the northeast Grand Banks between 1999 and 2002 composing 55% of the total of all seabirds recorded (Baillie et al. 2005). Numbers increased though the summer to a peak in September then decreased rapidly with stragglers into November. Greater Shearwater is expected to be common on the Orphan Basin from June to October with a few occurring in May and lingering into November.

4.6.1.1.2 Sooty Shearwater

Sooty Shearwater breeds on islands in the Southern Hemisphere from November to March. A large percentage of the population migrates to the Northern Hemisphere from April to October. It is a common bird during the summer months off Atlantic Canada, including Newfoundland. During the 2004 and 2005 seismic monitoring seasons Sooty Shearwater was observed nearly daily but in low numbers. It was greatly outnumbered by Greater Shearwater with which it was often associated. Densities observed ranged from 0.1 to 0.9 per km². Sooty Shearwaters are more numerous on shelf water of Newfoundland than on the Orphan Basin (Brown 1986; Lock et al. 1994).

On fixed platforms on the Grand Banks between 1999 and 2002, Sooty Shearwater was also greatly outnumbered by Greater Shearwater with the former representing 0.04% and the latter 55.0% of the total number of seabirds recorded by industry observers (Baillie et al. 2005). Numbers peaked at 2.5 birds per day at one drilling platform on the northeast Grand Banks in 2000 and 2001 (Baillie et al. 2005). The Sooty Shearwater is probably scarce to uncommon from May to November on the Orphan Basin.

4.6.1.1.3 Manx Shearwater

Most of the world population of Manx Shearwater breeds on islands in the northeast Atlantic Ocean. The only known established colony in the northwest Atlantic is at Middle Lawn Island, Burin Peninsula, Newfoundland (Lock et al. 1994). A small population of Manx Shearwater is present in Atlantic Canada during the summer months; most of these birds are probably non-breeding sub-adults from European breeding colonies. During the 2004 and 2005 seismic monitoring seasons Manx Shearwater was scarce on the Orphan Basin (Moulton et al. 2005; Moulton et al. 2006). Most of the 48 individuals observed 2004 and the 23 observed in 2005 occurred in July and the first weeks of August (Moulton et al. 2005; Moulton et al. 2006). A total of 39 were observed on drill platforms on the northeast Grand Banks 1999-2002 (Baillie et al. 2005) representing <0.1% of all the birds recorded. The Manx Shearwater is expected to be scarce on the Orphan Basin from May to October.

4.6.1.2 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 4.13). It is common in most Newfoundland waters during the summer months. Wilson’s Storm-Petrel visits the Northern Hemisphere from May to October after breeding in the Southern Hemisphere. The Orphan Basin is on the northern limit of its range.

4.6.1.2.1 Leach’s Storm-Petrel

Leach’s Storm Petrel is common in the Orphan Basin from May to October and probably also present in smaller numbers in April and November. Leach’s Storm-Petrel breeds on the north Pacific and north Atlantic oceans. It winters at sea in the middle latitudes and south of the equator in both oceans. Leach’s Storm-Petrel is an abundant breeder in eastern Newfoundland with more than four million pairs nesting on the Burin Peninsula, Avalon Peninsula and the northeast coast of the Newfoundland (Table 4.13). They may range far from breeding colonies to feed. Non-breeding sub-adults remain at sea beyond sight of land.

Leach's Storm-Petrel was common in the Orphan Basin during the 2004 and 2005 Orphan Basin monitoring program (Moulton et al. 2005; Moulton et al. 2006). The density of Leach's Storm-Petrel was consistent through June to September with most survey blocks containing 2.0 to 9.9 per km². Leach's Storm-Petrels were probably under-recorded from the oil platforms on the northeast Grand Banks between 1999 and 2002 because of the height of the observers above the water making the small dark birds very difficult to see (Baillie et al. 2005).

The largest colony in the world (3,600,000 pairs) is at Baccalieu Island on the northeastern Avalon Peninsula (Lock et al. 1994). Leach's Storm-Petrels are thought to fly considerable distances from breeding colonies in search of food. The maximum distances are not known but the Orphan Basin may be within reach of the Baccalieu Island breeding colony, particularly early in the breeding season when adults incubate in shifts lasting several days. Leach's Storm-Petrels require four to five years to reach maturity. The non-breeding sub-adults remain offshore during the summer months. It has not been determined if the Leach's Storm-Petrels on the Orphan Basin are adults or sub-adults or a combination of both. Leach's Storm-Petrel is common in the Study Area, probably arriving on the Orphan Basin in April and leave by the end of October or early November.

4.6.1.2.2 Wilson's Storm-Petrel

Wilson's Storm-Petrel breed on islands in the south Atlantic Ocean. They spend the non-breeding season (May to October) north of the equator. It reaches a northern limit off southern Newfoundland Wilson's Storm-Petrel, similar to Greater and Sooty Shearwater, breed in the Southern Hemisphere November to April and migrate north of the equator May to October. Although Lock et al. (1994) considers Wilson's Storm-Petrel to be common on the Grand Banks, it appears to be rare in the Orphan Basin. During the 2004 and 2005 seismic monitoring seasons totals of 2 and 6 respectively were observed. Wilson's Storm-Petrel comprised 0.2% of all the birds recorded by observers on an oil platform on the northeast Grand Banks 1999-2002 (Baillie et al. 2005). Wilson's Storm-Petrel is probably an occasional visitor to the Orphan Basin from June to September.

4.6.1.3 Alcidae (Auks)

Four species of auks have been recorded in the Orphan Basin: (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 and mostly winter south of the Orphan Basin area. The 2005 seismic monitoring program started in mid May. Significant numbers of Dovekie and Thick-billed Murre from mid May to mid June were probably lingering birds left over from the winter season (Moulton et al. 2005). This suggests there could be a significant winter population of these species on the Orphan Basin. There is no field data from the winter season on the Orphan Basin.

4.6.1.3.1 Dovekie

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

During the 2005 seismic season monitoring program Dovekie was fairly common from mid May to the first week of June (Moulton et al. 2006). Birds were feeding in small groups on the water and observed in northward migration. A major northward movement of Dovekies was noted 31 May and 1 June. On 31 May, approximately 1,500 Dovekies were observed flying north in flocks of 10-80 in the time period 0800-0930. Numbers declined during the second week of June. During the 2004 and 2005 seismic monitoring seasons there were occasional sightings in July and August (Moulton et al. 2005; Moulton et al. 2006). Adult Dovekies return to breeding grounds in April to early May (Gaston and Jones 1998). Non-breeding sub-adult birds migrate to the general area of breeding locations later than the adults. The moderate numbers of presumed sub-adult Dovekies present on the Orphan Basin in spring indicates the species is even more numerous in winter when the adults would augment populations. In the Study Area Dovekies are probably to uncommon to common October to May and very scarce to scarce June to September

4.6.1.3.2 Common Murre

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 4.13). About 80% of these breed on Funk Island approximately 300 km west of the Orphan Basin. The maximum distance Common Murres are known to forage from breeding sites is 200 km, placing the Orphan Basin beyond the reach of Funk Island birds during the breeding season May to July (Gaston and Jones 1998). During the 2004 and 2005 seismic monitoring seasons Common Murre was scarce on the Orphan Basin between mid May and late September (Moulton et al. 2005; Moulton et al. 2006). Common Murre is probably scarce on the Orphan Basin throughout the year.

4.6.1.3.3 Thick-billed Murre

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 4.13). Thick-billed Murre was fairly common on the Orphan Basin and adjacent areas during mid May to late June during the 2005 seismic survey monitoring. Typical day totals ranged from 20-40. Birds were observed both on the water and in flight. Flight directions were generally northward during the period but many birds were also on the water and presumably feeding. Distinct northward movements of birds were noted on

31 May (50 individuals), 1 June (50), 6 June (50) and 7 June (100). During both the 2004 and 2005 seismic monitoring seasons Thick-billed Murre was very scarce July to September. Like Dovekie, the Thick-billed Murres present on the Orphan Basin in late spring were probably remnants from a larger wintering population. It is estimated 4 million Thick-billed Murres winter in eastern Newfoundland, largely on the Grand Banks (Lock et al. 1994). Band returns show that the wintering population originates from breeding colonies in the Canadian Arctic (Hudson Strait and Lancaster Sound), west Greenland and Iceland (Lock et al. 1994). It is likely the Orphan Basin is part of the main wintering area for Thick-billed Murres in eastern North America. Thick-billed Murre is probably uncommon October to June and very scarce July to September.

4.6.1.3.4 Atlantic Puffin

The Atlantic Puffin breeds in the north Atlantic in Maine, Newfoundland and Labrador, Greenland, Iceland and northwest Europe. In North America, it winters from southern Newfoundland to 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 4.13). In eastern Newfoundland it is common on the shelf areas from April to November and rare from December to March. They are probably rare over deep water beyond the continental shelf. During the 2004 and 2005 seismic monitoring seasons a grand total of only 42 Atlantic Puffins were observed (Moulton et al. 2005; Moulton et al. 2006). This demonstrates their scarcity on the Orphan Basin. Observations were spread over the survey periods mid May to late September. Atlantic Puffin is probably a scarce visitor to the Orphan Basin, May to November.

4.6.1.4 Prey and Foraging Habits

Marine birds in the Orphan Basin consume a variety of prey ranging from small fish to zooplankton. Different methods for capturing food range from plunge diving from a height of 30 m into the water, feeding on the surface and sitting on the water then diving. The feeding habits of birds that occur in the Project Area are summarized in Table 4.14.

4.7 Marine Mammals and Sea Turtles

4.7.1 Marine Mammals

Two environmental monitoring programs (Lang and Moulton 2004; Moulton et al. 2005) conducted during the summer of 2004 and one conducted during the late spring and to early fall of 2005 (Moulton et al. 2006) provide new information on marine mammal and sea turtle distribution and abundances in and near the Orphan Basin Project Area.

Table 4.14. Foraging Strategy and Prey of Seabirds in the Study Area.

Species	Prey	Foraging Strategy	Time with Head Under Water	Depth
Procellariidae				
Northern Fulmar	Fish, cephalopods, crustaceans, zooplankton, offal	Surface feeding.	Brief	<1 m
Greater Shearwater	Fish, cephalopods, crustaceans, zooplankton, offal	Shallow plunging, surface feeding	Brief	<1 m
Sooty Shearwater	Fish, cephalopods, crustaceans, zooplankton, offal	Shallow plunging, surface feeding	Brief	<1 m
Manx Shearwater	Fish, cephalopods, crustaceans, zooplankton, offal	Shallow plunging, surface feeding	Brief	<1 m
Hydrobatidae				
Wilson's Storm-Petrel	Crustaceans, zooplankton	Surface feeding	Brief	<0.5 m
Leach's Storm-Petrel	Crustaceans, zooplankton	Surface feeding	Brief	<0.5 m
Sulidae				
Northern Gannet	Fish, cephalopods	Deep plunge diving	Brief	10 m
Phalaropodinae				
Red Phalarope	Zooplankton, crustaceans	Surface feeding	Brief	0 m
Red-necked Phalarope	Zooplankton, crustaceans	Surface feeding	Brief	0 m
Laridae				
Great Skua	Fish, cephalopods, offal	Kleptoparasitism	Brief	<0.5 m
South Polar Skua	Fish, cephalopods, offal	Kleptoparasitism	Brief	<0.5 m
Pomarine Jaeger	Fish	Kleptoparasitism	Brief	<0.5 m
Parasitic Jaeger	Fish	Kleptoparasitism	Brief	<0.5 m
Long-tailed Jaeger	Fish, crustaceans	Kleptoparasitism, surface feeding	Brief	<0.5 m
Herring Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5 m
Iceland Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5 m
Glaucous Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5 m
Great Black-backed Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5 m

Table 4.14. (Cont.)

Species	Prey	Foraging Strategy	Time with Head Under Water	Depth
Ivory Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5 m
Black-legged Kittiwake	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5 m
Arctic Tern	Fish, crustaceans, zooplankton	Surface feeding, shallow plunging	Brief	<0.5 m
Alcidae				
Dovekie	Crustaceans, zooplankton, fish	Pursuit diving	Prolonged	Max 30 m, average is <30 m
Common Murre	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 100 m, average 20-50 m
Thick-billed Murre	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 100 m, average 20-60 m
Razorbill	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 120 m, average 25 m
Atlantic Puffin	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 60 m, average <60 m

Sources: Cramp and Simmons (1983), Gaston and Jones (1998), Nettleship and Birkhead (1985) and Lock et al. (1994).

As part of the exploration licence holders' monitoring and mitigation program, biologists conducted marine mammal surveys aboard seismic vessels in the 2004 and 2005 seismic operations. In 2004 the SR/V *Veritas Vantage* (*Vantage*) conducted a 3-D seismic program which occurred from 26 June to 18 September 2004 (Moulton et al. 2005). In total, there were 1,198 h of observation along 10,541 km. Of this effort, 596 h (5,038 km) occurred during periods when the array was inactive and 602 h (5,503 km) occurred during periods when the array was active. In total, there were 151 sightings of 1,397 marine mammals during systematic watches from the *Vantage*. The specific results of marine mammal abundance and distribution are provided below. In 2005 the 3-D seismic program was conducted from 12 May to 10 October 2005 by Western Geco using two seismic vessels: M/V *Geco Diamond* and *Western Patriot*. In total, there were 2,656 h of observation along 22,664 km. Within the 'Seismic Analysis Area' where seismic data were acquired and the seismic vessel made turns, observation hours totalled 2321 h along 20,027 km (501 h with no airguns and 1820 h with airgun operations). In total, there were 409 sightings of 3,554 marine mammals during systematic watches within the Seismic Analyses Area.

The second monitoring program in 2004 for the exploration licence holders in the Orphan Basin Project Area was conducted from a research vessel, the Canadian Coast Guard Ship *Hudson* (Lang and Moulton 2004). A biologist conducted marine mammal (and seabird) surveys as the CCGS *Hudson* sailed from Dartmouth, NS along the Scotian Shelf and the southern Grand Banks to the Orphan Basin. In total there were 61.7 h of observations along 485 km during 24 June to 7 July 2004. Of this effort, 25.5 h and 36.2 h occurred when the ship was stationary and moving, respectively. In total, there were 20 sightings of 116 marine mammals during systematic watches and incidentally. The specific results of marine mammal abundance and distribution are provided below.

At least twenty-one species of marine mammal may occur in the region of the Orphan Basin including 16 species of cetaceans (whales and dolphins) and five species of phocids (seals) (the SEA of LGL 2003a; the 3-D Seismic EA of Buchanan et al. 2004) (Table 4.15). Of the 21 species of marine mammals that were listed in Buchanan et al. (2004), 15 were sighted in the Orphan Basin Project Area during 2004 and 2005 monitoring from the *Vantage* and *Hudson* (Table 4.15). An additional species, striped dolphin, not listed in the SEA or the EA, was also sighted in the Orphan Basin (Table 4.15).

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.

Population estimates and feeding information of many of the marine mammal species that occur within Orphan Basin are indicated in Tables 4.16 and Table 4.17.

Table 4.15. Marine Mammals (and their COSEWIC status) Known to Occur within the Orphan Basin Area (adapted from Buchanan et al. (2004)) and the Number of Marine Mammal Sightings Made during Monitoring from the *Vantage* and *Hudson* in 2004 and the *Diamond* and *Patriot* in 2005.

Species	COSEWIC Status[a]	No. of Sightings (individuals) during *Hudson* Monitoring [c]	No. of Sightings (individuals) during *Vantage* Monitoring 2004 [b]	No. of Sightings (individuals) during *Diamond* and *Patriot* Monitoring 2005 [e]
Baleen Whales (Mysticetes)				
Humpback Whale	NAR	0	13 (30)	36 (111)
Blue Whale	E	0	0	0
Fin Whale	SC	1 (7)	9 (16) [d]	16(24)
Sei Whale	DD	0	6 (9) [d]	15(24)
Minke Whale	NC	0	6 (6)	8(8)
Toothed Whales (Odontocetes)				
Sperm Whale	NAR	0	5 (5)	32(47)
Northern Bottlenose Whale [f]	E	0	3 (9)	7(21)
Sowerby's Beaked Whale	SC	0	0	1(4)
Common Bottlenose Dolphin	NAR	0	0	1 (15)
Killer Whale	DD	0	0	0
Long-finned Pilot Whale	NAR	1 (16)	43 (597)	101 (1713)
Short-beaked Common Dolphin	NAR	0	0	9 (88)
Atlantic White-sided Dolphin	NAR	0	4 (70)	18 (304)
White-beaked Dolphin	NAR	0	1 (5)	6 (52)
Harbour Porpoise	SC	0	1 (2)	9(24)
Risso's Dolphin	NAR	0	0	
Striped Dolphin	NAR	0	1(4)	2 (15)
True Seals (Phocids)				
Harp Seal	NC	0	1 (2)	5(603)
Hooded Seal	NAR	0	0	0
Grey Seal	NAR	0	0	0
Ringed Seal	NAR	0	0	0
Bearded Seal	NAR	0	0	0

[a] Based on COSEWIC (2005).
E: endangered; SC: special concern; NC: not considered; DD: data deficient; NAR: not at risk
[b] Sightings during systematic watches in 'Overall Area' (see Moulton et al. 2005).
[c] Sightings (systematic and incidental) in the Orphan Basin (see Lang and Moulton 2004).
[d] There were 12 sightings (18 individuals) of whales that were either fin or sei whales that are not included here.
[e] There were 15 sightings (24 individuals) of whales that were either fin or sei whales that are not included here.
[f] Refers to the Scotian Shelf population; this species is a candidate for endangered status. There is uncertainty about which population (Scotian Shelf or Davis Strait) of this species occurs in the Orphan Basin.

Table 4.16. Population Estimates of Marine Mammals that Occur in the Orphan Basin Area (updated from Buchanan et al. (2004)).

Species	Northwest Atlantic (NW) Population Size	Population Occurring in the Orphan Basin Area		
	Estimated Number	Stock	Estimated Number	Source of Updated Information
Baleen Whales				
Humpback Whale	5,505 (11,570 in North Atlantic)	NF/Labrador	1,700-3,200	Whitehead (1982); Katona and Beard (1990); Baird (2003)
Blue Whale	308 [a]	Northwest Atlantic	Unknown	Waring et al. (2004: Appendix III)
Fin Whale	2,814 [b]	Can. E. Coast	Unknown	Waring et al. (2004)
Sei Whale	Unknown	Nova Scotia	Unknown	COSEWIC (2005); Waring et al. (2004)
Minke Whale	4,018 [c]	Can. E. Coast	Unknown	Waring et al. (2004)
Toothed Whales				
Sperm Whale	4,702 [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	Northwest Atlantic	Unknown	Waring et al. (2004)
Risso's Dolphin	30,000	US East Coast	Unknown	Reeves et al. (2002)
Killer Whale	Unavailable		Unknown	Lien et al. (1988); Waring et al. (2004)
Long-finned Pilot Whale	14,524	Northwest Atlantic	Abundant	Nelson and Lien (1996); Waring et al. (2004)
Short-beaked Common Dolphin	30,768	Northwest Atlantic	Unknown	Katona et al. (1993); Waring et al. (2004)
Atlantic White-sided Dolphin	51,640 [e]	Northwest Atlantic	Unknown	Palka et al. (1997); Waring et al. (2004)
White-beaked Dolphin	Unknown	Northwest Atlantic	Unknown	Waring et al. (2004)
Harbour Porpoise	Unknown	Newfoundland	Unknown	Wang et al. (1996); COSEWIC (2005); Waring et al. (2004)
True Seals				
Harp Seal	5.2 (±1.2) million	Northwest Atlantic	Unknown	DFO (2000)
Hooded Seal	400,000-450,000	Northwest Atlantic	Unknown	Stenson et al. (1997)
Grey Seal	154,000	E. Canada	Unknown	Mohn and Bowen (1996)
Ringed Seal	Unavailable			Katona et al. (1993)
Bearded Seal	Unavailable			Katona et al. (1993)

[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 4.17. Prey of Marine Mammals that Occur in the Orphan Basin 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)
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)
Common 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 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. (2002)
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 (*in press*).
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)
Ringed Seal	Fish (polar cod), amphipods, krill, shrimp	Katona et al. (1993)
Bearded Seal	Fish (polar cod, sculpins, rough dabs, eelblennies), crabs, shrimp, molluscs, cephalopods, polychaetes, amphipods	Kovacs (2002)

Source: Mobil (1985) with updates where indicated.

4.7.1.1 Baleen Whales (Mysticetes)

The five species of baleen whales that occur in the Orphan Basin area include the humpback whale, the blue whale, the fin whale, the sei whale, and the minke whale (see Table 4.15). Although nearly all of these species experienced depletion due to whaling, it is likely that many are experiencing some recovery (Best 1993).

Of the five species of baleen whales that occur in the Orphan Basin area, four (fin, sei, humpback and minke whale) were sighted during the 2004 and 2005 monitoring program. The blue whale was not observed. During the 2004 monitoring program there were 59 sightings overall, totaling 96 baleen whales sighted. Baleen whales comprised 39.1% of all marine mammal sightings and 6.9% of all marine mammals (individuals; Table 4.18). During the 2005 monitoring program there were 95 sightings, totaling 193 baleen whales sighted (Table 4.18). Baleen whales comprised 47.2% of all marine mammal sightings and 5.4% of all marine mammals (individuals; Table 4.18).

Table 4.18. Summary of Baleen Whale Sightings Made during the 2004 and 2005 Monitoring Program.

	Baleen Whale							
	Fin	Sei	Fin/Sei	Humpback	Minke	Unidentified	Total Identified	Total
Numbers Observed 2004								
Sightings	9	6	12	13	6	13	46	59
Individuals	16	9	18	30	6	17	79	96
% of Total MM Sightings	6.0	4.0	7.9	8.6	4.0	8.6	30.5	39.1
% of Total MM Individuals	1.1	0.6	1.3	2.1	0.4	1.2	5.7	6.9
% of Baleen Whale Sightings [a]	19.6	13.0	26.1	28.3	13.0			
% of Baleen Whale Individuals [a]	20.3	11.4	22.8	38.0	7.6			
Relative Sighting Rates (sightings/h)[b]								
Total	0.011	0.002	0.009	0.014	0.009	0.011	0.044	0.054
July	0.021	0.005	0.021	0.032	0.026	0.016	0.105	0.121
August	0.004	0	0	0.008	0	0.008	0.011	0.019
September	0.009	0	0.009	0	0	0.009	0.018	0.028
Numbers Observed 2005								
Sightings	16	15	7	36	8	13	82	95
Individuals	24	24	8	111	8	18	175	193
% of Total MM Sightings	3.9	3.7	1.7	8.8	2.0	3.2	42.8	47.2
% of Total MM Individuals	0.7	0.7	0.2	3.1	0.2	0.4	4.9	5.4
% of Baleen Whale Sightings [a]	19.5	18.3	8.5	43.9	9.8			
% of Baleen Whale Individuals [a]	13.7	13.7	4.6	63.4	4.6			
Relative Sighting Rates (sightings/h)[b]								
Total	0.009	0.009	0.003	0.021	0.005	0.006	0.066	0.054
May	0.019	0.019	0	0.019	0	0	0.057	0.057
June	0	0.024	0	0.074	0.004	0.018	0.103	0.120
July	0.016	0.002	0.008	0.024	0.019	0.003	0.069	0.072
August	0.013	0.007	0.002	0	0	0.004	0.022	0.0269
September	0.004	0.004	0.004	0	0	0.004	0.011	0.016
October	0	0	0	0	0	0	0	0

[a] % of baleen whales identified to species level.

[b] In Seismic Analysis Area and excluding sea states >5 and visibilities <1 km.

4.7.1.1.1 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 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).

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 Orphan Basin 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 2003d), 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.

During the 2004 monitoring program, the humpback whale was one of the most frequently sighted baleen whales. Overall (1,198 h of observations), there were 13 sightings consisting of 30 individuals which accounted for 28.3% of all baleen whale sightings (38% of total baleen whale individuals). Humpbacks occurred in the Project Area as well as west and north of the Project Area (Figure 4.17). Humpbacks were sighted in water depths ranging from 1,280-2,460 m and mostly in July (there were no sightings in June, one in September, and two in early August). Humpback whales were sighted at an overall rate of 0.014 sightings/h but this rate was higher in July (0.032 sightings/h; Table 4.18). No humpback whales were identified during the *Hudson* cruise.

During the 2005 monitoring program, the humpback whale was the most frequently sighted baleen whale. Overall (2,656 h of observations), there were 36 sightings consisting of 111 individuals which accounted for 43.9% of all baleen whale sightings (63.4% of total baleen whale individuals). Humpback whales were sighted at an overall rate of 0.021 sightings/h with a peak of 0.074 sightings/h during June (Table 4.18).

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’).

4.7.1.1.2 Blue Whale

The blue whale probably numbers in the few hundreds in the northwest Atlantic (Waring et al. 1999). It is rarely sighted on the Grand Banks, and is probably relatively uncommon within the Study Area. Nothing is known about trends in blue whale abundance in the northwest Atlantic, but the population that summers around Iceland has been increasing at approximately five percent/yr (Sigurjónsson and Gunnlaugsson 1990). The blue whale is listed as ‘endangered’ (*SARA* Schedule 1).

One blue whale was sighted northwest of the Project Area during DFO surveys in spring 2004 (J. Lawson, DFO, pers. comm.); none were sighted during the OLABS surveys to the west of the Project Area during the early 1980s (McLaren et al. 1983) and none were observed during the 2004 and 2005 monitoring programs (Moulton et al. 2005; Moulton et al. 2006).

4.7.1.1.3 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 2,200 (Waring et al. 1999). 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 Orphan Basin 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 shallow (<400 m) and deep (>400 m) areas of the Orphan Basin area.

The fin whale is designated by COSEWIC and *SARA* as a species of 'special concern.' The fin whale was the second most abundant baleen whale observed in the Orphan Basin during the 2004 monitoring program. In the 2005 monitoring program fin whale and sei whale were tied for second most abundant identified baleen whale. Overall in 2004 (1,198 h of observations), there were nine confirmed sightings consisting of 16 individuals which accounted for 19.6% of all baleen whale sightings (20.3% of total baleen whale individuals). Most fin whale sightings occurred in the Project Area (Figure 4.18). There were 12 sightings of 18 individual whales which were identified as either fin or sei whales. If the proportions of fin and sei whales identified to species level are applied to these "unknown" fin/sei whales, this results in an additional 7 sightings of 12 individual fin whales. Therefore, it is possible that the total number of fin whales observed was ~16 sightings of 28 individuals. Fin whales were sighted in water depths ranging from 1,287-2,584 m and mostly in July. Fin whales were sighted at an overall rate of 0.011 sightings/h and this rate was higher in July (0.021 sightings/h; Table 4.18). There were two incidental sightings of eight fin whales during the *Hudson* cruise. A sighting of seven fin whales occurred in the Orphan Basin (EL1076) on 2 July 2004 (Figure 4.17).

Overall during the 2005 monitoring program (2,656 h of observation), there were 16 confirmed sightings consisting of 24 individuals which accounted for 19.5% of all baleen whale sightings (13.7% of total baleen whale individuals). Most fin whale sightings occurred in the Seismic Analysis Area (Figure 4.18). There were 7 sightings of 8 individual whales which were identified as either fin or sei whales. If the proportions of fin and sei whales identified to species level are applied to these "unknown" fin/sei whales, this results in an additional 4 individual fin whales. Fin whales were sighted at an overall rate of 0.009 sightings/h and this rate was higher in May (0.019 sightings/h) (Table 4.18).

4.7.1.1.4 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 is thought to range as far as the Grand Banks.

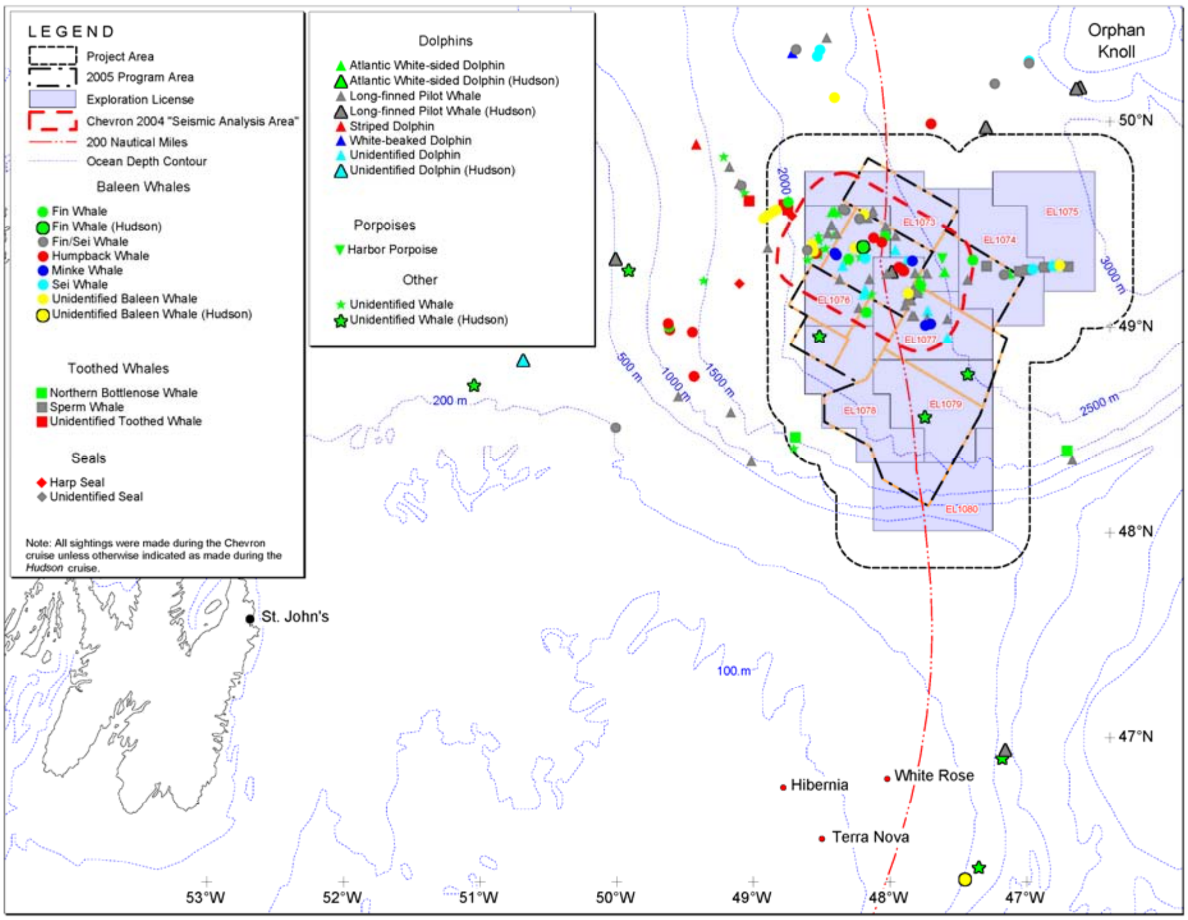


Figure 4.17. Marine Mammal Sightings during the 2004 Monitoring Program (26 June to 18 September 2004) and during the *Hudson* Cruise (24 June to 7 July 2004).

Current knowledge suggests that sei whales are uncommon visitors to the Orphan Basin area compared to more commonly sighted cetacean species. Based on the DFO cetacean sightings database (DFO 2003d), no sei whale sightings have been reported in the area since 1980. The Atlantic population of the sei whale is considered by COSEWIC as 'data deficient'. Sei whales were positively identified in the Orphan Basin during the 2004 and 2005 monitoring program. These observations are the first documented sightings of sei whales in the area since 1980 (Buchanan et al. 2004). Overall (1,198 h of observations) during the 2004 monitoring program, 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). Three of the six sightings occurred north of the Project Area, two sightings occurred in ELs 1074 and 1075, and there was one sighting in EL1076 (Figure 4.18). There were 12 sightings of 18 individual whales which were identified as either fin or sei whales. If the proportions of fin and sei whales identified to species level is applied to these "unknown" fin/sei whales, this results in an additional five sightings of six individual sei whales. Therefore, it is possible that the total number of sei whales observed was ~11 sightings of 15 individuals. Sei whales were sighted in water depths ranging from 2,313-2,839 m and from 30 June to 9 July 2004. Sei whales were sighted at an overall rate of 0.002 sightings/h (Table 4.18). There were no sightings of sei whales during the *Hudson* cruise.

Overall (2,656 h of observations) during the 2005 monitoring program, there were 15 confirmed sightings consisting of 24 individuals which accounted for 18.3% of all baleen whale sightings (13.7% of total baleen whale individuals). If the proportions of fin and sei whales identified to species level is applied to these "unknown" fin/sei whales, this results in an additional four individual sei whales. Sei whales were sighted at an overall rate of 0.009 sightings/h with the peak month being June with 0.024 sightings/h (Table 4.18).

4.7.1.1.5 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 2,790 individuals (Waring et al. 1999).

Minke whales commonly occur within the Orphan Basin area. Most of the reported sightings in the DFO database (DFO 2003d) 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. Overall (1,198 h of observations) in the 2004 monitoring program, there were six sightings consisting of six individuals which accounted for 13.0% of all baleen whale sightings (7.6% of total baleen whale individuals). Minke whales were sighted in water depths ranging from 2,208-2,452 m within the 2004 Program Area (Figure 4.18) and were only sighted in early July (3-10 July 2004). Minke whales were sighted at an overall rate of 0.009 sightings/h (Table 4.18). No minke whales were identified during the *Hudson* cruise. No minke whales were identified during the *Hudson* cruise. During the 2005 monitoring program overall (2,656 h of observations), there were eight sightings consisting of eight individuals which accounted for 9.8% of all baleen whale sightings (4.6% of total baleen whale individuals). Minke whales were sighted at an overall rate of 0.005 sightings/h (Table 4.18).

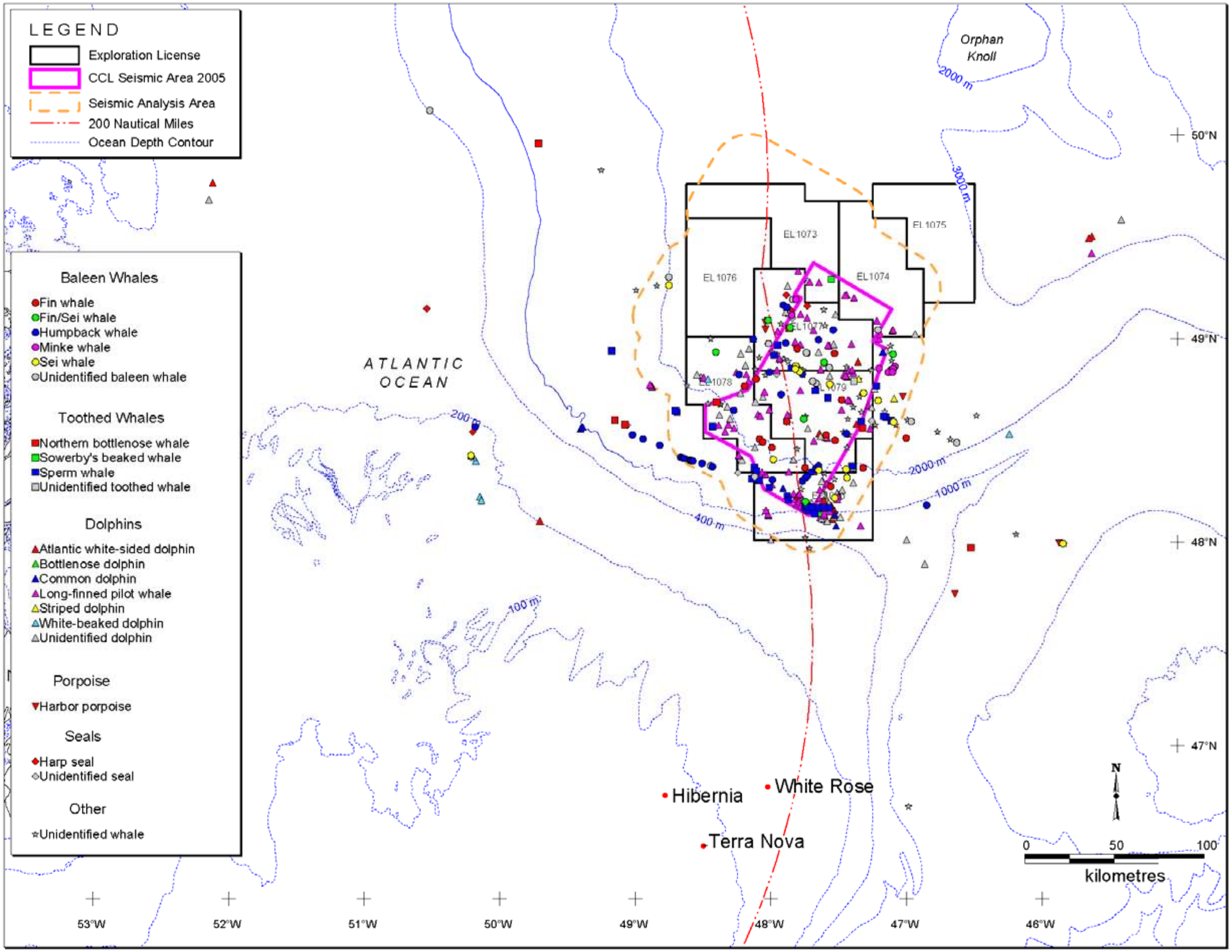


Figure 4.18. Distribution of Marine Mammal Sightings in the 'Overall Area' in 2005.

4.7.1.2 Toothed Whales (Odontocetes)

Buchanan et al. (2004) indicated that 12 species of odontocetes, more specifically, three species of large toothed whale, eight species of dolphins, and one species of porpoise may occur in the Orphan Basin. Of the 12 species of odontocetes that occur or that are thought to occur in the Orphan Basin, six were sighted during the monitoring program in 2004 and ten were sighted 205.

Overall during the 2004 monitoring program, there were 58 sightings totaling 1,244 dolphins. Species included: long-finned pilot whales, Atlantic white-sided dolphins, white-beaked dolphin, and striped dolphin. Dolphins comprised 38.4% of all marine mammal sightings and 89.0% of all marine mammals (individuals; Table 4.19). Dolphins were sighted in water depths ranging from 999 m to 2,734 m and at highest rates in July (0.079 sightings/h; Table 4.19) within the 'Seismic Analysis Area' shown in Figure 4.18.

During the 2005 monitoring program overall there were 191 dolphin sightings totaling 2,552 dolphins. Dolphins comprised 46.7% of all marine mammal sightings and 71.8% of all marine mammals (individuals; Table 4.19). Highest rates in of sightings/h were recorded in September (0.184 sightings/h) and October (0.262 sightings/h) July (0.079 sightings/h; Table 4.19) within the 'Seismic Analysis Area'.

There were relatively few sightings of large toothed whales. During the 2004 monitoring program, there were five sightings of sperm whales and three sightings of northern bottlenose whales. During the 2005 monitoring program there were 32 sighting of sperm whale, 7 sightings of northern bottlenose whale and one sighting of Sowerby's beaked whale.

4.7.1.2.1 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 northwest 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 (DFO 2003d) 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 near Orphan Basin. There are anecdotal reports of sperm whales just east of the 1,000 m contour, to the west of the Project Area (Skipper W. Kilfoy, FPI, pers. comm.). In general, whales in this area apparently are common when high densities of zooplankton are evident on the echosounder at about 30-40 fathom (55-73 m) (W. Kilfoy, pers. comm.).

Table 4.19. Summary of Dolphin Sightings Made during the 2004 Monitoring Program.

	Dolphin								
	Long-finned Pilot Wh	Atl. White sided Dolphin	Common Dolphin	White-beaked Dolphin c	Striped Dolphin c	Bottlenose Dolphin	Unidentified	Total Identified	Total
Numbers Observed 2004									
Sightings	43	4		1	1[c]		9	49	58
Individuals	597	70		5	4		568	676	1244
% of Total MM Sightings	28.5	2.6		0.7	0.7		6.0	32.5	38.4
% of Total MM Individuals	42.7	5.0		0.4	0.3		40.7	48.4	89.0
% of Dolphin Sightings [a]	87.8	8.2		2.0	2.0				
% of Dolphin Individuals [a]	88.3	10.4		0.7	0.6				
Relative Sighting Rates (sightings/h) [b]									
Total	0.042	0.005					0.012	0.047	0.060
July	0.053	0.016					0.011	0.068	0.079
August	0.046	0					0.015	0.046	0.061
September	0.009	0					0.009	0.009	0.018
Numbers Observed 2005									
Sightings	101	18	9	6	2	1	54	137	191
Individuals	1713	304	88	52	15	15	365	2187	2552
% of Total MM Sightings	24.7	4.4	2.2	1.5	0.5	0.3	13.2	33.5	46.7
% of Total MM Individuals	48.2	8.6	2.5	1.5	0.4	0.1	10.3	61.5	71.8
% of Dolphin Sightings [a]	73.7	13.1	6.6	4.4	1.5	0.7			
% of Dolphin Individuals [a]	78.3	13.9	4.0	2.4	0.7	0.7			
Relative Sighting Rates (sightings/h) [b]									
Total	0.038	0.006	0.003	0.002	0.001	0.001	0.020	0.051	0.072
May	0.095	0	0	0.019	0	0	0.038	0.114	0.152
June	0.028	0	0	0	0	0	0.007	0.028	0.035
July	0.034	0.005	0.005	0	0	0	0.013	0.046	0.059
August	0.053	0	0	0	0.004	0	0.035	0.058	0.094
September	0.082	0.035	0.011	0	0	0.004	0.051	0.133	0.184
October	0.200	0	0.015	0	0	0	0.046	0.216	0.262

[a] % of dolphins identified to species level.

[b] In Seismic Analysis Area and excluding sea states > 5 and visibility <1 km.

[c] Not sighted within the Seismic Analysis Area.

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 whales 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).

Sperm whale is considered 'not at risk' by COSEWIC. The sperm whale was sighted in relatively low numbers during the 2004 monitoring program in the Orphan Basin. Overall (1,198 h of observations), there were five sightings consisting of five individuals. Sperm whales were sighted in water depths ranging from 2,620-2,894 m within EL 1074 and 1075 of the Project Area (Figure 4.17) and were only sighted in early July (8, 12 July 2004). No sperm whales were identified during the *Hudson* cruise. During the 2005 monitoring program, overall (2,656 h of observations), there were 32 sightings consisting of 47 individuals. Sperm whale was sighted in all months from June to October with an overall rate of 0.018 sightings/h.

4.7.1.2.2 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. The Orphan Basin 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.

The northern bottlenose whale was sighted in relatively low numbers during the 2004 monitoring program in the Orphan Basin. Overall (1,198 h of observations), there were three sightings consisting of nine individuals. Northern bottlenose whales were sighted in water depths ranging from 1,600-2,127 m. There was one sighting that occurred in EL 1076 on 16 August 2004 and the other two sightings occurred south of the Project Area on 5, 14 September 2004 (Figure 4.18). No northern bottlenose whales were identified during the *Hudson* cruise. During the 2005 monitoring program, overall (2,656 h of observations), there were seven sightings consisting of 21 individuals occurring in May, June and July. Within the Seismic Analysis Area there were three sightings consisting of 11 individuals with an overall rate of 0.002 sightings/h. They occurred in 1,500-2,500 m of water.

4.7.1.2.3 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). Orphan Basin 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.

Sowerby's beaked whales are considered of 'special concern' by COSEWIC and *SARA* Schedule 3. No Sowerby's beaked whales were observed during the 2004 monitoring program or during the *Hudson* cruise. During the 2005 monitoring program, overall (2,656 h of observations), there was one sighting of four Sowerby's beaked whale in September. It occurred in 2,500 m of water.

4.7.1.2.4 Common Bottlenose Dolphin

A north-south migration has been assumed to occur along the east coast of North America, with common 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. It was not recorded during the 2004 monitoring program. One sighting of 15 individuals was recording in September during the 2005 monitoring program.

4.7.1.2.5 Risso’s Dolphin

Risso’s dolphin is widely distributed in tropical and warm temperate oceans (Reeves et al. 2002). 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 or near Orphan Basin (Reeves et al. 2002). Risso’s dolphin was not recorded on the 2004 or 2005 monitoring programs.

4.7.1.2.6 Killer Whale

The killer whale is a year-round resident that is thought to occur in relatively small numbers in the Orphan Basin 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. Killer whale was not recorded on the 2004 or 2005 monitoring programs.

4.7.1.2.7 Long-finned Pilot Whale

The most common toothed whale in Orphan Basin and also one of the few 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). 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 Orphan Basin area pilot whale sightings found in the DFO database (DFO 2003d) (3K, 3L and 3M) were reported in areas where water depth <400 m. It is considered ‘not at risk’ by COSEWIC.

Long-finned pilot whales were consistently sighted during the 2004 and 2005 monitoring programs and were by far the most abundant marine mammal seen. This result is consistent with the known distribution and abundance of pilot whales offshore Newfoundland. Overall (1,198 h of observations), there were 43 sightings consisting of 597 individuals which accounted for 87.8% of all dolphin sightings

(88.3% of total dolphin individuals). Pilot whales were sighted in water depths ranging from 999-2,575 m within and beyond the 2005 Program Area (Figure 4.18). They were sighted from 26 June to 15 Sep 2004 but highest sighting rates occurred in June (0.099 sightings/h) and July (0.053 sightings/h; Table 4.19). Long-finned pilot whales were sighted at an overall rate of 0.042 sightings/h (Table 4.19). There were five sightings of pilot whales consisting of 73 individuals in the Orphan Basin during the *Hudson* cruise. During the 2005 monitoring program, overall (2,656 h of observations), there were 101 sightings consisting of 1,713 individuals which accounted for 73.7% of all dolphin sightings (78.3% of total dolphin individuals). Highest sighting rates occurred in May (0.095 sightings/h), September (0.082 sightings/h) and October (0.200 sightings/h); (Table 4.19). Long-finned pilot whales were sighted at an overall rate of 0.038 sightings/h (Table 4.19).

4.7.1.2.8 Short-beaked (Common) Dolphin

The 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 to the 2,000 isobath. Short-beaked dolphins eat a variety of fishes and squids (Katona et al. 1993).

Common dolphin was not recorded during the 2004 monitoring program but was observed in 2005. During the 2005 monitoring program, overall (2,656 h of observation), there were nine sightings consisting of 88 individuals which accounted for 6.6% of all dolphin sightings (4.0% of dolphin individuals) (Table 4.19). It was observed in July, September and October with the highest sighting rate of 0.015 sightings/h in October (Table 4.19).

4.7.1.2.9 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 Orphan Basin 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 survey (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 in the Orphan Basin area are recorded in the DFO cetacean sightings database (DFO 2003d). The sightings that are recorded occurred both inside and outside the 400 m isobath. There also were relatively few sightings of Atlantic white-sided dolphins during the 2004 monitoring program. Overall (1,198 h of observations), there were four sightings consisting of 70 individuals which accounted for 8.2% of all dolphin sightings (10.4% of total dolphin individuals). Atlantic white-sided dolphins were sighted in water depths ranging from 2,226-2,734 m within the Project Area (Figure 4.18). They were sighted from 8-31 July 2004 at an overall rate of 0.005 sightings/h (Table 4.19). There was one sighting of white-sided dolphins (six individuals) during the *Hudson* cruise but the sighting was almost 300 km south of Orphan Basin. During the 2005 monitoring program, overall (2,656 h of observations), there were 18 sightings consisting of 304 individuals which accounted for 13.1% of all dolphin sightings (13.9% of total dolphin individuals). All sightings were in July and September with an overall rate of 0.006 sightings/h (Table 4.19).

4.7.1.2.10 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 have been estimated to 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 is no reliable population estimate for the northwest Atlantic. 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).

During the 2004 monitoring program, there was only one sighting of white-beaked dolphins and it consisted of five individuals. The sighting occurred on 4 July in 2,340 m of water. No white-beaked dolphins were sighted during the *Hudson* cruise. During the 2005 monitoring program, overall (2,656 h of observations), there were six sightings consisting of 52 individuals which accounted for 4.4% of all dolphins (2.4% of total dolphin individuals). All sightings were in May with a rate of 0.019 sightings/h (Table 4.19)

4.7.1.2.11 Striped Dolphin

Orphan Basin is outside the normal distribution of striped dolphin. There was one sighting of this species and it consisted of four individuals during the 2004 monitoring program. The sighting occurred on 14 September in 1,427 m of water about 75 km northwest of the 2005 Program Area. No striped dolphins were sighted during the *Hudson* cruise. During the 2005 monitoring program, overall (2,656 h of observations), there were two sightings consisting of 15 individuals which accounted for 1.5% of all dolphins (0.7% of total dolphin individuals). Both sightings occurred in August.

4.7.1.2.12 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’. There was one probable sighting of two harbour porpoises during the 2004 monitoring program (Figure 4.18). The sighting occurred on 15 July in 2,538 m of water. No harbour porpoises were sighted during the *Hudson* cruise. During the

2005 monitoring program, overall (2,656 h of observations), they were nine sightings consisting of 24 individuals in water depth ranging from 787 to 2,633 m (Figure 4.18). Seven out nine of sightings occurred in July.

4.7.1.3 True Seals (Phocids)

Five species of true seals are known to occur in the waters in and near Orphan Basin (see Table 4.15). Populations of harp, hooded, and grey seals in Canada are thought to be increasing (Waring et al. 1999). 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 (see Table 4.17), with considerable seasonal, geographic and interannual variation in diet (Hammill et al. 1995; Lawson and Stenson 1995; Wallace and Lawson 1997).

During the OLABS surveys in 1981 and 1982, bearded seals, harbour seals, harp seals, and hooded seals were observed. Grey seals and ringed seals, known to occur in the OLABS study area, were not identified during the surveys. Six harbour seals were seen between August and September, primarily inshore. Thirty-three bearded seals were observed primarily in the offshore and north of the Orphan Basin between March and May. An estimated 60,000 harp seals were seen during April to June and January to April periods. Most harp seals were hauled out on pack ice. One hundred and forty-seven hooded seals were observed in the offshore, north of the Orphan Basin, between February and April (McLaren et al. 1982).

Only the harp seal was positively identified during the 2004 and 2005 monitoring programs. Two harp seals (one adult and one probable subadult) were observed in July 2004 in 1,760 m and 2,042 m of water (Figure 4.18). Two other seals, not identified to species level, were also observed; one in July and one in August 2004. No seals were observed during the *Hudson* cruise. During the 2005 monitoring program there were five sightings of harp seals, including groups of 500 and 100 seen on 22 May and 26 June respectively. These large groups were west of the Orphan Basin in 169 m (group of 100) and 308 m (group of 500) of water and were heading north. Other sightings of single harp seals occurred in early July in 2500 m of water in the Orphan Basin. There were five sightings of unidentified seals from May to August occurring in water ranging in depth from 1645 to 2427 m.

4.7.1.3.1 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 close to the northeast corner of Orphan Basin. 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 these animals during those years (Stenson and Kavanagh 1994). Sighting effort from these surveys within the Orphan Basin area was low, but harp seals were present in low numbers in the area. 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). In 1994, the total population estimate of harp seals in the northwest Atlantic was 4.5 million to 4.8 million, with a suggested growth rate of approximately five percent/yr since 1990 (Shelton et al. 1996).

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 flatfish (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, *in press*).

4.7.1.3.2 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 Orphan Basin area during these surveys were less frequent than harp seal sightings. The number of visitors to the area is unknown. However, these numbers may be increasing as hooded seals are apparently expanding their southern range of occurrence (McAlpine et al. 1999).

The most recent estimate of pup production at "the Front" off Labrador, made in 1990, was approximately 83,000 (Stenson et al. 1997), suggesting a current total population of hooded seals in the northwest Atlantic of 500,000 (Whitehead et al. 1998).

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).

4.7.1.3.3 Grey Seal

Grey seals in the Orphan Basin area are migrants from the Sable Island and Gulf of St. Lawrence breeding populations. This species occurs in the 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 154,000 in 1994 (Mohn and Bowen 1996).

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).

4.7.1.3.4 Ringed Seal

The ringed seal is the most common Arctic seal and its distribution is circumpolar, encompassing all of the European and Canadian Arctic and extending southward to areas that include Labrador, and occasionally northeast Newfoundland and the Gulf of St. Lawrence. They dive to depths of at least 100 m to feed on polar cod, amphipods, krill and other shrimplike crustaceans (Katona et al. 1993). Compared to harp and hooded seals, ringed seals do not commonly occur in the Orphan Basin area.

4.7.1.3.5 Bearded Seal

The bearded seal has a patchy distribution throughout much of the Arctic and sub-Arctic. This seal's preferred habitat is drifting pack ice in areas over shallow water shelves and, therefore, they are often found in coastal areas. While some of these animals are resident throughout the year in certain locations within their distribution, others follow the retraction of the pack ice northward during the summer and the advance southward once again in the late fall and winter (Kovacs 2002). Bearded seals typically occur north of Orphan Basin but small numbers of bearded seals could stray from Labrador waters to the area.

This seal species is primarily a benthic feeder. They do not tend to dive any deeper than 100 m although there are exceptions to as deep as 500 m. Prey includes polar cod, sculpins, rough dabs, eelblennies, crabs, shrimps, molluscs, cephalopods, polychaetes and amphipods (Kovacs 2002).

4.7.2 Sea Turtles

Sea turtles are probably not common in the Orphan Basin 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 Orphan Basin: (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 region due to lack of information. The leatherback turtle is listed as endangered by COSEWIC (2005) 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* (2005). The Kemp's ridley is also listed as endangered and the loggerhead turtle is listed as threatened by NMFS and FWS (Plotkin 1995).

No sea turtles were observed during the 2004 and 2005 monitoring programs in Orphan Basin or during the *Hudson* cruise. Also, leatherbacks equipped with satellite tags did not occur in the Project Area but some did migrate through the Grand Banks south of Newfoundland (James et al. 2005).

4.7.2.1 Leatherback

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 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. Apparently, more leatherbacks visit waters near the Orphan Basin Area than was once believed (M. James, pers. comm.). An adult male that was satellite-tagged in waters near Cape Breton Island, Nova Scotia in early September 1999, travelled to Placentia Bay, Newfoundland by the end of the month before migrating south to warmer waters. 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).

4.7.2.2 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 region 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 may be found 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).

4.7.2.3 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 region is unknown. 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).

5.0 Effects Assessment

5.1 Potential Effects of CSEM

The review of information contained in the following sections is largely gleaned from a major review of information conducted by LGL for the ExxonMobil Upstream Research Corporation (Fechhelm et al. 2001), with updates.

5.1.1 Electromagnetism

Electromagnetic fields (EMF) are generated by anything that carries or produces electricity. EMFs consist of an electric field component (E) that arises from differences in potential among electric charges (i.e., electromotive force) and a magnetic field component (H) that arises from the motion of electric charges (i.e., current). The coexisting electric and magnetic fields each consist of waves that travel together in space at the speed of light (Figure 5.1). The electromagnetic wave is characterized by a frequency and a wavelength. Frequency is the number of cycles of a wave per unit time and is measured in hertz Hz (1 Hz = 1 cycle per second). Wavelength is the distance traveled by the wave in one cycle (Vitale 1995; World Health Organization 2005, and others).

Electric fields are measured in volts per meter (E = V/m). Magnetic fields (H) are measured as amperes per meter (H = A/m) but are typically expressed in terms of magnetic flux or field density as tesla (T) in MKS units and as gauss (G) in CGS units. For general conversion, 1 μT = 10 mG = 0.8 A/m. Because the vast majority of research into geomagnetic navigation in the animal kingdom uses the tesla measure, all of the magnetic information provided in this report is in units of nanno teslas (nT). As a reference, the Earth's geomagnetic field ranges from about 60,000 nT at the magnetic poles to 30,000 nT at the equator (Vitale 1995; World Health Organization 2005, and others).

The electromagnetic spectrum encompasses all possible wavelengths of electromagnetic radiation. At the low end (low frequency) of the spectrum are radio waves like those used in AM (750-1,000 kilohertz or kHz) and FM (80-100 megahertz or Mhz) radio transmissions (Figure 5.2). Gamma rays from cosmic sources and from radioactivity are at the high end of the spectrum where frequencies can range from 1018 to 1020 Hz. It is the frequency (wavelength) of electromagnetic waves that determines their energy level. Electromagnetic waves consist of energy particles (quanta) and quanta of higher frequency waves carry more energy than lower frequency waves. High-frequency waves like gamma rays given off by radioactive elements, cosmic rays, and X-rays contain so much energy per quantum that they can break down molecular bonds and are classified as "ionizing radiation". Ionizing radiation can have serious detrimental effects on humans and animals and are not relevant to a discussion of CSEM. Low frequency fields like those associated with radio and microwave frequencies are insufficient to break molecular bonds and are classified as "non-ionizing radiation". Extremely low frequency (ELF) fields are defined as those less than 300 Hz and include common household electrical systems that operate at 60 Hz standard for North America. These low frequencies and long wavelengths carry very little energy (Vitale 1995; National Institute of Environmental Health Sciences/National Institute of Health 2001; World Health Organization 2005, and others). CSEM is classified as ultra low frequency (1 Hz), with low electric field strengths (<30 mV/m) and low magnetic field strengths (<2 A/m or 2,500 nT).

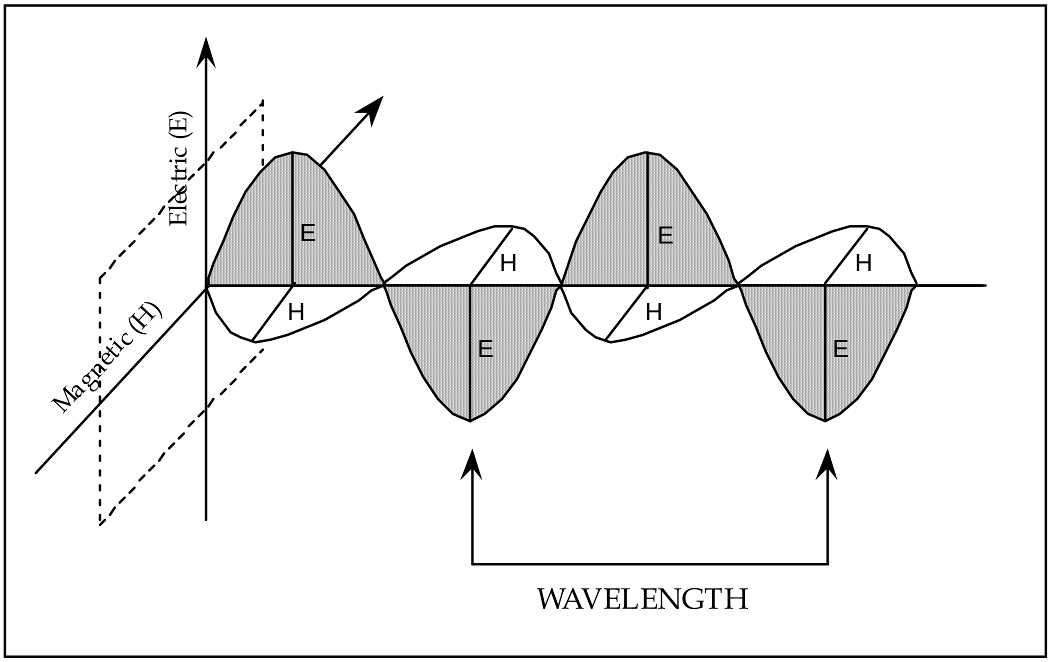


Figure 5.1. Electromagnetic Wave.
Source: World Health Organization (2005).

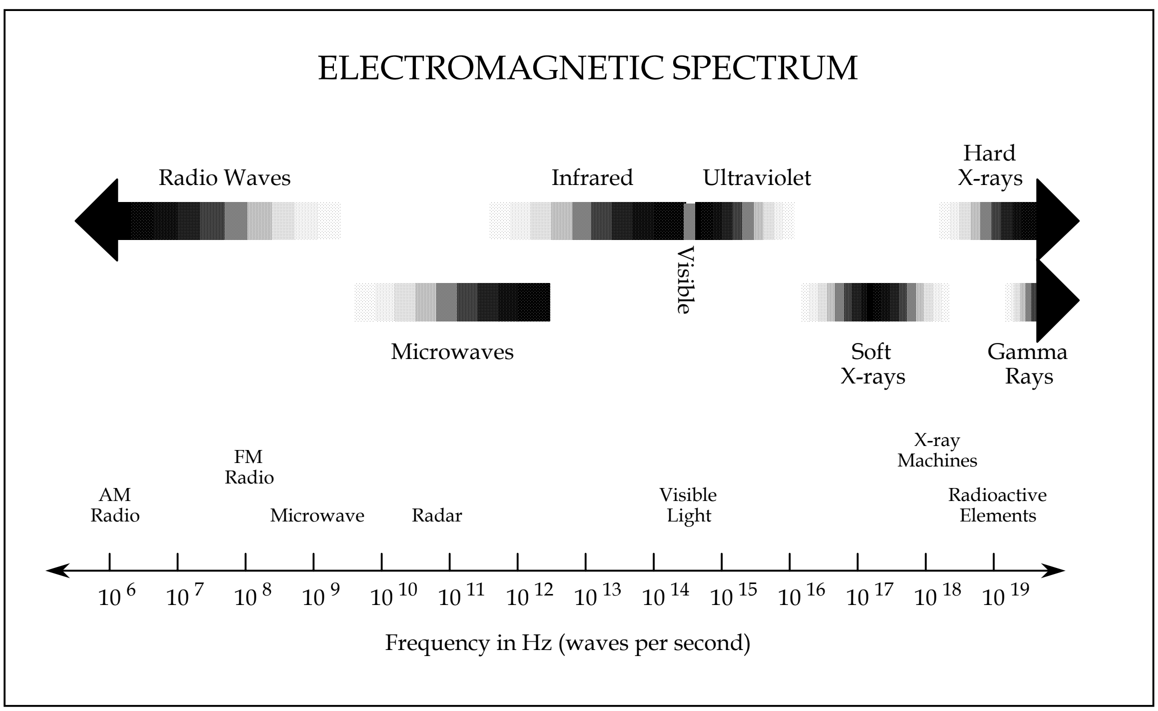


Figure 5.2. The Electromagnetic Spectrum.
Source: University of California (1996).

5.1.2 Electrical Induction

An electrical current or electromotive force is generated, or "induced", in any conductor moving through a magnetic field (as per Faraday's Law). When physical energy (e.g., steam from a coal or nuclear plant, water flowing through a hydroelectric dam, wind, etc.) forces a conductor to move within a magnetic field, electricity is generated (e.g., an electrical generator). Magnetic fields have polarity (north and south poles) and the direction of current flow within a conductor is a function of the direction in which the conductor moves relative to the north-south orientation of the magnetic field. If a conductor moves from left to right relative to the north-south orientation of the magnetic field, current will flow in one direction (direct current or DC), and if it moves from the right to the left current will flow in the opposite direction. If a conductor is moved back and forth within the magnetic field, the current within the conductor will alternately flow in opposite directions (an alternating current or AC). A current may also be induced in a stationary conductor if the surrounding magnetic field is in motion. In both situations, electrical induction depends upon movement. Either a conductor must move within a magnetic field, or a magnetic field must move past a stationary conductor. If both elements are motionless, no electric current is induced.

As a magnetic field induces an electric current in a conductor, an electric current likewise creates a magnetic field in the space surrounding the conductor. For example, when current flow is initiated in a wire, a magnetic field expands around the conductor. When current flow eventually stabilizes, the surrounding magnetic field stops expanding and becomes a static magnetic field. If the current is shut off, the magnetic field collapses. The polarity of the magnetic field depends upon the direction of current flow. When current flow reverses in a conductor, the polarity of the surrounding magnetic field reverses.

The interrelationship between magnetic and electric fields, motion and change, is the principle behind an AC transformer in which two conductors are situated proximal to each other but are not in physical contact. As current begins to flow through a conductor, the surrounding magnetic field expands. If the expanding magnetic field lines move past the second conductor it induces an electric current within it. Reversing the direction of current flow in the first conductor reverses the polarity of the magnetic field, which, in turn, reverses the flow direction in the second conductor. AC current can effectively be transferred from one conductor to another through open space by means of the alternating magnetic field.

The relevance of electrical induction to CSEM is that all animals are electrical conductors. Biological organisms continually generate internal voltage gradients and electrical currents as part of normal functions, sensory and motor mechanisms, reproductive processes, and membrane integrity. EMFs of sufficient strength have the ability to induce micro-currents within an organism and possibly disrupt these normal electrical functions. Induction of micro-currents could be associated with either the electrical or magnetic component of the CSEM wave.

5.1.3 Potential Health Effects of Non-Ionizing Energy

There is a large volume of literature (more than 25,000 publications over the last thirty years—WHO 2005) concerning the potential biological effects of non-ionizing radiation. Focus has been on human health issues such as reproduction, fetal development, cataracts, cancer, headaches, and many others. Most current researchers conclude that exposure to low frequency, low intensity electrical or magnetic fields has minimal health risk although they do not rule out future discoveries of risk from chronic long term exposure. Furthermore, human health guidelines cited in WHO (2005) list limits for the general public of 100 μT (500 μT for workers) at 50 Hz (83 μT at 60 HZ) for magnetic fields and 5,000 V/m for electrical fields. These levels are well above what would be generated by CSEM. Thus, it is reasonable to predict that low frequency CSEM covering a small area over a short period of time will have no discernible health effects on marine biota (including fish eggs) of the Orphan Basin and thus direct health effects are not considered further in this EA. Potential concerns do exist in regard to animals that may use geomagnetism to assist navigation or electro-reception to assist in finding food. These aspects are discussed in the following sections.

5.1.4 Geomagnetism

5.1.4.1 Earth's Magnetic Field

The earth's magnetic field is created by the rotation of the planet's fluid iron core. It is a dipole field with a magnetic north-south pole which is 11 degrees off the earth's rotational axis. Two principal features of the Earth's geomagnetic field are inclination and intensity. At any point on the Earth, magnetic field lines intersect the planet's surface at a specific angle (inclination) relative to the horizontal, ranging from 0° (parallel to the Earth) at the geomagnetic equator, to 90° at the geomagnetic poles (see Figure 5.3). Because the geomagnetic field is roughly symmetrical around the Earth's surface, lines of equal inclination exist as equivalent rough lines of latitude around the geomagnetic axis. The intensity of the geomagnetic field also varies (Figure 5.4). It is highest near the magnetic poles at 60,000 nT, is about 40,000-50,000 nT at mid latitudes, and decreases to about 30,000 nT at the geomagnetic equator (see Kirschvink et al. 1986; Wiltschko and Wiltschko 1995a, and others). There are also variations in intensity due to local magnetic deviations, distortions and anomalies that vary irregularly over the earth's surface. Regional gradients are small (intensity changes of about 3.4 nT/km in North America) whereas local anomalies can be quite large (e.g., 19,000 nT above the background field 445 km SSW of Moscow (see Kirschvink et al. 1986; Wiltschko and Wiltschko 1995a).

Magnetic fields in the ocean are more variable than on land due to movement of the earth's tectonic plates, and magnetic highs and lows have been developed parallel to the axes of mid oceanic ridges, most of which run north-south. Thus, it is possible to discriminate broad scale patterns in inclination and total field intensity that vary with latitude and fields associated with ocean tectonics provide some longitudinal gradation (see Kirschvink et al. 1986; Wiltschko and Wiltschko 1995a).

The earth's magnetic field is also subject to short- and long-term variations and disturbances. Solar radiation impinging on the earth's surface can cause daily fluctuations in field intensity of up to 100 nT and shifts in inclination of up to 0.33°. These daily perturbations vary with latitude and season. Solar storms also cause slight shifts in field intensity and inclination. The geomagnetic field also undergoes long-term drift with field intensity varying about 0.05% per year with period of several thousand years. There is westward drift in the field of about 0.2° longitude per year (Kirschvink et al. 1986; Wiltschko and Wiltschko 1995a).

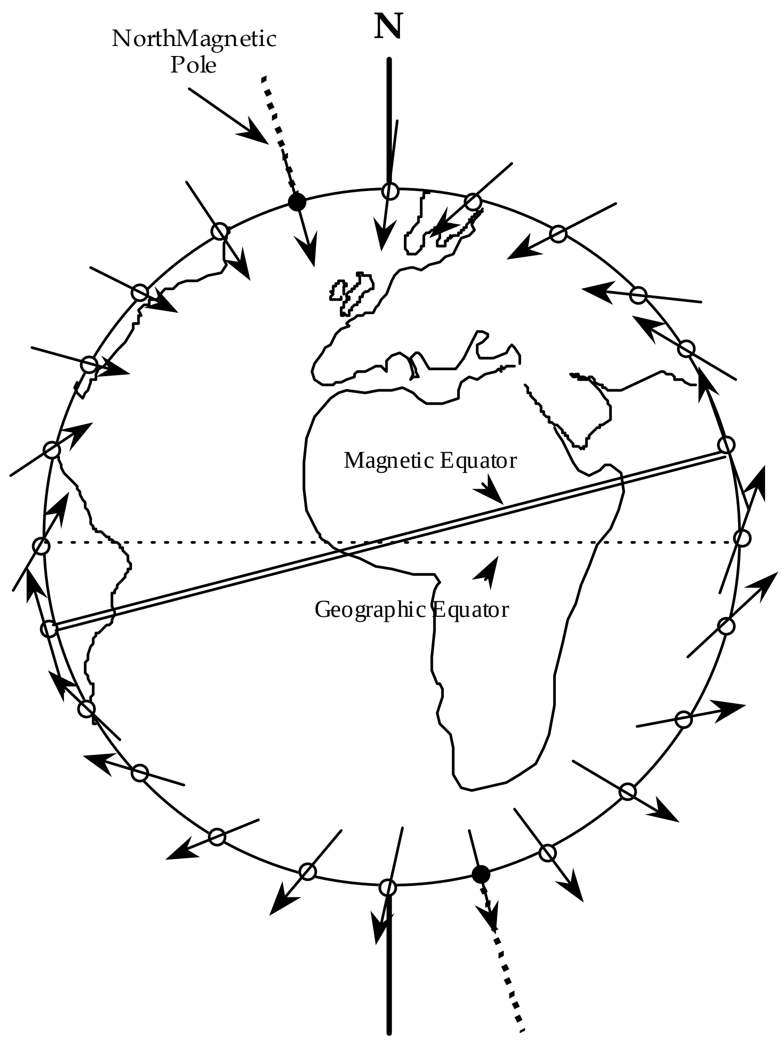
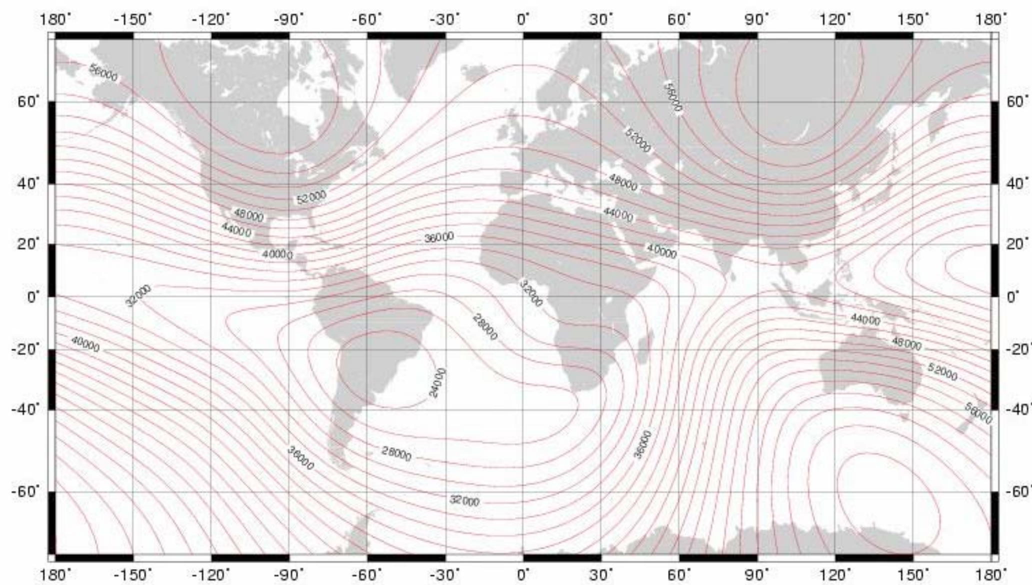


Figure 5.3. The Earth's Geomagnetic Field.
Source: Wiltschko and Wiltschko (1995a).



Total intensity (*F*) at 2005.0 from the World Magnetic Model (WMM2005). Contour interval is 2005 nT and projection is Mercator. This is an example of an isodynamic chart. Credit: British Geological Survey (Natural Environment Research Council).

Figure 5.4. Global Geomagnetic Field Lines (total intensity) in nT.
Source: US Dept. of Defense World Magnetic Charts.

5.1.5 Geomagnetic Orientation

It was theorized as early as 1859 that animals may use magnetic fields for orientation (von Middendorf 1859) and in 1882 it was proposed that homing pigeons use field intensities and inclinations to navigate (Viguier 1882). Since then the use of magnetic information has been shown in a wide range of species from protozoa to marine mammals, representing about 36 orders, 15 classes, among six phyla (Wiltschko and Wiltschko 1995a).

There appear to be three potential mechanisms for magnetoreception by animals: (1) magnetized particles, (2) photopigments, and (3) electrical induction (Wiltschko and Wiltschko 1995a; Ritz et al. 2000; Walker et al. 2003).

5.1.5.1 Magnetic Particles

Marine magnetotactic bacteria have been shown to orient to and move in a north-south direction (Blackmore 1975). Magnetized magnetite crystals have been found in some species of insects, chitons, crustaceans, amphibians, reptiles, fish, birds and mammals, including humans; many have the ability to precipitate ferromagnetic magnetite (Kirschvink and Gould 1981; Frankel et al. 1979; Walcott et al. 1979; Kirschvink et al. 1985, 1992; Mann et al. 1988). It is unknown how the presence of magnetite may influence the behaviour of large animals but the mechanism presumably would have to act at the neural cell level.

Species that have been found to contain magnetic material are shown in Table 5.1. Species listed that are may occur in Orphan Basin include European eel, wolffish, Atlantic herring, eelpout, Atlantic mackerel, Atlantic salmon, and humpback whale.

Table 5.1. Selected Animal Species with Magnetic Material Found in their Bones or Tissues. Modified from Wiltschko and Wiltschko (1995a).

Species	Reference
Arthropoda, Insecta	
Honeybee, *Apis mellifera*	Gould et al. (1978)
Monarch butterfly, *Danaus plexippus*	Jones and MacFadden (1982)
Ant, *Pachycondyla marginata*	Acosta-Avalos (1999)
Fire ant, *Solenopsis* sp.	Esquivel et al. (1999)
Termites, *Nasutitermes* spp.	Maher (1998)
Mollusca, Polyplacophora	
Chiton, *Cryptochiton stelleri*	Lowenstam (1962); Towe et al. (1963)
Arthropoda, Crustacea	
Barnacle, *Balanus eburneus*	Buskirk and O'Brien (1985)
Brown Shrimp, *Penaeus aztecus*	Buskirk and O'Brien (1985)
Atlantic spiny lobster, *Palinurus argus*	Lohmann (1984)
Vertebrata, Amphibia	
Red-spotted newt, *Notophthalmus viridescens*	Brassart et al. (1999)
Vertebrata, Reptilia	
Green sea turtle, *Chelonia mydas*	Perry et al. (1985)
Vertebrata, Chondrichtyes	
Guitarfish, *Rhinobatos rhinobatos*	O'Leary et al. (1981)
Vertebrata, Osteichtyes	
Yellowfin tuna, *Thunnus albacares*	Walker et al. (1984)
European eel, *Anguilla anguilla*	Hanson et al. (1984a,b)
Elephant nose, *Gnathonemus petersii*	Hanson and Westerberg (1987)
Wolfish, *Anarhichas lupus*	Hanson and Westerberg (1987)
Atlantic herring, *Clupea harengus*	Hanson and Westerberg (1987)
Carp, *Cyprinus carpio*	Hanson and Westerberg (1987)
Eelpout, *Zoarces viviparus*	Hanson and Westerberg (1987)
Atlantic mackerel, *Scomber scombrus*	Hanson and Westerberg (1987)
Perch, *Perca fluviatilis*	Hanson and Westerberg (1987)
Chinook salmon, *Oncorhynchus tschawytscha*	Kirschvink et al. (1985)
Sockeye salmon, *O. nerka*	Mann et al. (1988); Walker et al. (1988)
Atlantic salmon, *Salmo salar*	Moore et al. (1990)
Vertebrata, Aves	
Pigeon, *Columba livia*	Walcott et al. (1979); Hanzlik et al. (2000)
Sparrow, *Zonotrichia leucophrys*	Presti and Pettigrew (1980)
Bobolink, *Dolichonyx oryzivorus*	Beason and Nichols (1984)
Bob-white, *Colinus virginianus*	Edwards et al. (1992)
Swift, *Chaetura pelagica*	Edwards et al. (1992)
Starling, *Sturnus vulgaris*	Edwards et al. (1992)
Vertebrata, Mammalia	
Bat, *Eptesicus fuscus*	Buchler and Wasilewski (1985)
Wood mouse, *Apodemus silvaticus*	Mather and Baker (1981)
Human, *Homo sapiens* (Primates)	Baker et al. (1983); Kirschvink et al. (1992)
Pacific dolphin, *Delphinus delphis*	Zoeger et al. (1981)
Humpback whale, *Megaptera novaeangliae*	Bauer et al. (1985)
Gerbils, *Meriones* spp.	Komerovsky (1993)

5.1.5.2 Photopigments

It has been hypothesized that electrons from visual pigments excited by light interact with the geomagnetic field to produce a signal detected by the animal's visual system (Leask 1977). Several elaborate and complex models have been developed linking visual or photochemical senses with magnetoreception and orientation (Edmonds 1996; review in Ritz et al. 2002). A number of studies support the photoreceptor mechanism in several species of passerine birds (e.g., Wiltschko and Wiltschko 1995b, 1999) and one species of swimming newt (Phillips and Borland 1992a,b,c).

As far as we are aware, this mechanism has not been reported in any species that may occur in Orphan Basin.

5.1.6 Electroreception

Electroreception occurs primarily in fishes. Electroreceptive fishes are not to be confused with electric fishes. [Electric fishes like the electric catfish, electric rays, and the electric eel emit massive fields of electric energy that is used to stun prey and predators; electric fishes are not relevant to this EA.] Electroreceptive fishes refer to animals that can detect weak electric fields for use in prey location, communication, and possibly navigation.

Electroreception is present within the two major subdivisions of fishes: the cartilaginous fishes (Chondrichthyes) which includes sharks, skates, rays, and ratfishes, and the bony fishes (Osteichthyes) which include a number of freshwater species including freshwater catfishes, birchirs, gars, knifefishes, paddlefish, and surgeons (Colling and Whitehead 2004). The principal groups of electroreceptive marine fishes of interest for this report are the Chondrichthyes: sharks, skates, rays, and ratfishes (see review in von der Emde 1998).

There are two types of electroreceptor organs: ampullary receptors, which are termed the ampullae of Lorenzini in elasmobranchs (sharks, skates, and rays), and tuberous electroreceptors. Tuberous electroreceptor organs are found exclusively in South American Gymnotids and African Mormyrids (von der Emde 1998) and, therefore, are not relevant to this EA.

Ampullae of Lorenzini appear to be present in all elasmobranch species. Ampullae are found scattered over the head in sharks, and the head and pectoral fins in skates and rays. In marine species, ampullae consist of clusters of up to 400 tube-like canals each about 1 mm in diameter and up to 20 mm in length. Each canal runs from an opening in the skin down to basal swellings called ampullae. Electroreceptor cells line the walls of the ampullae, and each has a synaptic contact with an electrosensory nerve fiber. The canals are filled with transparent, jelly-like mucopolysaccharides that have an electric resistance similar to surrounding seawater. In contrast, the walls of the canals, the intervening connecting tissue, and the skin of the fish have much higher electrical resistances. The canals act as electrical cables connecting receptor nerve cells deep within the fish with the outside medium. There are also inherent structural components of the ampullae that shunt high frequency fields away from basal receptor cells making them low frequency electroreceptive organs that are most sensitive to frequencies between 1 to 8 Hz (von der Emde 1998; Bleckman and Hofmann 1999; Bodznick et al. 2003).

Internal-external voltage gradients drive the electroreceptor system. When the outside medium becomes electrically negative relative to the inside, the potential is conducted through the canal to the receptor cell where it depolarizes the cell membrane. This depolarization leads to an increase in the electrical impulse frequency within the connecting nerve fiber. Conversely, when the external medium becomes electrically positive relative to the inside, the potential is conducted down the canals to the receptor cell where it hyperpolarizes the cell membrane. This causes a decrease in nerve impulse activity. The sensitivity of the ampullary receptor cells results from the constant interplay between negative and positive electrical potentials that are continually transmitted along the canals. The amplitude and frequency of the encoded stimuli are transmitted to the brain via nerve connections to the receptor cell. The clustering of ampullae and canals within the ampullae over the surface of the body result in unequal simulation relative to weak electric fields proximal to the fish. This unequal stimulation enables elasmobranchs to determine the intensity, spatial configuration and direction of the low-frequency electrical source (von der Emde 1998; Tricus 2001).

It is well documented that ampullae of Lorenzini in marine fish are capable of detecting weak electric currents in seawater (Murray 1960, 1962; Kalmijn 1966, 1971). Kalmijn (1966) showed that swimming sharks and rays exhibited avoidance responses when subjected to voltage gradients of 1-10 µV/cm. Sedate sharks and rays visibly responded to a square wave field of 5 Hz with a voltage gradient of 0.1 µV/cm. Changes in the heart rate of a ray were detected down to a voltage gradient of 0.01 µV/cm. The dogfish (*Mustelus canis*) showed behavioral responses to gradients as low as 5 nV/cm (Kalmijn 1982).

In a series of major laboratory experiments, Kalmijn (1971) demonstrated conclusively that sharks and rays can use their electrosensory organs to detect prey. Small, live flounder were placed in the bottom of a laboratory pool and allowed to burrow in the sand. Bottom cruising sharks (*Scyliorhinus canicula*) and rays (*Raja clavata*) elicited sharp and sudden attack behavior when they came within 15 cm of the flounder even though the prey was completely hidden. Flounder were then buried in the sand and covered with an agar cover designed to let the electric field pass unimpeded while attenuating other stimuli (e.g., mechanical, olfactory). When sharks and rays roamed within 15 cm of the buried flatfish they again exhibited sharp attack responses, sometimes trying to dig up the prey. When the experiment was repeated with the agar chamber covered with plastic, thereby blocking any electrical fields, the sharks and rays did not detect the flatfish at any distance. Finally, Kalmijn (1971) buried electrodes in the sand that gave off electrical fields similar to those propagated by the flatfish. The sharks and rays again attacked the hidden electrodes when they came within range.

In nighttime experiments conducted at sea, dogfish (*M. canis*) executed feeding responses to dipole DC electric fields designed to mimic those given off by prey (Kalmijn 1982). Underwater lights located at depths of 2.5 to 3.5 m provided dim lighting. Of the 136 attack responses exhibited by small (30-40 cm) dogfish, 49 were initiated from distances of 15 cm or more, sensing voltage gradients ≤0.033 µV/cm. In 16 of those responses, they struck from 18 cm or more, detecting gradients as low as ≤2.6 nV/cm. Large dogfish initiated 44 of 112 attacks from 30 cm or more exhibiting sensitivity down to ≤1.9 nV/cm. In open-water (40 m depth) studies of the blue shark (*Prionace glauca*), the sharks repeatedly struck at DC dipole electric fields similar in strength to those used in the dogfish trials. Because the experiments were conducted at night under limited underwater lighting, the distances from which the sharks attacked could not be determined. In the same report, Kalmijn (1982) demonstrated that, under laboratory conditions, the stingray *Urolophus halleri* was able to respond and orient relative to uniform DC electric fields at voltage gradients of only 5 nV/cm.

Despite the sensitivity of ampullae of Lorenzini, the electro-detection capability of elasmobranchs is quite limited in effective range. Kalmijn's (1971), live flounder were not detected by either sharks or rays beyond a distance of about 15 cm. Dogfish detection of electric fields (Kalmijn 1982) decreased rapidly with distance out to maximum ranges of 30 to 50 cm depending upon the size of the shark. The dogfish had to be enticed toward the electric dipoles by liquefied herring. In general, elasmobranchs need to be within one metre of their prey to detect it (Montgomery and Penkhurst 1997). The limited range of electro-detection is largely due to the fact that bioelectric fields that animals produce in seawater are stray fields and voltage gradients rapidly fall off with distance (Kalmijn 1971).

There is preliminary evidence that electric organs are used for communication in several species of skate (Bratton and Ayers 1987) and electric organs appear to be universal within all 234 species of skates (Rajidae) (Jacob et al. 1994). Also, electrocyte morphology and size of electric organ varies among genera of skates and both may be species specific (Jacob et al. 1994). Discharge also varies among different species and probably among different genera (Brock et al. 1953; Bratton and Ayers 1987). There are also isolated reports of electroreceptive capabilities in Chimaera (Fields et al. 1993). Chimaera, also known as ratfish, are a primitive group of cartilaginous, bottom-dwelling fishes that inhabit the outer continental shelf and slope worldwide in tropical to temperate seas (McEachran and Fechhelm 1998).

Electrosensitivity may also be a function of the depth at which the animals live. In a study of skate species that live at depths ranging from 63 to 2,058 m, Raschi (1986) (*in* Collins and Whitehead 2004) found that the number and size of ampullae increased significantly with depth. Results suggest that species inhabiting deep regions of the ocean, where sunlight does not penetrate, possess higher numbers of receptor cells and may rely more heavily on electroreception that shallower species (Raschi and Adams 1988 *in* Collins and Whitehead 2004).

A variety of sharks, rays, skates, and ratfishes may occur in the Orphan Basin including:

- Great white shark (*Carcharodon carcharias*)
- Black dogfish (*Centroscyllium fabricii*)
- Portuguese dogfish (*Centroscymnus coelolepis*)
- Basking shark (*Cetorhinus maximus*)
- Porbeagle shark (*Lamna nasus*)
- Blue shark (*Prionace glauca*)
- Greenland shark (*Somniosus microcephalus*)
- Piked dogfish (*Squalus acanthias*)
- Arctic skate (*Amblyraja hyperborea*)
- Thorny skate (*Amblyraja radiata*)
- Spinetail ray (*Bathyraja spinicauda*)
- Barndoor skate (*Dipturus laevis*)

- Sailray (*Dipterus linteus*)
- Winter skate (*Leucoraja ocellata*)
- Smooth skate (*Malacoraja senta*)
- Bigelow's ray (*Rajella bigelowi*)
- Round ray (*Rajella fyllae*)
- Smalleyed rabbitfish (*Hydrolagus affinis*) [Chimaeridae]

Electromagnetic-studied species that potentially occur in Study Area

- Atlantic or striped wolffish (*Anarichas lupus*)
- Atlantic herring (*Clupea harengus*)
- Atlantic mackerel (*Scomber scombrus*)
- Atlantic salmon (*Salmo salar*)
- Blue shark (*Prionace glauca*)
- Dogfish (*Squalus* sp.)
- Leopard shark (*Galeocerdo cuvier*) [possible but improbable]
- Hammerhead shark (*Sphyrna* sp.) [possible but improbable]

5.1.7 Navigation

In order to use geomagnetism to navigate, an animal must have the ability to detect some parameter (e.g., total field intensity, polarity, inclination angle) of the earth's magnetic field. Studies have demonstrated an inclination compass and a polarity compass (birds--e.g., Wiltschko and Wiltschko 1995a) and intensity detection in some animals (sea turtles--e.g., Lohmann and Lohmann 1996b). The inclination compass detects and interprets the inclination angle of the earth's magnetic field to determine "toward the pole" versus "toward the equator" and the polarity compass distinguishes between north and south by the polarity vector. Juvenile loggerhead sea turtles can distinguish changes in field intensity (e.g., Lohmann and Lohmann 1996b).

Two navigational models are currently being investigated: (1) bi-coordinate geomagnetic navigation system, and (2) topotaxis. In the bi-coordinate system, the animal would have to detect at least two distinct parameters of the earth's geomagnetic field; these parameters would have to vary relative to each other across the earth's surface to allow a grid to be formed. This is the main hypothesis in long distance sea turtle navigation. In the topotaxis system, the animal would have to have the ability to navigate the highs and lows of the local geomagnetic landscape; it has been theorized that some cetaceans and sharks may use this system.

Species that have been shown to use magnetic compass orientation are listed in Table 5.2. None of the species listed are known to occur in Orphan Basin although related species may.

Table 5.2. Animal Species that have been Shown to use Either an Inclination, Polarity, or Field Intensity Magnetic Compass. Modified from Wiltschko and Wiltschko (1995a).

Species	Reference
Mollusca, Gastropoda	
Nudibranch, *Tritonia diomedea*	Lohmann and Willows (1987)
Arthropoda, Crustacea	
Atlantic spiny lobster, *Palinurus argus*	Lohmann (1985), Lohmann et al. 1995)
Beachopper, *Talitrus saltator*	Arendse (1978)
Sandhopper, *Talorchestia martensii*	Pardi et al. (1985)
Riparian talitrid, *Orchestra cavimana*	Arendse and Barendregt (1981)
Isopod, *Idotea baltica*	Ugolini and Pezzani (1992)
Arthropoda, Insecta	
Compass termite, *Amitermes meridionalis*	Jacklyn (1992)
Harvester termite, *Trinervitermes geminatus*	Rickli and Leuthold (1988)
Honeybee, *Apis mellifera*	DeJong (1982), Schmidt and Esch (1993)
Flour beetle, *Tenebrio molitor*	Arendse and Vrins (1975)
Fruitfly, *Drosophila melanogaster*	Phillips and Sayeed (1993)
Moth, *Noctua pronuba*	Baker and Mather (1982)
Moth, *Agrotis exclamationis*	Baker (1987)
Vertebrata, Osteichtyes	
Sockeye salmon *Oncorhynchus nerka*	Quinn (1980), Brannon et al. (1981) Quinn and Brannon (1982)
Sockeye salmon, *O. keta*	Quinn and Groot (1983)
Chinook salmon, *O, tshawytscha*	Taylor (1986)
Rainbow trout, *O. mykiss*	Chew and Brown (1989)
Yellowfin tuna, *Thunnus albacares*	Walker (1984)
Vertebrata, Amphibia	
Red-spotted newt, *Notophthalmus viridescens*	Phillips (1986)
Vertebrata, Reptilia	
Loggerhead sea turtle, *Caretta caretta* (hatchlings, juveniles)	Lohmann 1991; Light et al. (1993); Lohmann and Lohmann (1994a, 1994b, 1996b); Goff et al. (1995)
Leatherback sea turtle, *Dermochelys coriacea* (hatchlings)	Lohmann and Lohmann (1993)
Vertebrata, Aves	
European robin, *Erithacus rubecula*	Wiltschko and Merkel (1966)
Wheatear, *Oenanthe oenanthe*	Sandberg et al. (1991)
Pied flycatcher, *Ficedula hypoleuca*	Beck and Wiltschko (1981)
Common whitethroat, *Sylvia borin*	Wiltschko and Merkel (1971)
Garden warbler, *S. borina*	Wiltschko (1974)
Blackcap, *S. atricapilla*	Viehmann (1979)
Goldcrested kinglet, *Regulus regulus*	Weindler (1994)
Donnock, *Prunella modularis*	Bingman and Wiltschko (1988)
Silvereye, *Zosterops lateralis*	Wiltschko et al. (1993)
Yellow-faced honeyeater, *Lichenostomus chrysops*	Munro and Wiltschko (1993)
Scarlet grossbeak, *Carpodactus erythrinus*	Shumakov and Vinogradova (1992)
Indigo bunting, *Passerina cyanea*	Emlen et al. (1976)
Savannah sparrow, *Passerculus snadwichenis*	Bingman (1981)
Bobolink *Dolichonyx oryzivorus*	Beason and Nichols (1984)
Pigeon, *Columbia livia*	Walcott and Green (1974)
Vertebrata, Mammalia	
African mole rat, *Cryptomys* sp.	Marhold et al. (1991)

5.1.7.1 Magnetic Orientation in Marine Animals

5.1.7.1.1 Marine Invertebrates

The western Atlantic spiny lobster (*Panulirus argus*) has been the subject of several magnetic orientation studies. The spiny lobster undertakes mass migrations in which thousands of lobsters walk across the seafloor in head-to-tail procession. In behavioural studies, Lohmann (1985) conditioned lobsters to exit a test tank with six tunnel directions via the north tunnel (0°) in response to food rewards. When deprived of food rewards and the tank rotated, lobsters entered tunnels aligned with the north-south axis (0-180°) significantly more often than other tunnels but were unable to distinguish north from south along the axis. When lobsters were tested in an altered magnetic field in which magnetic north was rotated 60° counterclockwise, the lobsters shifted to the new north-south magnetic axis.

Lohmann et al. (1995) tested the spiny lobster's ability to discriminate geomagnetic direction in open-ocean field studies off Key Largo, Florida. Lobsters were tested in underwater arenas consisting of 1.5-m squares of transparent acrylic. Lobsters first had their eyestalks covered to deprive them of sight. Individuals were tethered to the center of the underwater test arena where divers monitored the direction in which they walked. Once a lobster had established a course of direction it was exposed to one of three conditions (1) a reversal in the horizontal component (polarity) of the Earth's field, (2) a reversal in the vertical component (inclination) of the Earth's field; or (3) no change in the ambient Earth field (controls).

Although different lobsters initially walked in different directions, neither controls nor lobsters subjected to the reversed vertical field exhibited any significant deviation in the heading over the following five minutes of observation. In contrast, individuals subjected to a reversed horizontal field began changing their direction of movement within two minutes and by five minutes had reversed their direction (mean angle of 183°) of movement. The altered direction was statistically significant. Because inverting the vertical component of the Earth's field had no effect on orientation, the authors concluded that lobsters orient to the polarity of the Earth's field (polarity compass) and not its inclination (inclination compass).

Boyles and Lohmann (2003) captured juvenile lobsters in Florida Bay, placed them in covered containers and then transported them by boat for 45-60 minutes along circuitous routes to one of two test sites. The following morning, the eyestalks of the lobsters were covered with rubber caps to deprive them of visual cues. The animals were then tethered to a tracking system in the center of a circular water-filled tank. In each test, lobsters walked in a general direction toward their capture site. Lobsters captured 12 km NNE of their test site significantly oriented with a mean angle of 38° (capture site was 36°). Lobsters captured 14 km WSW of their test site significantly oriented with a mean angle of 222° (capture site was 250°). An additional group of lobsters captured at the WSW site were tested at a different laboratory facility. Those animals significantly oriented with a mean angle of 105°, which was in the direction of their capture site. In another set of experiments, lobsters were transported by boat to a test site SSW of their capture site and then tested under two different magnetic fields. One field exists at a location ~400 km north of the test site, the other ~400 km to the south. Lobsters significantly oriented with a mean angle of 199° in the northern field and significantly oriented with a mean angle of 1° in the southern field. Results suggest that the lobsters were orienting toward their point of origin using geomagnetic cues.

The only other marine invertebrate that has been investigated is the marine nudibranch (mollusc) (*Tritonia diomedea*). Lohmann and Willows (1987) observed the body angle alignment of *Tritonia* under two geomagnetic fields: the Earth's normal field, and a field in which the horizontal component of the Earth's field was neutralized. In the Earth's field, the orientation of the animals was significant along a mean angle of 87.6° (approximately east). Animals tested in the canceled field oriented randomly. Results suggested that eastward orientation was mediated by magnetic field detection. Preferred magnetic direction also shifted with the day of the lunar month. Lohmann et al. (1991) then measured intracellular electrical activity in the brain neurons of living *Tritonia* in response to changes in ambient Earth-strength magnetic fields. Of the 50 different neurons that were selected for long-term response, only two (LPe5 and RPe5) showed altered electrical activity in response to magnetic stimuli. The response was abolished when the brain was isolated from the periphery of the animal by severing nerves. The authors hypothesized that LPe5 is one component of a neural circuit mediating detection of the Earth's magnetic field or orientation to it. In a follow-up set of experiments, Wang et al. (2003) measured neural activity while subjecting *Tritonia* to regular geomagnetic reversals. Electrophysiological activity (electrical spiking or action potentials) increased significantly in animals during periods of magnetic reversal compared to baseline periods in which the field remained unaltered.

Lobster do not occur in deep Orphan Basin but other decapod crustaceans (including shrimp) undoubtedly do occur there. Nudibranchs would also occur there but, to our knowledge, they have not been documented there.

5.1.7.1.2 Fishes

Most research on fish migration has focused on salmon and eels as both groups travel great distances at sea.

Salmonids

Most species of salmon travel long distances from their natal streams to oceanic feeding grounds. Biological magnetite has been found in Pacific (chinook, sockeye, chum) and Atlantic salmon (Table 5.1). Of the salmonids, only adult Atlantic salmon (*Salmo salar*) may occur in Orphan Basin as a migrant. Interestingly, brown trout (*Salmo trutta*) have magnetically sensitive nerves in the ophthalmic branch of the trieminal nerve that connects to specialized cells containing magnetite (Walker 1997).

Various studies (mostly with fry) have reported some ability of Pacific salmon to orient magnetically but magnetic information can be over-ridden by other clues such as light, currents and olfactory ones (Quinn 1980; Brannon et al. 1981; Quinn et al. 1981; Quinn and Brannon 1982; Quinn and Groot 1983; Taylor 1987).

Chum salmon, some with a generator attached to their heads that produced an alternating field intensity of about 600,000 nT, were tracked at sea with no observable affect on their movements (Yano et al. 1997). The generator attached to the head may not have been capable of total geomagnetic disruption as it has been shown that at least chinook (Kirschvink et al. 1985), sockeye (Walker et al. 1988) and Atlantic salmon (Moore et al. 1990) may have magnetic sensors in their lateral lines. However, a recent review by Doving and Stabell (2003) is skeptical that fish are able to form and "memorize" a geomagnetic map of the earth's field that is "noisy" with short term and long term variability, geological anomalies, and magnetic storms (±200 nT).

Eels

Magnetite and hematite deposition has been reported in eel skulls, vertebral columns, and pelvic girdles of the European eel by Hanson et al. (1984a,b). Early studies with European eel elvers reported directional preferences that disappeared when the magnetic field was neutralized (Branover 1970; Ovchinnikov et al. 1973). Subsequent studies on America eels have failed to show any particular sensitivity to magnetic fields or any magnetic compass abilities. However, magnetosensitivity has been shown in the "glass eel" stage (transparent, 5-6 cm long juveniles) of *Anguilla japonica*, a related species in the Pacific with a similar migratory lifestyle (Nishi and Kawamura 2005).

The migratory patterns of American eel (*Anguilla rostrata*) are not well known but the species may occur in Orphan Basin as a migrant.

Cartilaginous Fishes (Elasmobranchs and Chimaera)

It has been theorized that the electroreceptive system of elasmobranchs allows them to sense voltage gradients generated by currents flowing through the earth's magnetic field ("passive" model) or by the animal sensing the voltage gradients produced within its body when swimming through the magnetic field ("active" model). Theoretically, the elasmobranch electrosensory system could provide it with a 360° navigational ability (Paulin 1995; Kalmijn 2000, 2003; Montgomery and Walker 2001).

Some species have been shown to detect magnetic fields in captivity and to use that information to get a food reward (e.g., leopard shark and stingray—Kamijin 1978; sandbar and hammerhead shark—Meyer et al. 2004).

A major acoustic telemetry study tracked 22 blue sharks over the shelf and slope between George's Bank and Cape Hatteras (Carey and Scharold 1990). They noted that the sharks maintained constant headings in deep water day and night thus ruling out celestial clues. The authors also ruled out chemical clues due to the complex mixing of different water masses which should have resulted in searching patterns. The sharks' tracks were not altered by geomagnetic anomalies which ruled out topotaxis. Thus, Carey and Scharold concluded that the sharks were navigating using a polarity or inclination compass. In contrast, Klimley (1993) suggested evidence of topotaxis in hammerhead sharks in the Gulf of California.

While the electroreceptive sensitivity of sharks, skates, and rays is well established, and a few studies have shown that these fishes can detect the Earth's geomagnetic field, there is little empirical evidence that elasmobranchs use geotaxis to navigate. Most of the theory to date is speculation.

Elasmobranchs that have been recorded in DFO RV data (2002-2004) for Orphan Basin include:

- Thorny skate (*Amblyraja radiata*) – 162 individuals
- Black dogfish (*Centroscyllium fabricii*) – 33 individuals
- Jensen's skate (*Raja jenseni*) – 23 individuals
- Spinytail skate (*Raja batda*) – 22 individuals
- White skate (*Raja lintea*) – 12 individuals
- Deepsea catshark (*Apristurus profundorum*) – 14 individuals
- Catsharks (unspecified) – 8 individuals
- Skates (unspecified) – 8 individuals
- Greenland shark (*Somniosus microcephalus*) – 2 individuals
- Smooth skate (*Malacoraja senta*) – 2 individuals
- Dogfish shark (*Squalidae*) – 1 individual
- Arctic skate (*Amblyraja hyperborea*) – 1 individual
- Winter skate (*Leucoraja ocellata*) – 1 individual
- Round skate (*Raja fyllae*) – 1 individual

Deep water chimaera, smalleyed rabbitfish (Class: Holocephali, *Hydrolagus affinis,* 3 individuals) have also been recorded in the 2002-4 RV survey data.

5.1.7.1.3 Sea Turtles

There is a large body of research concerning sea turtles and geomagnetic orientation and migration. Most of this deals with hatchlings and there is little evidence to support the hypothesis that adult sea turtles use geomagnetism to navigate long distances.

Of the eight species of sea turtles found worldwide only the leatherback (*Dermochelys coriacea*) may occur in Orphan Basin. As the leatherback breeds in southern waters, juveniles probably do not occur in Orphan Basin. Leatherbacks were not observed during the offshore seabird and marine mammal surveys conducted during the Orphan Basin 3D Seismic Program during 2004-5 (Moulton et al. 2005, 2006) but they have been reported as far north as Labrador.

There is strong evidence that sea turtle hatchings (at least loggerhead and leatherback sea turtles) (Lohmann and Lohmann 1994a,b, 1996a,b) and loggerhead juveniles (Avins and Lohmann 2003) use geomagnetic clues to assist navigation. Experiments support the hypothesis that young turtles can respond to three parameters of the earth's magnetic field: angle, polarity and intensity thus enabling them to use a bi-coordinate system. Such a system might act alone or with other clues such as light, temperature, current, or chemical gradients (Lohmann and Lohmann 1994b; Avins and Lohmann 2003, 2004).

In contrast, there is little scientific evidence that adult sea turtles use geomagnetic navigation. Adult loggerheads and green turtles are known to travel large trans-oceanic distances. For example, loggerheads have been known to traverse the Pacific and green turtles regularly travel 4,000 km round trip between their feeding grounds off Brazil to breeding grounds on the Ascension Islands in the South Atlantic. There is satellite tagging evidence of relatively straight-line travel with these species (Papi et al. 1995; Nichols et al. 2000) but their navigation mechanism is unknown. Celestial navigation appears unlikely because their in-air eyesight is poor. Papi et al. (2000) attached six powerful magnets to adult female green turtles and saw no difference between magnetically disturbed turtles and those without magnets. Green turtles have been observed via satellite tagging to exhibit behaviour characteristic of a search pattern for chemical clues (Luschi et al. 2001; Akesson et al. 2003).

It is unlikely (but possible) that sea turtles will be encountered in the Orphan Basin Study Area.

5.1.7.1.4 Cetaceans (Whales and Dolphins)

Magnetized material has been found in Pacific dolphin (Zoegler et al. (1981) and humpback whale (Fuller et al. 1985). It has been theorized based on a major study of strandings data in the UK that cetaceans use geomagnetic information for orientation. Klinowska (1985) concluded that live strandings around the UK involved oceanic species that stranded in areas where geomagnetic contour lines ran perpendicular to shore. This theory was further supported by the data that showed live strandings generally occurred 1-2 days after major geomagnetic storms (Klinowska 1986). Cornwell-Husten (1986, Kirschvink et al. (1986), Kirschvink (1990), and Walker et al. (1992) found similar and/or supporting results for some US strandings data.

A live mass stranding of 19 white-sided dolphin in County Mayo, Ireland found results consistent with the previous major UK study but the authors (Rogan et al. 1997) could not rule out other potential factors such as the presence of a sick male animal (the largest animal in the group) and a gradually sloping beach. A study of strandings data (1957-1998) in Hawaii associated mass strandings with fringing reefs, shallow water, sandy bottoms and gradual sloping beaches with speculation (but no conclusive evidence) on some involvement of geomagnetic factors (Mazzuca et al. 1999).

In contrast there are some studies that show no evidence of the use of cetacean use of geomagnetics to orient or navigate. Brabyn and Frew (1994) examined whale strandings in New Zealand dating back to 1940 following the analytical methods used by Klinowska (1985) and Kirschvink et al. (1986). The New Zealand cetacean strandings showed no relationship to regions where geomagnetic contours were perpendicular to the coastline nor to geomagnetic maxima or minima. The authors note that one explanation for the difference in their results and those of Klinowska (1985) and Kirschvink et al. (1986) is that much of New Zealand is surrounded by a shallow marine platform characterized by no consistent pattern in geomagnetic anomalies. In contrast, the sea floor off the east coast of the US and the UK is characterized by strong magnetic lineation. In effect, New Zealand does not have a geomagnetic field of sufficient pattern or intensity to support a cetacean navigation system.

Hui (1994) analyzed data from 140 sightings of free-ranging common dolphin in the Southern California Bight to determine if there were associations with topography and geomagnetic features. Using total geomagnetic intensity maps, the author measured the acute-angle difference between the magnetic heading of the observed dolphins and the line tangent to the nearest magnetic contour line to see if the dolphins travel parallel to (or at a preferred angle with) the magnetic gradient. The author found no associations with magnetic intensity gradients or directional orientation with magnetic patterns but did find an association between dolphin sightings and bottom topography.

The difficulty in studying the possible role of geomagnetic navigation in cetaceans is that the large size of the animals makes them almost impossible to control for behavioural studies. Bauer et al. (1985) attempted to condition bottlenose dolphins, a common species used in experiments, to respond to magnetic fields but was unsuccessful.

About 14 cetacean species may occur regularly in Orphan Basin in summer (see Table 4.15).

5.2 Scoping, Consultations and Methodology

5.2.1 Scoping

Scoping was conducted through meetings with regulators in April 2006 (C-NLOPB and DFO) and stakeholders in May 2006 (see section below). Previous EA material for Orphan Basin seismic and drilling programs, ExxonMobil zone of influence modeling results, and a major literature review conducted by LGL on the potential effects of CSEM (Fechhelm et al. 2001) were reviewed.

5.2.2 Consultations

In preparation for the proposed CSEM survey operations in the Orphan Basin area, consultations were undertaken with relevant government agencies, representatives of the fishing industry and other interest groups. The purpose of these consultations was to provide further details about the CSEM technology, describe the planned survey, identify any issues and concerns, and gather additional information relevant to the preparation of the EA report.

A short summary description of the proposed survey and a survey location map, along with a more detailed Power Point presentation on CSEM technology, were sent to all agencies and stakeholder groups. Meetings were subsequently arranged with several groups during which EMC managers, and their consultants, provided additional information on the proposed survey and responded to various questions and comments.

Consultations were undertaken with the following agencies and interest groups:

- Fisheries and Oceans
- Environment Canada
- Natural History Society
- Alder Institute
- One Ocean
- Fish, Food and Allied Workers Union (FFAWU)
- Association of Seafood Producers
- Fishery Products International

Appendix I provides a list of agency and industry officials consulted for this EA report.

5.2.3 Issues and Concerns

During the consultations, most of the questions and comments from various stakeholders were related to the nature and operation of CSEM technology in general. No significant concerns or issues were raised about potential negative effects from the proposed survey on the marine environment, marine resources or on established fishing activities. However there were a variety of questions about existing research data on the known effects of CSEM survey operations, as well as several pertaining to topics such as survey timing and proposed monitoring programs, among others, as discussed below.

Comments and questions noted and discussed during the consultations are summarized below, by agency or group meeting.

DFO, FFAWU and One Ocean. Several DFO managers also attended the meeting with FFAWU and One Ocean representatives. Following the presentation there was a question about specific studies on the potential effects of CSEM operations on fish behaviour. EMC representatives noted that CSEM effects on fish behaviour are predicted based on information about fish behaviour near submarine electrical cable facilities which, in general, generate higher levels of electro-magnetic activity compared to CSEM technology. It has been observed that fish appear to act normally, i.e. no significant change in behaviour, in the vicinity of these transmission facilities.

FFAWU representatives asked if EMC had consulted with various stakeholders in other CSEM survey areas about the potential effects on the marine environment. It was noted that discussions with agencies in other jurisdictions (e.g. in Brazil, Norway and the Gulf of Mexico) had taken place, and that EAs had not been triggered. Regulators had agreed that the effects were, essentially, benign.

In response to an FFAWU question about analysis of DFO RV data, LGL noted that the EA report would include a discussion of data available from DFO's annual trawl surveys. DFO managers asked if the survey planned to conduct acoustic monitoring in order to record sound transmissions from marine mammals. EMC representatives noted there were no plans to undertake acoustic monitoring.

DFO's marine mammal specialist said that the department would like to obtain marine mammal observation data collected by the survey as soon as it became available. He noted that this information would be very useful in planning for a major international whale survey scheduled for the Grand Banks area in 2007. DFO managers also noted that, although some species are capable of diving to depths of 1.5 km, survey activities would likely have no significant effects on sea turtles, or on marine mammals. There was also a question about possible effects on bottom-laid fish eggs.

Environment Canada. Most of the questions from EC managers focused on the technical aspects of CSEM technology, and no significant concerns or issues were raised. EMC representatives noted that the survey would undertake monitoring programs for seabirds and marine mammals, etc., although these observations will be primarily for scientific research purposes (as opposed to mitigative measures per se). LGL mentioned that bird observation monitoring may have to be conducted in accordance with stationary protocols given the slow speed (1.5 knots) at which the survey vessel will be moving.

It was agreed that it would be interesting to examine the data from EMC's monitoring program to see if there are any differences in the data collected during this survey compared to the findings from previous seismic surveys; i.e. the CSEM survey would not generate noise levels associated with seismic operations. A question was asked if there was any information on biological communities associated with potential oil seeps in Orphan Basin. [It was subsequently determined that the seep data are proprietary and while it has been speculated that there are chemosynthetic communities associated with mounds near Orphan Knoll to the east of the Study Area, there is no direct evidence at present.]

Natural History Society (NHS). Most of the discussion at the NHS meeting dealt with various technical questions about CSEM technology. In response to a question about the differences between the effects of CSEM survey equipment, versus those associated with underwater electrical transmission lines, EMC representatives noted that the field strength of the CSEM system is below the levels associated with those facilities.

NHS representatives suggested that any CSEM effects would likely be felt most by any bottom dwelling species, and some concern was expressed about potential behavioural and other effects of the electro-field gradient on deep-water elasmobranchs. NHS said it was possible that some animals might move away from any areas affected by survey operations, and that it might be some time before they moved back to their usual territory: this being more of a concern for sedentary, short-range elasmobranchs. (In a follow-up email comment from an NHS member, it was suggested that special attention be paid to potential effects on any deep-water sharks known to inhabit areas within the survey area. It was further noted that these sharks are particularly sensitive to electrical fields and, in addition, are a globally threatened species (D. Haedrich, pers comm., May 2006).

5.2.4 Assessment Methodology

EA methodology is the same as all previous EAs for Orphan Basin (e.g., Buchanan et al. 2004; LGL 2005, and others) and compatible with all of those conducted on the Grand Banks (e.g., Petro-Canada 1996; Husky 2000, and others). Guidance is contained in CEA Agency documents (CEA Agency 1994, 2000). The effects assessment considers mitigation measures. VECs include:

- Fish and Fisheries
- Marine Birds
- Marine Mammals
- Sea Turtles
- *SARA* Species

5.3 Physical Environment/Effects of the Environment on the Project

The physical environment of the Orphan Basin and the potential effects of that environment on activities such as seismic surveys and drilling were discussed in detail in the previous EAs. In short, the physical environment of the Orphan Basin is not unlike that encountered on the Grand Banks, just to the south, except that water depths are significantly greater and ice and iceberg conditions are not as severe. The conclusions were that conditions during July to September would not normally hamper seismic vessel operations or drilling although concerns about fog were expressed by the regulators. During 2004, additional environmental observations were obtained by the EOs. The data on fog are summarized below.

During the 2004 seismic monitoring program in Orphan Basin, EOs collected environmental data, including systematic records of visibility (i.e., estimated distance an observer could see). During 1,198 h of observations from the seismic ship in 2004, 22.4% were limited by visibility <500 m (Figure 5.5). Poor visibility due to fog was most evident in July when 33.0% of sighting conditions were <500 m.

As in the previous EAs, effects of the environment on the Project are judged *not significant* as wind and sea conditions during July and August (the preferred time for surveys) are typically the most amenable. The CSEM technology can be used in somewhat rougher conditions than seismic because of the robustness of the towed gear and less concern with ocean background noise.

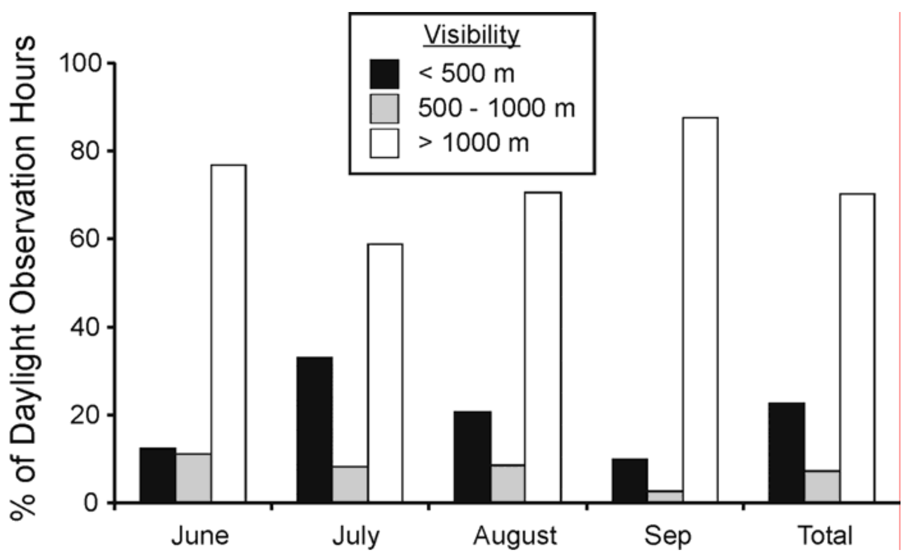


Figure 5.5. Summary of Monthly Visibility Conditions during Marine Mammal Monitoring from the SR/V *Veritas Vantage* on the Orphan Basin in 2004.

5.4 Potential Interactions of the Project with the Environment

Potential interactions of Project Activities with the Biological Environment and the Fisheries are shown in Table 5.3. These interactions are discussed in the following effects prediction sections.

Table 5.3. Potential Interactions between the Project and Environmental Components. The x's denote potential interactions but do not imply any particular level of effect, which could range from no effect to negligible to significant.

Environmental Component	Receiver Deployment	Receiver Retrieval	CSEM Source	Towing Operation	Lights	Small Accidental Spills (e.g., flotation and hydraulic)
Benthos	x	-	x	-	-	-
Invertebrates	x	-	x	-	-	x (plankton)
Bony fish migration (e.g., Atlantic salmon)	-	-	x	-	-	-
Elasmobranch migration	-	-	x	-	-	-
Elasmobranch prey detection	-	-	x	-	-	-
Sea turtle migration	-	-	x	-	x	-
Sea bird stranding	-	-	-	-	x	x (oiling)
Cetaceans	-	x	x	x	-	-
Fisheries (fixed) gear)	-	-	-	x	-	x (oiling)
SARA species	x	x	x	x	-	-

5.5 Modeling of Geomagnetic and Electric Fields Generated by the Source-check

Modeling by the ExxonMobil Upstream Research Company showed that the largest magnetic field is at the source. This is less than 10% of the earth's magnetic field strength and has a polarity reversal of seconds to one minute duration. Intensity drops to background fluctuation levels (100 nT) within about 400 m of the source (given a 500 A source). An exposure time for a stationary point is on the order of 20 minutes for an exposure level of ≥100 nT.

Similarly, modeling of the electric field showed the largest field strength at the source. The maximum mid-dipole strength was 3 µV/cm with a temporal polarity reversal of seconds to one minute. Intensity drops rapidly with distance from source (about 1.0 µV/cm at about 500 m and about 0.1 µV/cm at about 1,000 m (about 1,200 m for a 1,000 A source). Source level exposure times were calculated as 25 minutes at ≥1.0 µV/cm to 45 minutes at ≥0.1 µV/cm.

5.6 Criteria for Effect

In addition to the effects assessment procedures described above, the project-specific criteria on geographic extent, frequency and duration were used for all effects assessment with some minor exceptions as noted in the text (see Table 5.4). These criteria are common to all assessments of all VECs.

Table 5.4. Geographic Extent and Duration of Potential Effects – All VECs.

	Great Barasway	**Chapel Arm**	**Sunnyside**	**Total**
No. Receiver Locations	46	54	39	139
Survey lines (km)	387	555	289	1,231
Instantaneous ZOI (km^2)[1]	N/A	N/A	N/A	50
Total ZOIs (m^2)[2]	1,548	2,220	1,156	4,924
Instantaneous duration (d)[3]	0.04	0.04	0.04	0.04
Total duration (d)	19	18	12	49
Frequency (per yr)[4]	1	1	1	1 (3)
Reversibility[5]	R	R	R	R
Context[5]	P	P	P	P

1 Zone of influence based upon CSEM source at a fixed point with a maximum "effects swath" of 4 km (radius of circle).
2 Zone of influence based upon total surveys lines and a maximum effects swath of 4 km.
3 Instananeous duration is the amount of time a fixed point may receive the CSEM energy with a vessel speed of 2 kts (3.7 km/h) and a maximum effects swath of 4 km.
4 Frequency is the number of events per year (as per *CEAA*) but it can be viewed in different ways depending upon how it is broken down. For example, one could consider the frequency by the number of lines or the number of locations or the number of surveys per year, or presumably even the number of effects per year.
5 Reversibility refers to the ability for recovery (R=reversible). No mortalities, with the exception of potential ship strikes or seabird strandings, no mortalities are likely or anticipated. Mortalities are irreversible (IR) at the individual level but reversible at the population level, at least in most cases.
6 Ecological/Socioeconomic/Economic Context considered simply as "P" for pristine or "NP" for non-pristine, showing signs of human impact.

The other key criterion under *CEAA* is magnitude which is mostly a function of particular species' sensitivities.

5.7 Potential Effects – Benthos/Invertebrates

A small amount of benthic habitat (about 1 m^2 per concrete base) will be altered as the concrete receiver base settles on the bottom. The concrete base will sink in soft substrate (which is probably the most common substrate in the great depths of the Study Area) and eventually be covered completely for no loss of habitat. In the event that the base lands on relatively hard bottom, it will increase hard substrate habitat for sessile organisms upon which fish feed. Thus, on balance the overall effect of the anchors will range from *no effect* to *negligible effect*.

The very low frequency, very short duration energy should have no effect on benthic invertebrate health. Magnetic material has been found in marine bacteria and several marine invertebrate species within the groups molluscs (e.g., nudibranchs and chitons) and crustaceans (e.g., barnacle, shrimp, lobster). In addition to bacteria, marine invertebrates that have been observed to use geomagnetics for orientation include a nudibranch, Atlantic spiny lobster (does not occur in Orphan Basin but related species might), and an isopod.

Some benthic invertebrates may detect the CSEM source and may even react to it. However, the geographic extent of exposure will be small (<50 km^2 worst case total), the maximum duration of potential effect for any one point will be very short (on the order of an hour), and any effects should be quickly reversible. Because the source is AC current, any effect on orientation or navigation will be negligible. Thus, the magnitude of any effects could range from negligible to low, with some uncertainty around the absolute level of effect because of the lack of experimental or field data using this specific technology on marine invertebrates.

Any effects on marine benthic invertebrates or their habitat from the CSEM survey are predicted to be *not significant*.

5.8 Potential Effects – Fish

The best of our knowledge, no one has reported effects of electromagnetics on fish eggs (R. Fechhelm, LGL, pers. comm.). Fish eggs do not contain magnetite and, after numerous research studies, no one has reported significant effects on animal or human eggs from low level, short duration electromagnetic energy. Thus, discussion in the following sections is limited to juvenile and adult stages of fish.

5.8.1 Bony Fish

Some electromagnetic-studied fish species that potentially occur in Study Area include:

- **Atlantic or striped wolffish (*Anarichas lupus*).** These species lays eggs on the bottom in rocky areas, probably at depths shallower that the Program Area. Profile is in the section on *SARA*.

- **American eel (*Anguilla rostrata*).** This species is catadramous, spawning in the mid-Atlantic, and migrating to rivers in North America. Its migration routes are unknown.

- **Atlantic herring (*Clupea harengus*).** This herring is benthopelagic, migratory species reported from 0-200 m depths. It exhibits schooling in coastal waters, with complex feeding and spawning migrations. Herring spend the day in deep water, but rise to the surface at night. They probably do not occur not in Study Area.

- **Atlantic mackerel (*Scomber scombrus*).** Atlantic mackerel is pelagic and migratory, occurring at 0-200 m depths. They are abundant in cold and temperate shelf areas, and form large schools near the surface. They overwinter in deep water but move closer to shore in spring when water temperatures range between 11° and 14°C. They do probably do not occur in the Study Area.

- **Atlantic salmon (*Salmo salar*).** Although probably not the most likely route, Atlantic salmon from Newfoundland and Labrador may migrate through the Study Area on their way to oceanic feeding grounds off West Greenland.

The very low frequency, very short duration radiation should have no effect on bony fishes. Bony fishes in general do not appear to be particularly sensitive to low frequency electromagnetic alternating current. Atlantic salmon (*Salmo salar*) is a bony fish that may occur in the Study Area and has been implicated with geomagnetic capabilities. Most of the research has been conducted with Pacific salmon and thus may not be applicable. Atlantic salmon is a prime candidate for geomagnetic orientation and navigational abilities because it contains magnetite, probably has magnetically sensitive nerve structures similar to *Salmo trutta*, and it migrates long distances. Nonetheless, current scientific thinking is that salmonids use a variety of navigational clues, all of which probably over-ride any geomagnetic information and a fully memorized geomagnetic map in a fish seems unlikely given their known capabilities as well as the fixed and transient magnetic anomalies that they would encounter.

Atlantic mackerel (*Scomber scombrus*), Atlantic herring (*Clupea harengus*), and Atlantic or striped wolffish (*Anarichas lupus*) also have been found to contain magnetic material. Other bony fishes that have been found to contain magnetic material and that may have related species that migrate through the area include eelpout (*Zoarces viviparous*) and Yellowfin tuna (*Thunnus albacares*) and European eel (*Anguilla anguilla*); the latter two are known to migrate long distances. [American eel, *A. rostrata* has been tested for geomagnetic orientation and results were mixed. The glass eel stage of a closely related species, the Pacific eel (*Anguilla japonica*), may use geomagnetic clues to some extent based on recent research.]

The migratory patterns of any of the above species are not well known, particularly in the deep Orphan Basin area. Canadian salmon from rivers in Newfoundland and Labrador are known to feed off Greenland. Atlantic salmon have been reported in the surface waters on the Grand Bank and to the east over water as deep as 4,000 m (Reddin 1985 *in* SEA LGL 2003). If they did occur in central Orphan Basin they would be near-surface where any field from the source would be absent or at least very weak. It is believed that the proposed survey would interact with few, if any, of the above species given the deep water of the Project Area and the generally shallow or near-surface and/or seasonal distribution of most of these species.

If migrating bony fish are in the immediate area (within several km of the sources) and do detect the EM source, and then react to it, their reaction should be short-lived and variable (because of the alternating current) and their other navigational clues would still be functioning. If it is an irritant they have good mobility and can leave the immediate area.

It is predicted that any potential effects on bony fishes will be of small geographic extent (well within 50 km^2), short duration (no more than a few hours unless they are traveling with the vessel and at the same speed in which case any effect could last somewhat longer), and low magnitude (based on the results of laboratory experiments). There will be *no effect* to *negligible effect* on their health or behaviour. Thus, any effects on bony fishes are predicted to be *not significant*.

5.8.2 Cartilaginous Fishes

Cartilaginous fishes of interest include elasmobranchs and rat-tails. The cartiliaginous fishes are deemed to be most likely to be able to detect the electrical fields produced by CSEM because of their sensitive electroreceptive organs. Of these, it may be the skates that could be exposed to the source and induced fields the longest because they are closely associated with the bottom. While they have rapid escape mechanisms, all species may not be capable of sustained swimming. Elasmobranch (Class Elasmobranchii) fishes that could potentially occur in the Study Area include those listed below.

<u>Sharks</u>

- Great white shark (*Carcharodon carcharias*)
- Black dogfish (*Centroscyllium fabricii*)
- Portuguese dogfish (*Centroscymnus coelolepis*)
- Basking shark (*Cetorhinus maximus*)
- Porbeagle shark (*Lamna nasus*)
- Blue shark (*Prionace glauca*)
- Greenland shark (*Somniosus microcephalus*)
- Piked dogfish (*Squalus acanthias*)

<u>Skates and Rays</u>

- Arctic skate (*Amblyraja hyperborea*)
- Thorny skate (*Amblyraja radiata*)
- Spinetail ray (*Bathyraja spinicauda*)
- Barndoor skate (*Dipturus laevis*)
- Sailray (*Dipterus linteus*)
- Winter skate (*Leucoraja ocellata*)
- Smooth skate (*Malacoraja senta*)
- Bigelow's ray (*Rajella bigelowi*)
- Round ray (*Rajella fyllae*)

<u>Chimera (non-elasmobranch cartilaginous fish, aka rat-tails)</u>

- Smalleyed rabbitfish (*Hydrolagus affinis*) [Chimaeridae]

Elasmobranchs that may occur in the Study Area and have been implicated in one way or another with geomagnetic or electroreceptive capabilities include:

- Blue shark (*Prionace glauc*a)
- Dogfish (*Squalus* sp.)
- Leopard shark (*Galeocerdo cuvier*) [possible but improbable occurrence]
- Hammerhead shark (*Sphyrna* sp.) [possible but improbable occurrence]

Species profiles of some relevant cartilaginous fishes are provided below.

<u>Class Elasmobranchii</u>

- **Great white shark (*Carcharodon carcharias*).** 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).

- **Black dogfish (*Centroscyllium fabricii*).** The black dogfish is a bathydemersal fish that has been recorded at depths ranging between 180 to 1,600 m. This elasmobranch is typically found on the outermost continental shelves and upper slopes, primarily below 275 m. At higher latitudes, the black dogfish may move up to surface waters, especially during the winter (Scott and Scott 1988; SAUP 2006).

- **Portuguese dogfish (*Centroscymnus coelolepis*).** This bathydemersal fish is known to occur at depths ranging from 270 to 3,765 m. The Portuguese dogfish typically occurs on continental slopes and abyssal plains (Scott and Scott 1988; SAUP 2006).

- **Basking shark (*Cetorhinus maximus*).** The basking shark is a highly migratory, pelagic shark that is known to occur anywhere from surface to a depth of 2,000 m. This fish can be found on continental and insular shelves, offshore, and often close to land. It is believed that basking sharks occur near bottom in very deep water during the winter months (Scott and Scott 1988; SAUP 2006).

- **Porbeagle shark (*Lamna nasus*).** This shark is a large cold-temperate pelagic/epipelagic species whose range extends from Newfoundland to as far south as possibly South Carolina. While most common on the continental shelf, the porbeagle shark does sometimes occur further offshore (Scott and Scott 1988). The porbeagle has a low fecundity, late age at sexual maturation, and low natural mortality. It mates primarily between September and November, followed by live birth of the pups eight to nine months later. This shark likely reproduces annually (DFO 2005a,b). Common prey of porbeagle includes small pelagic fishes (herring, mackerel), groundfishes (cod, hake, haddock, cusk) and squid (Scott and Scott 1988). Porbeagle sharks are migratory, pelagic fish that are known to occur at surface to as deep as 715 m. The 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; SAUP 2006).

- **Shortfin Mako Shark** (*Isurus oxyrinchus*). The known depth range of occurrence of this migratory 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.

- **Blue shark (*Prionace glauca*).** 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).

- **Greenland shark (*Somniosus microcephalus*).** This benthopelagic shark has a recorded depth range of surface to 1,200 m. It is typically found on continental and insular shelves as well as on upper slopes down to at least 1,200 m. In the Arctic and boreal Atlantic, the

Greenland shark occurs inshore in the shallow subtidal zone and at the surface in shallow bays and river mouths during colder months. This fish typically retreats to depths of 180 to 550 m when the water temperature rises (Scott and Scott 1988; SAUP 2006).

- **Piked dogfish (*Squalus acanthias*).** The piked dogfish is possibly the most abundant of the living sharks. Its pelagic and migratory lifestyle is characterized by a wide depth distribution (surface to 1,460 m). This dogfish occurs both inshore and offshore on continental and insular shelves, and on the upper slope areas (Scott and Scott 1988; SAUP 2006).

- **Arctic skate (*Amblyraja hyperborea*).** The Arctic skate is a bathydemersal fish that is known to occur at depths ranging between 300 and 2,500 m. It is typically found on the lower continental slope. These skates tend to prefer polar temperatures throughout their life cycle. Arctic skate eggs are incubated successfully and regularly in water as cold as 0°C (Scott and Scott 1988; SAUP 2006).

- **Thorny skate (*Amblyraja radiata*).** This demersal skate moves about the ocean bottom in areas with water depths ranging between 20 and 1,000 m. Thorny skates are both eurybathic and eurythermic, and can be found on all types of substrate (Scott and Scott 1988; SAUP 2006).

- **Spinetail ray (*Bathyraja spinicauda*).** The bathydemersal spinetail ray has been recorded over a depth range of 140 to 800 m (Scott and Scott 1988; SAUP 2006).

- **Barndoor skate (*Dipturus laevis*).** This migratory, demersal skate is known to occur from the intertidal zone to depths of 750 m. This euryhaline fish can withstand salinities as low as 21 to 24 ppt to as high as 35 ppt along the edge of the continental shelf. Barndoor skates have been observed on all kinds of bottom substrate (Scott and Scott 1988; SAUP 2006).

- **Sailray (*Dipterus linteus*).** The known depth range of this bathydemersal elasmobranch is from 150 to 650 m. The sailray typically occurs in moderately deep water but mainly around 250 m in boreal and arctic latitudes (Scott and Scott 1988; SAUP 2006).

- **Winter skate (*Leucoraja ocellata*).** This demersal skate occurs in relatively shallow areas where depths range between intertidal and 90 m. Winter skate appear to prefer sandy and gravelly bottoms in shoal water in the northern part of their range and in deeper water in the southern part of their range (Scott and Scott 1988; SAUP 2006). Electric organ discharge (EOD) activity in winter skate seems to be more frequent during dark periods. The individual EOD of this species is monophasic, head-negative, and lasts approximately 217 ms (Mortensen and Whitaker 1973; Møller 1995).

- **Smooth skate (*Malacoraja senta*).** This highly mobile bathydemersal skate is known to occur over a depth range of 45 to 915 m. Smooth skate inhabit soft mud and clay bottoms of the deeper troughs and basins, and sands and shells, gravel and pebbles of the offshore fishing banks. No occurrence of this fish has been recorded in less than 8 m of water (Scott and Scott 1988; SAUP 2006).

- **Bigelow's ray (*Rajella bigelowi*).** The bathydemersal Bigelow's ray is typically found on continental slopes and deepwater rises in depths ranging between 650 and 4,155 m (Scott and Scott 1988; SAUP 2006).

- **Round ray (*Rajella fyllae*).** The bathydemersal round ray is typically found in deeper shelf and slope waters in depths ranging between 170 and 2,050 m (Scott and Scott 1988; SAUP 2006).

Class Holocephali

- **Smalleyed rabbitfish (aka deepwater chimaera) (*Hydrolagus affinis*).** Depth of occurrence of this bathydemersal chimaera ranges between 300 and 2,400 m. Smalleyed rabbitfish are typically found between upper continental slopes to deep-sea plains (Scott and Scott 1988; SAUP 2006).

Most of the fishes listed above occur in shallower water than the Project Area and/or frequent near-surface waters, and thus will not be exposed to any electromagnetic fields from the proposed survey. A review of geomagnetic and electroreceptive capabilities is contained in Section 5.1. In summary, it appears that the proposed survey is unlikely to disrupt any navigation abilities of elasmobranches. The source current is alternating and thus any potential effect on orientation or navigation will be "self-cancelling." Geomagnetics (if in fact they are used) are not their only navigational clue, and the duration of exposure is short. Similarly, the surveys are unlikely to disrupt prey detection by elasmobranches because the use of electroreception as an aid to prey detection appears to vary with species but is known to be short range (within a few metres) in those that have been studied.

It is predicted that any potential effects on elasmobranch fishes will be of small geographic extent (well within 50 km^2), short duration (no more than a few hours unless they are traveling with the vessel and at the same speed in which case any effect could last somewhat longer), and low magnitude (based on the results of laboratory experiments). There is some evidence that sharks might be repelled by the source as some shark repellent devices use electricity, in which case they will avoid any potential effects by leaving the area. On the other hand, LGL personnel (V. Moulton, B. Mactavish) have heard anecdotal reports of sharks attacking seismic cables which presumably emit some sort of electro-magnetic field. Sharks have been reported to bite underwater electrical cables (reviewed in Gill et al. 2005). In previous CSEM surveys by ExxonMobil off Brazil, West Africa, Columbia, and Norway, there are no reports of sharks attacking the source (S. Dewing, EMC, pers. comm.). It is reasonable to infer that elasmobranches will be repelled as they get closer to the source and the field gets stronger. There is uncertainty within specific predictions of geographic extent, duration, and magnitude because of the paucity of information on deepwater species and the lack of field studies. [Nonetheless, we are confident of the prediction of non-significance based on professional judgment.] There will be *no effect* to *negligible effect* on their health or behaviour. Thus, any effects on elasmobranch fishes are predicted to be *not significant*.

5.9 Potential Effects – Sea Turtles

Sea turtles that may occur in the Study Area and have been implicated in one way or another with geomagnetic capabilities include:

- Leatherback turtle [not reported in Orphan Basin after two summers of monitoring by marine biologists from a seismic vessel]
- Loggerhead [possible but improbable occurrence]

Leatherbacks have been recorded diving to depths greater than 1,000 m (Eckert 1989) and thus could encounter the CSEM fields. There will be *no effect* on sea turtles from a brief encounter with the source. They may not regularly occur in Orphan Basin as evidenced by extensive surveys for marine mammals and sea turtles conducted during the 2004 and 2005 3D seismic programs and thus there is probably little opportunity for interactions. Even if they did occur there, most of the time they would be near-surface where any field from the source would be absent or at least very weak. In addition, based on available information, adult sea turtles do not appear to be sensitive to or to utilize electromagnetic fields. Thus, it is predicted that there will be no effect on health, and no or negligible effect on navigation (due to alternating nature of current and the very brief exposure period). The CSEM surveys will have *no significant effect* on sea turtles.

5.10 Potential Effects – Seabirds

Birds of the Order Procellariformes (shearwaters and petrels) have been shown to exhibit magnetic orientation (Wiltschko and Wiltschko 1995a). While very common in Orphan Basin, these species feed near the surface by plunging (shearwaters) or surface skimming (petrels) and will not be exposed to the geomagnetic field from the source. It is thought that alcids, which spend relatively long periods of time underwater, would have the most potential to be exposed to some level of electromagnetics, but again their normal depth of feeding would be some distance from the source which will be towed 50 m off the bottom in very deep water (2,000 to 4,000 m). Very few alcids were observed in the Orphan Basin during the 2004 monitoring program but they were relatively abundant at the start of the 2005 program which started earlier (in May as opposed to June). They are expected to be rare during the proposed CSEM program. The three most abundant species were Greater Shearwater, Leach’s Storm-Petrel, and Northern Fulmar.

There are only two potential adverse interactions between seabirds and the Project: (1) stranding, and (2) accidental oiling.

During the monitoring program in 2004, Leach’s Storm-Petrels stranded on seven of the 84 nights during the program (Moulton et al. 2005). There were a total of 43 individuals stranded, including 30 on the night of 18 August. Of the 43 birds, 39 were released in good health and four died (an insignificant portion of the total population). The relatively low number of strandings was thought to be partially due to the mitigation of lowering light levels on the ship at night. During the 2005 seismic program, EOs aboard the two seismic ships successfully released 112 of 123 stranded seabirds; this mitigation measure reduced seabird mortalities considerably.

Buoyancy for towed gear is either solid and/or liquid, depending upon the contractor. There is some potential for oiling of small numbers of seabirds if the liquid (typically Isopar) or hydraulic fluid (typically Tellus 32) escaped. [Note that if the oil leaked at depth, little or no oil would likely reach the surface.]

Thus, while there is some potential for effects on individual seabirds, mostly petrels, *no significant effects* on seabird populations are predicted for any of the Project Activities because the number of animals affected will be small.

5.11 Potential Effects – Cetaceans

The Orphan Basin monitoring program in 2004-5 provided new and relevant distribution and abundance data on marine mammals within the Study Area (see Figures 4.17 and 4.18). Baleen whales, dolphins, and to a lesser extent, large toothed whales, regularly occur within the Project Area during summer months (Moulton et al. 2005, 2006).

Direct health effects on marine mammals are unlikely given what is known from the large body of research on the effects of electromagnetic radiation on mammals. The ultra low frequency, AC current, and short duration of exposure used in CSEM support a *no effect* on health conclusion.

Ship strikes are unlikely given the slow speed (about 1.5-2 kts) of the vessel while towing the source. In addition, the most vulnerable species to ship strikes, Atlantic right whale, is very unlikely to occur in Orphan Basin.

Cetaceans are theorized to use geomagnetics for long distance navigation and thus could potentially be temporarily disturbed by the field emanating from the source. Cetaceans that are known to occur in the Study Area and have been implicated in one way or another with geomagnetic capabilities include:

- Humpback whale
- Fin whale
- White-sided dolphin

All of these species (and other cetaceans that potentially use geomagnetics) may occur in Orphan Basin. Some maximum dive depths for species occurring in Orphan Basin are shown in Table 5.5.

Some species such as sperm whale or northern bottlenose whale could be exposed more than others due to deep dives (Table 5.5). Given their apparent rarity in the Project Area, there appears to be little potential for interaction with these species. Nonetheless, the ramp-ups would give them warning and they can move away from the irritant, if in fact it is one. In any event, their exposure times will be very short because their encounter at depth with a moving field will be limited. Given that the source current is alternating and the duration of exposure is short unless the cetaceans travel with the vessel for some distance (even then, a portion of their time is spent at or near surface where the signal from the source will be very weak or non-existent), the fact that animals use more than one clue to navigate, significant effects are unlikely.

Table 5.5. Maximum Dive Depths Reported for Selected Cetacean Species.

Species	Maximum Reported Dive Depth (m)	Source
Common dolphin	260	Stewart 2002
Atlantic white-sided dolphin	Shallow (Pacific form: 214)	Berta and Sumich 1999
Risso's dolphin	400-1,000?	
Striped dolphin	200	web
Harbour porpoise	70-100	Stewart 2002
Fin whale	500	Berta and Sumich 1999
Humpback whale	148	Berta and Sumich 1999
Blue whale	150-200	Stewart 2002
Sei whale	Shallow?	
Minke	Shallow?	
Sperm whale	3,000	Jefferson et al.1993; Clarke 1976; Watkins et al. 1985
Pilot Whale	610	Jefferson et al. 1993; Bower and Henderson 1972
Bottlenose Dolphin	555	Jefferson et al. 1993; Ridgway 1986; Harrison and Kooyman 1971
Killer whale	260	Jefferson et al. 1993; Bower and Henderson 1972
Northern bottlenose whale	1,000	Reeves et al. 1993

It is predicted that any effects on navigation will be "self-cancelling" and certainly of low geographic extent (maximum 50 km^2), low magnitude, and short duration (less than a few hours). Effects of the CSEM survey on cetaceans will be *not significant*.

5.12 Potential Effects – *SARA* Species

SARA and COSEWIC (i.e., potential *SARA* species in the future) species of at least some relevance to CSEM surveys in Orphan Basin include porbeagle shark, blue shark, white shark, wolffish, American eel, leatherback sea turtle, Ivory gull, right whale, and blue whale.

The distribution of the above-named species is unknown in the Study Area but they may only occur there very rarely. Because these species are rare, the magnitude of exposure is short range, the duration of exposure is short, and any effects are recoverable, most within a few minutes, then adverse significant effects are highly unlikely.

Leatherback sea turtles are expected to be uncommon in Orphan Basin. This is supported by the monitoring programs in 2004-5; no leatherbacks were sighted during 1,198 h of observations in 2004 or 2,656 h during 2005 (Moulton et al. 2005; 2006).

Ivory Gulls (listed as "special concern" under Schedule 1 of *SARA*) are expected to be scarce in the Orphan Basin as it is associated with ice, and none were observed there in 2004 or 2005. During the monitoring programs in 2004 and 2005, no Ivory Gulls were sighted during the 1,489 10-minute counts.
Blue whales are uncommon in the Orphan Basin during summer. This is supported by the monitoring programs in 2004 and 2005; no blue whales were sighted during 1,198 and 2,656 hours of observations,

respectively (Moulton et al. 2005, 2006). It is possible that the blue whales may be relatively more abundant (although still uncommon) in the southern portion of the Project Area, given the shallower water depths. However, blue whales are still likely uncommon and the implementation of appropriate mitigation measures will minimize the potential for impacts. North Atlantic right whales are highly unlikely to occur in the Project Area.

All of these species are expected to be scarce or absent during summer surveys over deepwater in Orphan Basin and thus unlikely to be exposed to any risks from the surveys. If they are exposed, as discussed in previous sections on seabirds, sea turtles, elasmobranches, bony fishes, and cetaceans, any effects would be low magnitude, small geographic extent (<50 km^2), short duration (a few hours), and thus *not significant*. No harm or mortality to *SARA* species or their habitat will be caused by the Project nor is it the Proponents intent to cause harm.

5.13 Potential Effects – Fisheries

There will be *no effect* on the fisheries of Orphan Basin from biological effects as discussed in Section 4.4 Furthermore, fishing activity in Orphan Basin is light and there is no directed fishery for elasmobranches (especially skates), arguably the group of animals that could be most affected by CSEM. Damage to fixed fishing gear (i.e., deepwater gillnets in this case) will be avoided by use of fisheries mitigations (see Section 3.7) such as Notice to Mariners and the presence of a fisheries liaison officer (FLO) (an experienced fisher). Potential for gear damage will be low because of the low level of fishing activity in deep Orphan Basin and the shorter length of towed gear (relative to seismic surveys) and the shorter turning radius of a CSEM vessel. In addition, the CSEM vessel moves very slowly (1.5-2 kts) and thus there is sufficient time for all parties to react and avoid other gear or vessels. If gear is damaged, the compensation program will alleviate any financial losses. Thus, any effects on the fisheries will be *not significant*. Communication with DFO will eliminate any potential conflict with research vessel cruises.

5.14 Follow-up

Follow-up procedures will include:

- In the unlikely event that marine birds, sea turtles, or mammals are injured or killed by Project equipment or accidental spills of fuel, lubricants or hydraulics, a report will be filed with C-NLOPB and the need for follow-up monitoring assessed.
- Any dead or distressed marine mammals or sea turtles will be reported immediately to the C-NLOPB.
- A marine mammal, sea bird, and sea turtle monitoring report, intended to add to scientific database, based on data collected by EOs will be submitted to the C-NLOPB.

5.15 Residual Effects Summary

A summary of residual effects from the Project are shown in Table 5.6. The Project will have *no significant effect* on the environment and VECs of Orphan Basin.

Table 5.6. Significance of Potential Residual Environmental Effects of the Proposed 2005 Seismic Program on VECs in the Orphan Basin (table format adapted from Buchanan et al. 2004; note that "Probability of Occurrence" and "Scientific Certainty" ratings are not included as there were no predicted significant effects).

Valued Environmental Component: Fish, Fisheries, Birds, Turtles, Mammals				
	Significance Rating	**Level of Confidence**	**Likelihood**	
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Probability of Occurrence**	**Scientific Certainty**
Project Activities				
Vessel Presence/Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Garbage (N/A)	-	-	-	-
Electromagnetic				
Physical effects	NS	3	-	-
Behavioural effects	NS	3	-	-
Helicopters	NS	3	-	-
Shore Facilities (N/A)	-	-	-	-
Accidental Spills	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse 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
N/A = Not Applicable

[a] Not Applicable. There will not be any new onshore facilities required. Existing infrastructure will be used.

5.16 Cumulative Effects

Cumulative effects within the Project are *negligible*. To our knowledge there are no projects that would generate underwater electromagnetic fields (e.g., underwater electrical or telecommunications cables—LGL 2003) and thus no cumulative effect from this source. It is also necessary to assess cumulative effects from other activities outside the Project that are planned for the area. These activities may include:

- Commercial fishing [Note that there are no recreational or aboriginal fisheries in Orphan Basin.]
- Vessel traffic (e.g., transportation, defense, yachts)

- Hunting (e.g., seabirds, seals)
- Offshore oil and gas industry

Commercial fishing has been discussed in detail in Section 4.4. Commercial fishing activities, by their nature, cause mortality and disturbance to fish populations and may cause incidental mortalities or disturbance to seabirds, marine mammals, wolffish, and sea turtles. It is predicted that the CSEM surveys will not cause any mortality to these VECs (with the potential exception of small numbers of petrels) and thus there will be no or negligible cumulative effect from mortalities.

In the summer, the main North Atlantic shipping lanes between Europe and North America lie to the north of Orphan Basin into the Strait of Belle Isle. In the winter, that traffic shifts to the main shipping lanes along the southern Grand Banks into the Gulf of St. Lawrence. During the 2004-5 seismic surveys, few ships were seen during the Orphan Basin surveys (CCL, unpublish. data). Thus, potential for cumulative effects with other shipping is predicted to be negligible.

The vast majority of hunting of seabirds (mostly murres) in Newfoundland and Labrador waters occurs near shore from small boats and thus, there is little or no potential for cumulative effects on this VEC. Similarly, most, if not all, seal hunting would occur inshore of Orphan Basin.

Offshore oil and gas industry 2006 projects listed on the C-NOPB/CEAA registry (www.cnopb.nfnet.com as viewed 23 May 2006) that could overlap in timing with the proposed CSEM program include two seismic programs off Labrador and, on the Grand Banks one 3D seismic survey, at least one VSP program, and at least one geohazard survey, and some exploratory and development drilling (perhaps one jack-up and one semi-submersible). In addition, there are three existing offshore production developments (Hibernia, Terra Nova, and White Rose) on the northeastern part of the Grand Banks. Any effects from these activities will not overlap geographically with those in Orphan Basin as they are too distant from the proposed CSEM program area. Similarly, any effects from the CSEM will not extend more than a few kilometres and thus Project activities will not overlap with other oil and gas activity in Newfoundland and Labrador waters. One possible exception is the Orphan Basin drilling program which is planned for the northern part of the Project Area. It is the Proponents' plan to conduct that CSEM survey in that area prior to the commencement of drilling activity in Orphan Basin and in that case there would be no potential overlap.

The current scientific prediction is it that *no adverse significant residual effects* (including cumulative) will result from the CSEM survey.

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Personal Communication

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Appendix I: Report on Industry and Agency Consultations

List of Persons Consulted

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