5.0 ENVIRONMENTAL SETTINGS

5.1 PHYSICAL AND MARINE SETTING

5.1.1 Meteorology and Climate

Winters are very cold, with typical daytime temperatures for January between -10 and -15˚C, colder than Newfoundland and more like the frigidity of the southern Prairies. An occasional incursion of Atlantic air will warm up the winter. The summer season is brief and cool along the coast because of the cold Labrador Current. July average temperatures are from 8 to 10˚C along the coast but are 3 to 5˚C warmer in the interior. The pleasantness of the summer day along the coast is often determined by the wind direction - westerly winds bring clear, mild continental air, whereas easterlies, blowing off the Labrador Current, bring cold, cloudy, and moist weather.

The limitation of the ocean's influence; however, is not a serious disadvantage, because in this region its effect on the climate is generally unpleasant. The Labrador Sea is infested with floating pack ice and icebergs for eight months of the year. The masses of ice keep sea temperatures below 4˚C. An east wind off the Labrador Current is a cool wind in summer, often with light rain or drizzle. In winter, when the Atlantic air is relatively mild, the accompanying weather includes cloud and frequent snow flurries. Whenever easterly winds bring very moist air from the Atlantic, widespread fog occurs.

Precipitation is heaviest in the south and decreases northwards. On the whole it is much lighter than in Newfoundland, although amounts can vary considerably from year to year. Southern Labrador is not unlike the moist northern shores of Newfoundland, with 1000 mm, as a typical yearly fall of precipitation. About 45% of this occurs as snow. Over much of Labrador 800 mm is a more typical amount, with about half of it snow. In summer, rainfall is quite reliable, with seasonal totals seldom less than 175 mm in the north and 275 mm in the south. Snowfall is heavy, with Churchill Falls in the interior having 481 cm, making it one of the snowiest places in Canada. Goose Bay has a mean snowfall of 445 cm. In the south, Cartwright averages 440 cm, and in the north Nain is typical with 424 cm. The ground is snow-covered for eight months in the far north and for six months in the south.

5.1.2 Physical Oceanography

5.1.2.1 Wave Conditions

The grid point locations used for this Study Area are within the same area as in the Labrador Shelf SEA which are shown in Figure 5.1.

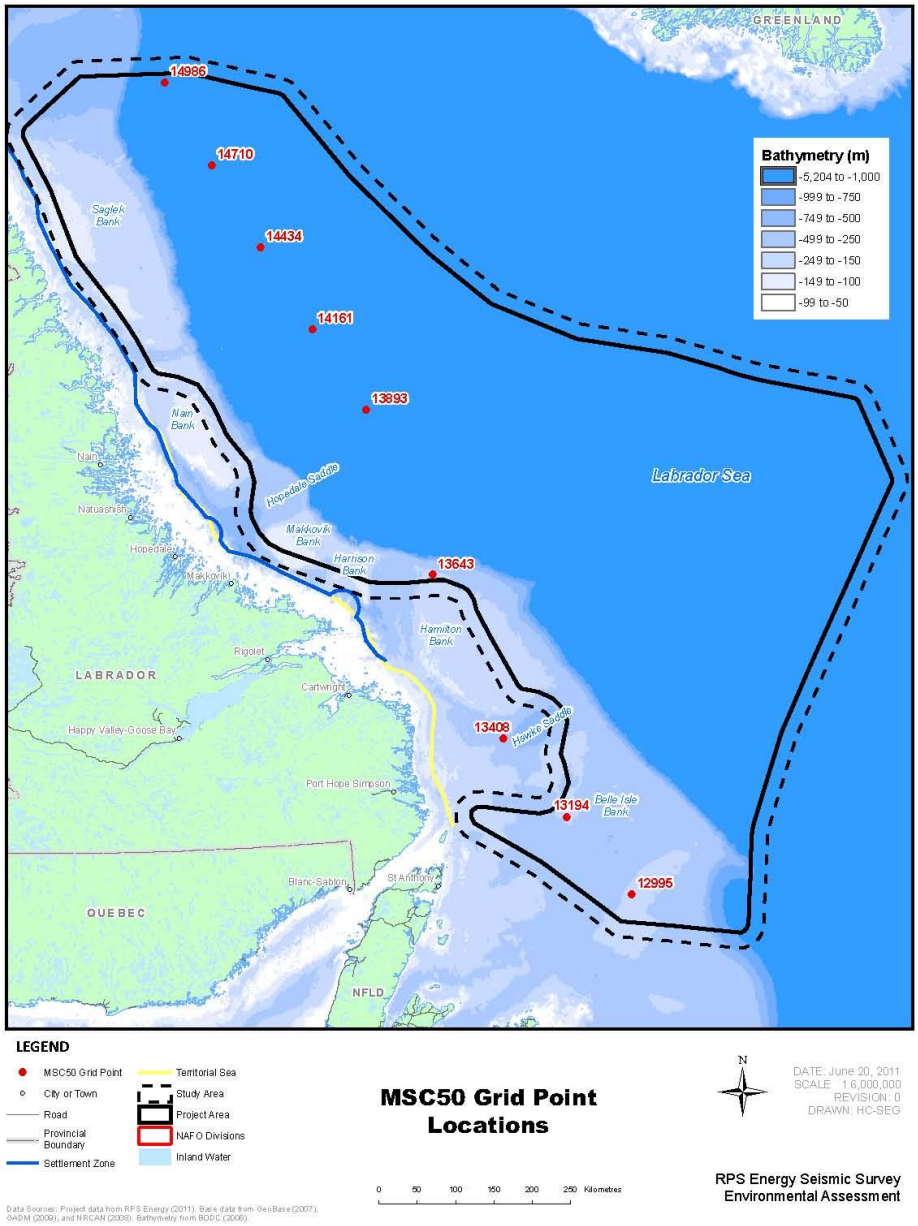

Figure 5.1: Location of the MSC50 Grid Points

Plots of monthly mean and maximum wave height are shown in Figure 5.2. Extreme 10-year, 50-year, and 100-year significant wave heights are shown in Table 5.1.

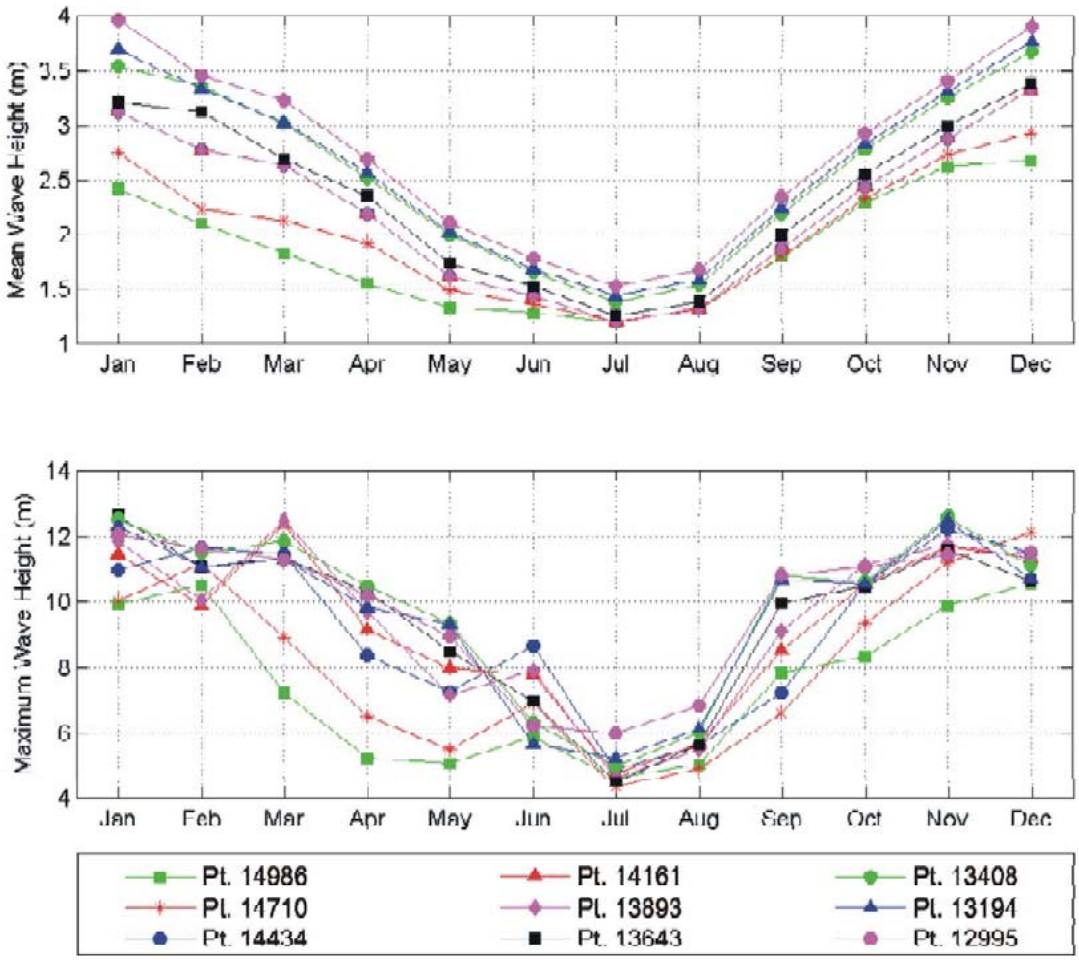

Figure 5.2: Mean and Maximum Significant Wave Height by Grid Point

Table 5.1 Extreme Significant Wave Heights

Grid Point	10-Year Maximum (m)	50-Year Maximum (m)	100-Year Maximum (m)
14986	9.63	10.81	11.26
14710	10.55	12.13	12.72
14434	11.07	12.35	12.82
14161	11.15	12.49	12.99
13893	11.14	12.51	13.01
13643	11.19	12.56	13.07
13408	11.66	12.78	13.19
13194	11.72	12.77	13.16
12995	11.41	12.11	12.36

The monthly wave statistics for the MSC50 grid points within the Study Area (values are based on 50 years of hindcast data) show the highest waves typically occur from November to March. The maximum significant wave height of 12 m was recorded in November and January.

5.1.2.2 Wind Conditions

The MSC50 hindcast was used to extract monthly wind parameters for each of the grid point locations shown in Figure 5.3 of the plots of monthly mean and maximum wind speeds for all grid point locations. Extreme 10-year, 50- year, and 100-year wind speeds are shown in Table 5.2.

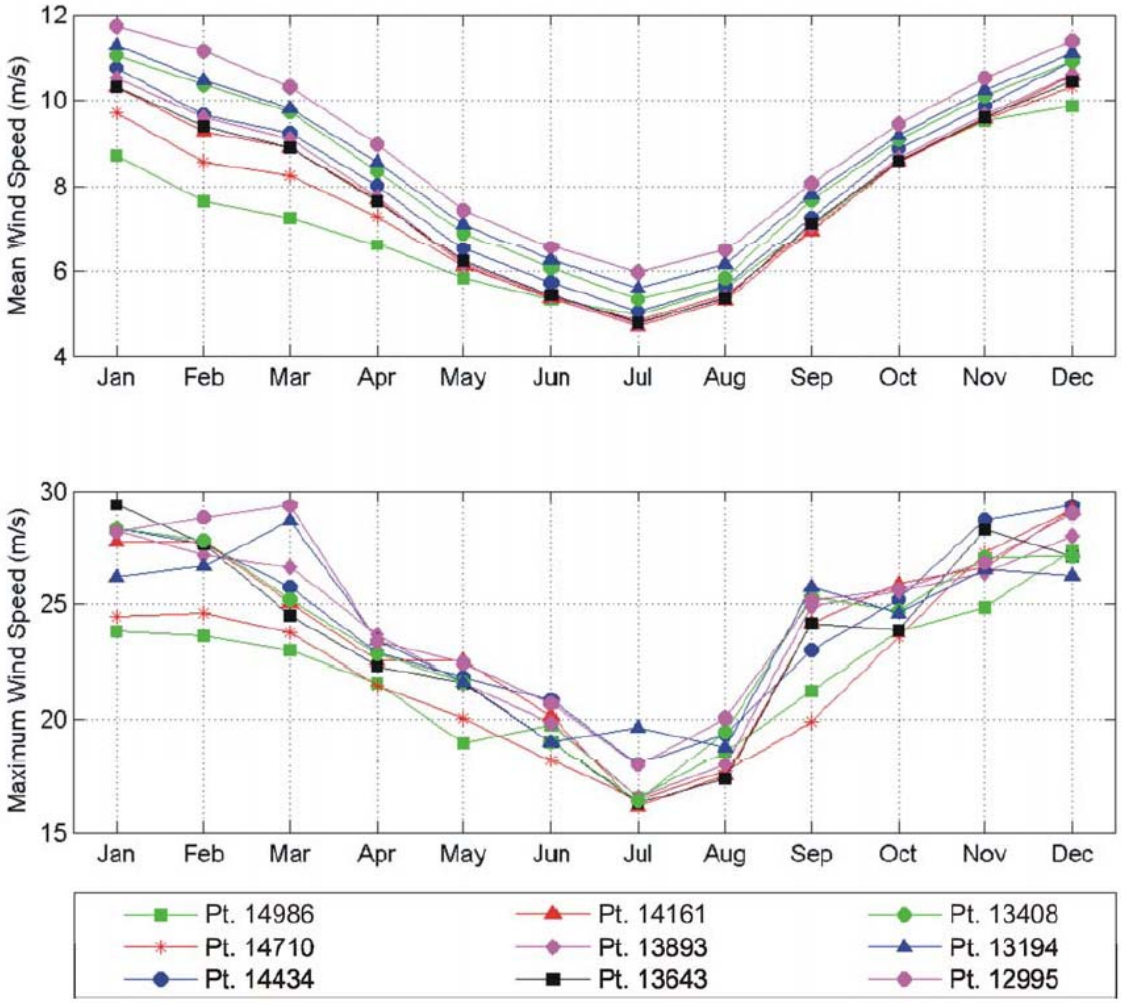

Figure 5.3: Mean and Maximum Wind Speeds by MSC50 Grid Points

Table 5.2 Extreme Wind Speeds

Grid Point	10 Year Maximum (m/s)	50 Year Maximum (m/s)	100 Year Maximum (m/s)
14986	25.40	27.33	28.04
14710	26.52	28.98	29.88
14434	27.42	29.29	29.98
14161	26.99	29.14	29.93
13893	26.80	28.59	29.23
13643	26.98	29.44	30.34
13408	26.90	28.59	29.20
13194	26.79	28.61	29.28
12995	28.22	30.27	31.02

5.1.2.3 Temperature and Salinity

Sea surface temperatures in the Labrador Shelf Area remain relatively cold in the north (typically -2°C to 0°C) throughout the year. South of 55°N temperatures range from approximately 0°C during the winter months to approximately 10°C during summer. Salinity hovers around 30 psu (practical salinity units) inshore and over the banks during spring and summer, and increases to greater than 35 psu at the edge of the Labrador Shelf. During fall and winter, it tends to increase to approximately 33 psu inshore and remains fairly constant at approximately 35 to 36 psu over the edge of the shelf.

5.1.2.4 General Ocean Circulation

The Labrador Current, originating in the Davis Strait, is a combination of the West Greenland Current, the Baffin Island Current, and inflow from Hudson Bay. It flows along the Labrador coast and consists of two major streams, the inshore and offshore stream (Figure 5.4).

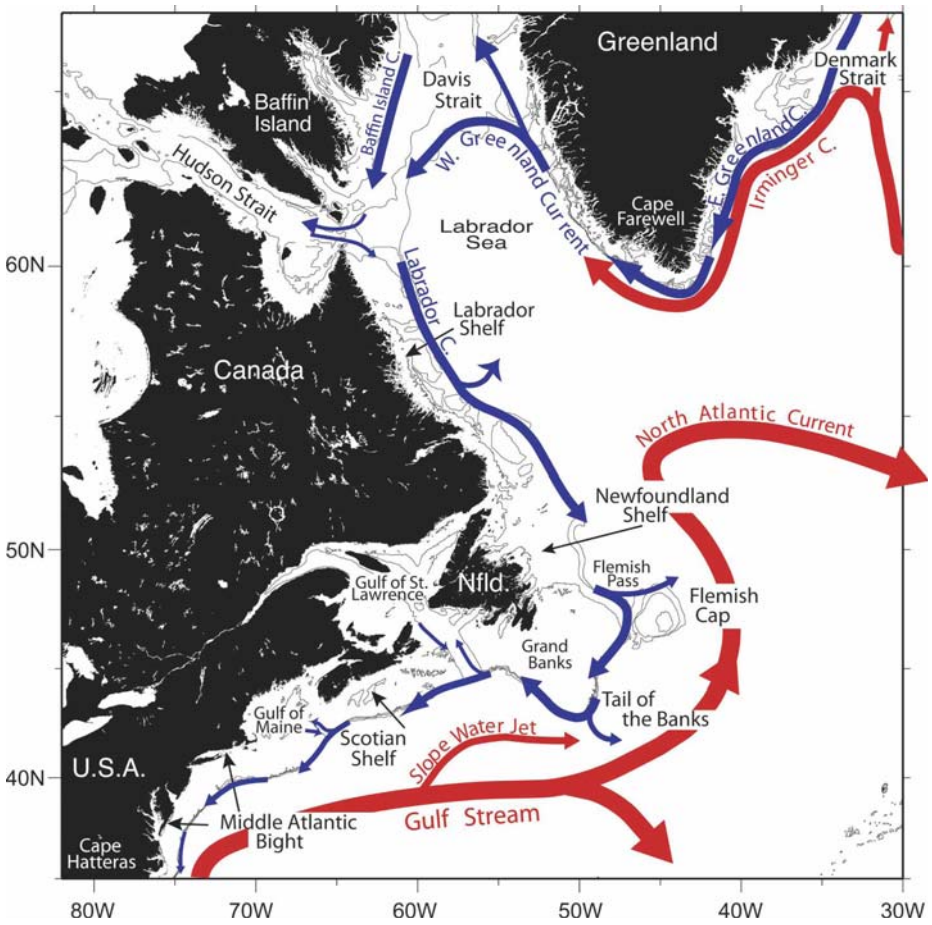

Figure 5.4 Surface Circulation Features in the Western North Atlantic
The path of the shelfbreak jet (blue) and the warmer currents originating from the Gulf Stream (red) are shown. [Source: Fratantoni and Pickart, 2007 as reported in Southern Newfoundland SEA Section 2.2.1 (LGL 2009)].

The inshore stream, consisting of water from Hudson Strait and the Baffin Current, flows along the coast and in the Marginal Trough, located inside the banks. The offshore stream consists of water from the West Greenland current and flows along the outer edge of the banks and over the continental slope. Hydrographic observations in the Labrador Sea from the 1930s to the 1990s reveal large annual and decadal variations in water mass properties. In the late 1960s to early 1970s, the intermediate and deep waters of the Labrador Sea were at their warmest and saltiest since the 1930s. It took only two decades for all the waters to reach the lowest ever observed temperature and salinity of the entire water column.

The presence of the banks between the two main streams of the Labrador Current tends to limit mixing of the streams so that they maintain their water properties along the length of the coast. Mixing of the streams occurs through the saddles, which are oriented approximately perpendicular to the coast. The currents on the banks between the two streams are weak and much more variable. Mean velocities are greatest along the slope and in the Marginal

Trough, while the maximum speeds are greatest along the slope and in the Cartwright Saddle.

The most comprehensive physical study of currents offshore Labrador was contracted by Petro-Canada during the summer of 1980. Prior to the 1980 Physical Oceanography Study offshore Labrador, currents were measured by various researchers. The measurements on the continental slope were made mainly during the winter season, and the banks during the summer season. The current information indicates that the net flows are stronger over the steepest portion of the continental slope than over the continental shelf or locations further offshore. While the magnitude of the vector mean currents are much less on the continental shelf than those measured on the slope, the current speeds on the shelf can still be strong. The maximum current speed on the slope was measured as 0.94 m/s at a depth of 100 m, and the maximum speed on the shelf was measured as 0.79 m/s at a depth of 13 m.

The largest tidal variations occurred at semi-diurnal frequencies. For the semi-diurnal M2 constituents, the largest amplitude in the Project Area was 2.6 cm/s at 269 m depth. The amplitude of the largest diurnal constituent (K1) was 1.1 cm/s. With the exception of tides, the major part of the temporal variability of the currents occurred at periods greater than two days. Over the banks, relatively more activity occurs at periods of four to seven days.

The currents offshore Labrador are dominated by low frequency oscillations. Fissel and Lemon (1982) found that despite the general similarity of the flow within each regime, cross-spectral analysis between horizontally separated pairs of current records did not reveal statistically significant coherences beyond those that would be expected to arise at random. Much of the spatial variability is linked to bathymetry, while the temporal variability may be linked to meteorological forcing as suggested by the period of the oscillations.

5.1.3 Ice Conditions

The mean annual number of weeks of pack ice found in the SEA Area is shown in Figure 5.5. Figure 5.6 shows the mean monthly concentrations when ice is present in July. There is no other pack ice from August to November. It should be noted that for clarity, only the 200, 1,000 and 3,000 m bathymetry lines are shown in these figures.

The average start of the ice season ranges from mid-November in the north, to December in the south. Ice growth typically continues until late spring, when the pack ice begins to melt and dissipate through the month of July. The ice season ends, on average, by late-June/early-July in the south but extends until late-July/early-August in coastal and northern regions. The mean annual number of weeks for ice presence is one week in the offshore areas. The average annual concentration in the vicinity of the banks is 3/10 to 4/10, decreasing with distance from shore. This observation includes all conditions (including areas designated as open water and ice-free). When ice is present, the mean annual concentration varies from 3/10 to 9/10 over the entire Labrador Shelf Area; and multi-year ice concentration displays a high degree of variability. Occasionally occurring in small areas of concentrations of 2/10, it tends to appear in trace amounts within the overall pack throughout most of the season.

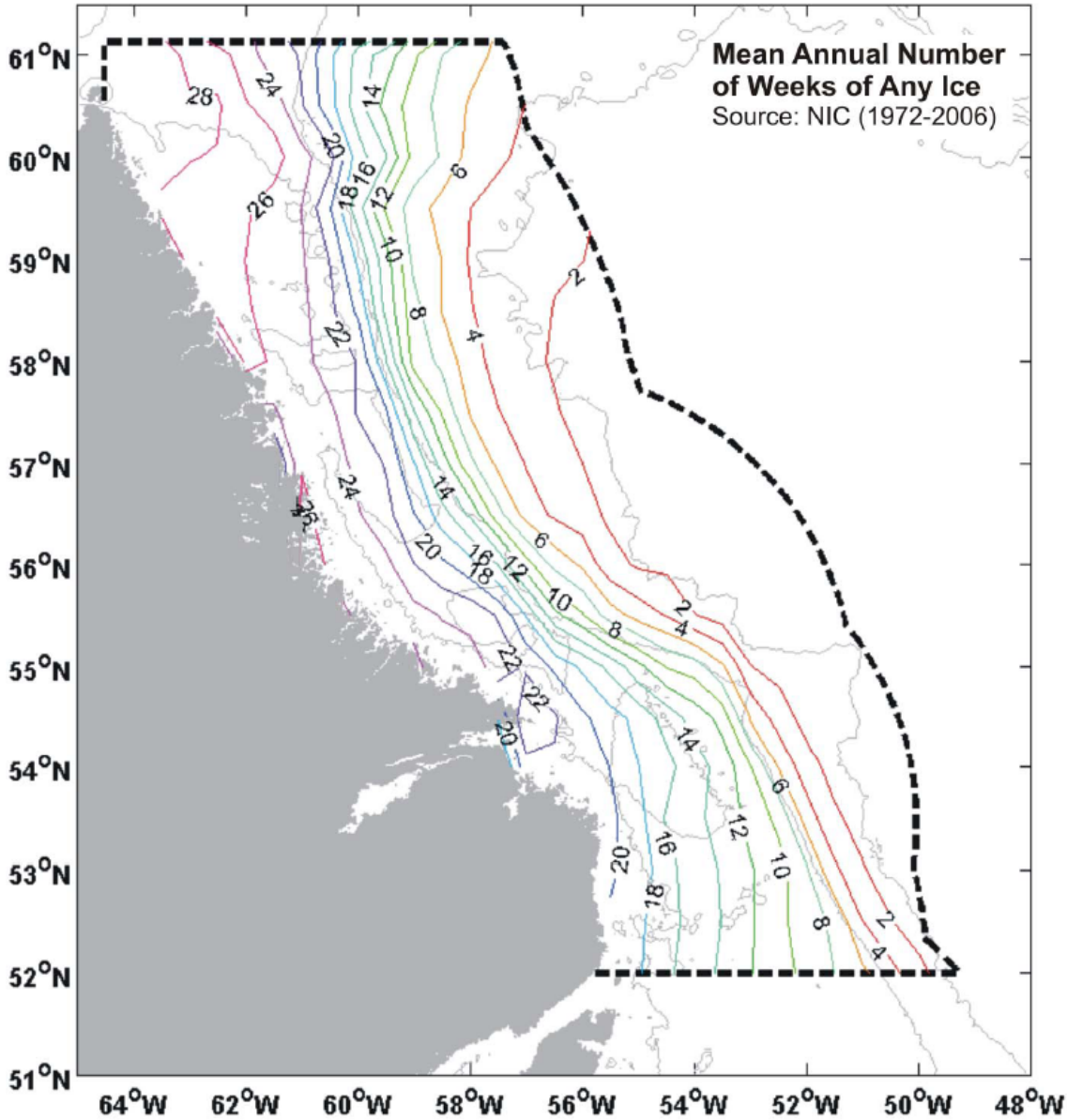

Figure 5.5: Mean Number of Weeks Per Year the Ice Pack is Present

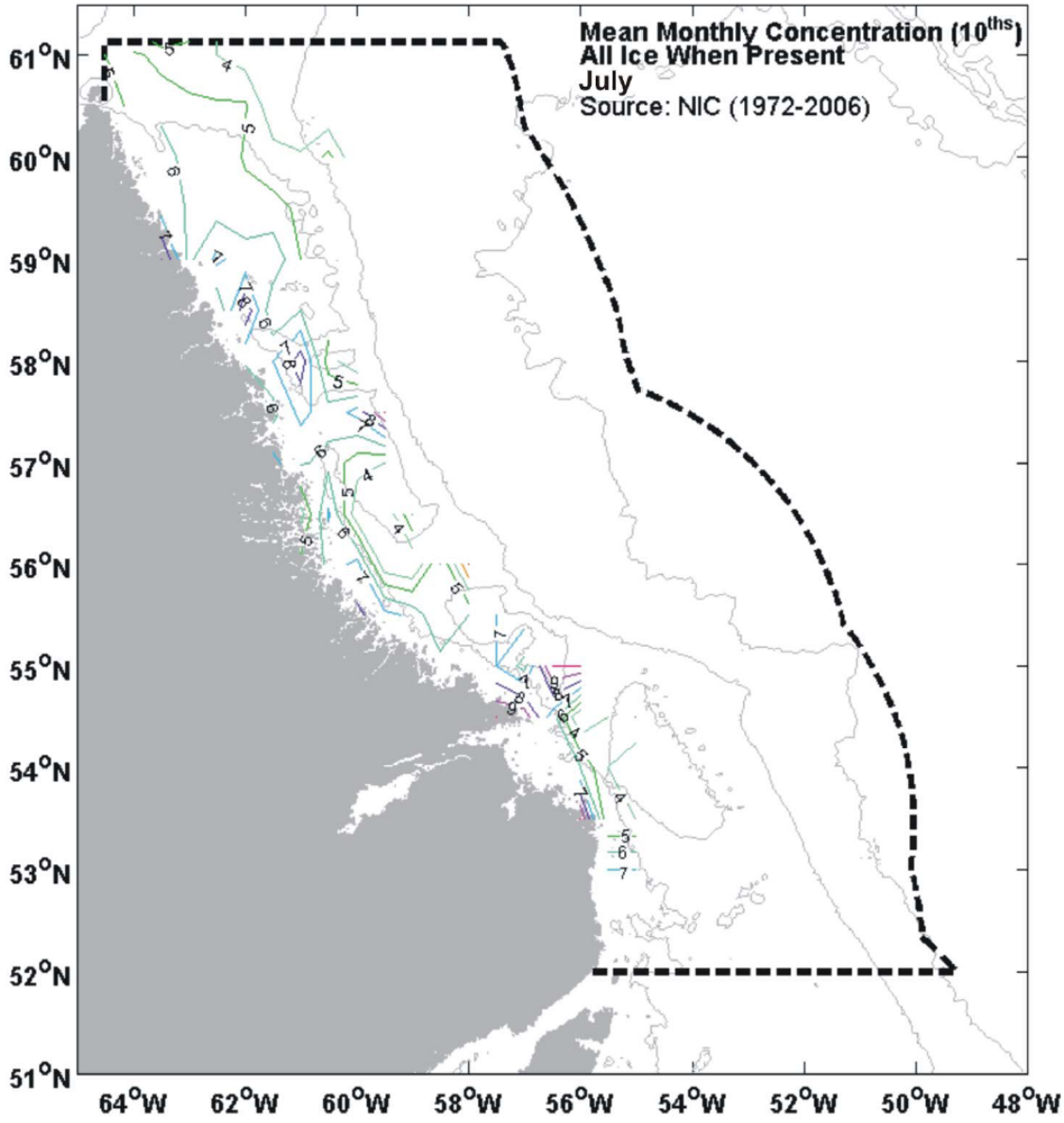

Figure 5.6: Mean Monthly Pack Ice in Conditions in July

5.1.4 Icebergs

Icebergs are masses of fresh water ice which calve each year from the glaciers of Greenland. Icebergs are moved by both the wind and ocean currents, and typically spend one to three years traveling a distance up to 2,897 km (1,800 miles) to the waters of Newfoundland. The West Greenland and Labrador Currents are major ocean currents which move the icebergs about the Davis Strait, along the coast of Labrador, to the northern bays of Newfoundland, and to the Grand Banks. Icebergs will exhibit little or no melting in sea temperatures of about 5ºC or less while waves and warm air temperatures will tend to erode

them in their travels. A medium iceberg (15 to 30 m or 32.8 to 49.2 ft high, 45 to 90 m or 147.6 to 295.3 ft long) will deteriorate in sea water of 4.4ºC in about 10 days.

The presence of easterly and northeasterly winds can strongly influence the numbers of icebergs that make their way to the Newfoundland coast, onto or off the Grand Banks, and through the Strait of Belle Isle into the Gulf of St. Lawrence. This combined with prevailing wind directions and sea and air temperatures will determine whether and for how long any icebergs stay in a particular region. The majority of icebergs on the East Coast will be present from March to June or July. By August in most years, the icebergs both along the coast and offshore Newfoundland will have drifted south of the Grand Banks or melted.

5.1.5 Bathymetry

Water depths within the Project Activity Area range from about 300 m to 3,000 m. A coarse scale bathymetry map is provided as Figure 5.7.

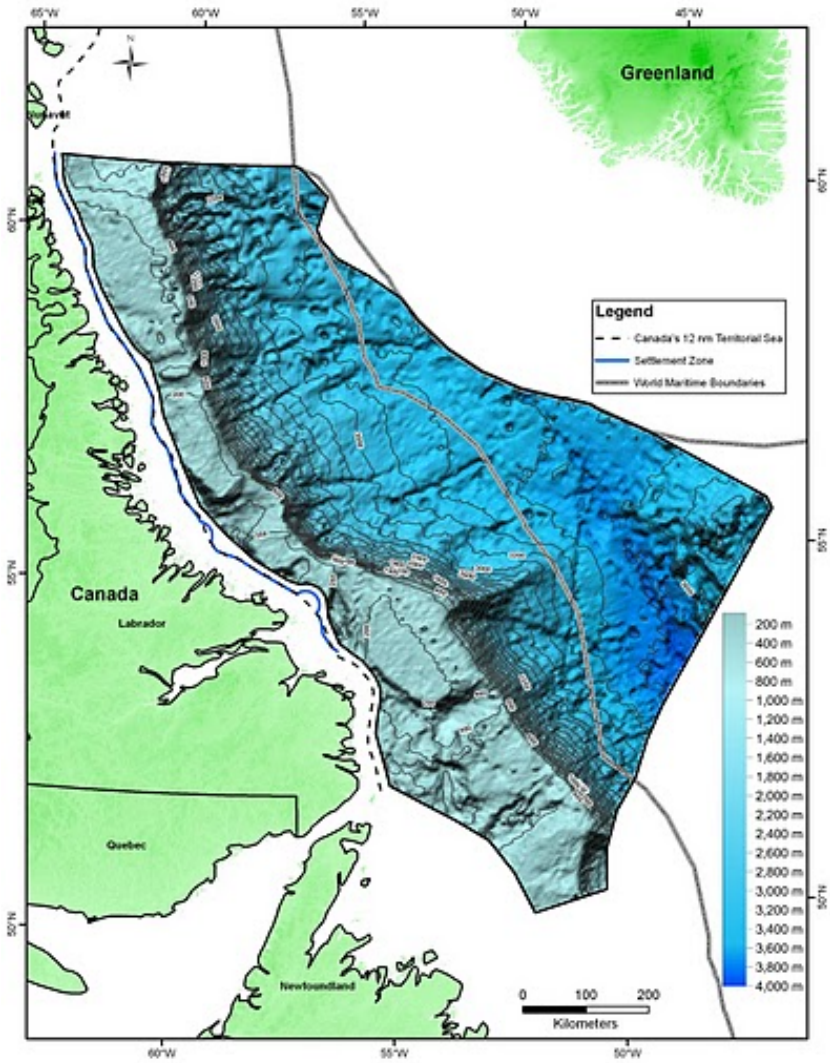

Figure 5.7: Regional Bathymetry

5.1.6 Geology

The seabed and near-seabed material of the Labrador Shelf Area is a combination of bedrock, till and marine sediments. The Labrador Shelf Area has a moderate risk for earthquake hazard.

The Labrador shelf is approximately 150 km wide, with water depths of less than 70 m, within 2 km of shore. Deep saddles run in a northeast-southwest direction and there are separate shallow offshore banks with water depths less than 200 m. The banks extend to the edge of the shelf that rapidly drops off to depths greater than 3,000 m. The Labrador Shelf can be divided into four distinct regions: the coastal embayment, a shallow rough inner shelf, a marginal trough; and a smooth, shallow outer shelf consisting of banks and intervening saddles.

5.2 NOISE ENVIRONMENT

Sound is generated by many sources, and in the uppermost part of the ocean, weather has a significant impact on the sound level. Ambient noise is that sound received by an omni-directional sensor which is not from the sensor itself or the manner in which it is mounted. Ambient noise is made up of contributions from many sources, both natural and anthropogenic. These sounds combine to give the continuum of noise against which all acoustic receivers have to detect required signals. Ambient noise is generally made up of three constituent types – wideband continuous noise, tonals and impulsive noise and covers the whole acoustic spectrum from below 1 Hz to well over 100 kHz. Above this frequency the ambient noise level drops below thermal noise levels.

There are a number of basic mechanisms by which ambient noise is generated. All of the sources of ambient noise involve one or more of these basic generation mechanisms:

Impact noise - Impact noise occurs when water strikes water (*e.g.,* breaking waves); water strikes solid (*e.g.,* waves hitting a rock); solid strikes water (*e.g.,* hail hitting the water surface); or solid strikes solid underwater [*e.g.,* sediment noise ("siltation")]. It is usually a broadband, transient noise, possibly with resonant peaks if solids are involved.

Bubble noise - There are several types of bubbles in sea water. Passive bubbles are quiescent and do not generate noise. Active bubbles are formed during an energetic process such as breaking waves or rain striking the surface. These bubbles oscillate and generate comparatively narrowband signals centered on the resonant frequency of the bubble, typically in the range 15 to 300 kHz. Collective oscillations of bubble clouds, particularly under breaking waves, can have resonant frequencies which are much lower than this.

Turbulence - Turbulence associated with surface disturbance or turbulent tidal flow around an obstruction generates low frequency continuous noise.

Seismic - Movement of the seabed can be coupled into the water column and generate very low frequency noise.

Cavitation - Propellers and other fast moving objects in the water can cause cavitation noise when the pressure in the flow around the moving object goes sufficiently negative. This causes a cavitation bubble which very quickly collapses, causing a loud transient sound. The resulting spectrum is wideband but generally has a peak between 100 Hz and 1 kHz.

Machinery noise - Machinery generally produces a broadband continuous spectrum with tonals superimposed resulting from the rotation rates of the various parts of the machinery. There may also be impulsive sounds.

Tonals - Some systems either deliberately, or as a by-product, generate high levels of tonal signals (*e.g.,* sonar systems, seal scarers).

Sources of ambient noise include:

- wind-sea noise
- precipitation noise
- surf noise and sediment transport
- commercial shipping and leisure craft
- industrial noise
- military noise
- sonar
- fishing activity
- aircraft
- biological noise
- thermal noise

5.2.1 Comparison of Noise Levels

A comparison of natural and potential exploration-related noise levels is provided in Table 5.3

Table 5.3: Comparison of Natural and Seismic Exploration-related Sound Levels

Source	Source Level (dB re 1µPa)	Sound Frequency (Hz)	Notes
Ambient Noise			
Calm Seas	60	-	
Moderate Waves/surf	102	100 to 700	
Fin whales	160 to 186	20	Fin whales produce series of one to five second noise pulses across 3 to 4 Hz around the 20 Hz level.
Seismic Exploration			
Small Single Airgun	216	10 to 5,000	0 to peak
Medium Single Airgun	225	10 to 5,000	0 to peak
Large Single Airgun	232	10 to 5,000	0 to peak
GSC 7900 Array	259	10 to 5,000	0 to peak

Source	Source Level (dB re 1µPa)	Sound Frequency (Hz)	Notes
ARCO 4000 Array	255	10 to 5,000	0 to peak
GECO 3100 Array	252	10 to 5,000	0 to peak
Supply boats	170 to 180	100	
Other Industrial Noise			
Fishing trawlers	158	At 100	
Commercial freighter	172	-	
Supertanker *Chevron London*	190	dominant tone of 6.8 Hz	
Helicopter (Sikorsky @ 305 m above water)	105	-	
Source: Richardson *et al*. 1997, in Hurley and Ellis 2004; Lawson *et al*. 2000 in Hurley and Ellis 2004; Thompson *et al*. 2000, in Hurley and Ellis 2004.			

Wenz (1962) published a thorough study of noise in the ocean, and a composite of his conclusions are given in Figure 5.8. The figure also gives the limits of prevailing noise, showing that for the frequency band 10 to 100 Hz, the noise level is between 40 and 100 dB, but with a strong increase with lower frequencies. At sound frequencies below 500 Hz, shipping noise is an important factor and above 500 Hz, wind and wave conditions are the primary cause of deep ocean ambient noise (Davis *et al*. 1998). Most of the man-made noise is continuous signals, such as from shipping etc. Industrial activities and oil exploration create repeated signals of short duration, such as explosions and seismic signals.

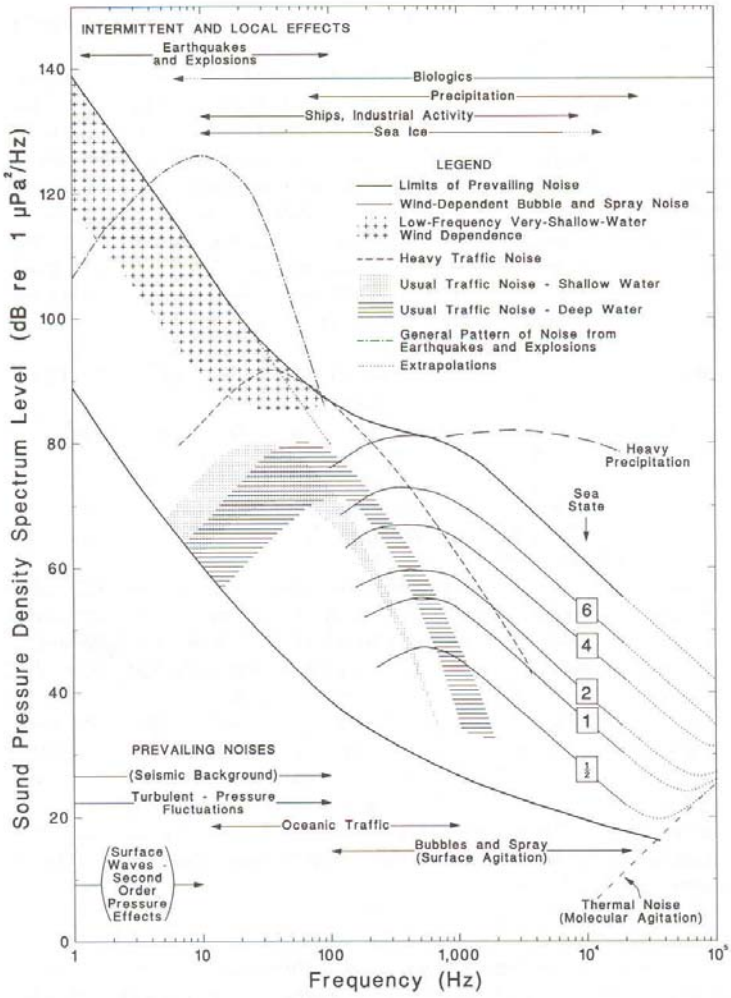

Figure 5.8: Ambient Noise Spectra Attributable to Various Sources (Wenz 1962)

Figure 5.9 shows noise frequencies levels generated from ships, aircraft, and sonar relative to hearing sensitivities of marine life.

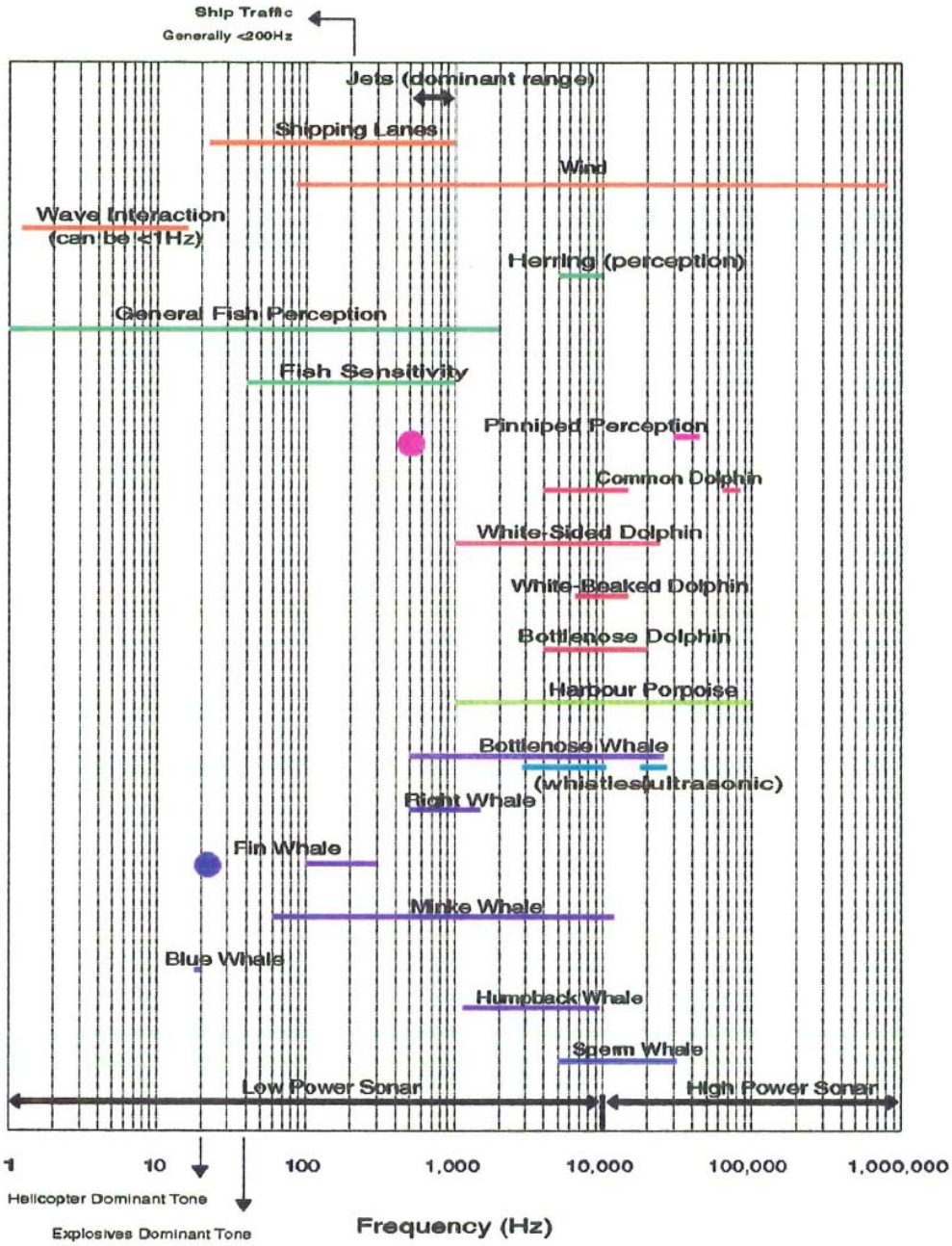

Figure 5.9: Anthropogenic Noise Frequencies in Relation to Marine Mammal Hearing

5.2.2 Acoustic Propagation

Sound produced by the various ambient noise sources has to propagate through the very complex underwater environment. Because of variations in temperature, salinity, and pressure the path followed by the waves can deviate markedly from a straight line. The structuring is most marked in the vertical plane, causing the waves to be refracted upwards

or downwards, depending on the sound speed gradient, but horizontal structuring can also be encountered. As the waves are refracted up or down they may interact with the surface and the seabed by reflection and scattering. The level of signal arriving at a distant point is therefore a complex sum of many paths that may or may not interact with the seabed and sea surface. The multiple paths followed by the sound waves can cause dispersion in time of the acoustic energy and can also cause a variation in propagation loss with frequency. Propagation loss varies on a diurnal and annual basis as the air temperature variations warm and cool the water.

5.2.3 Source and Receiver Depths

Because of the temperature structuring of the water column, if the source and receiver depths vary the propagation loss can vary significantly. If a surface duct is formed by an isothermal layer near the surface this variation can be very large.

Marine mammals use sound for communication and navigation, and locally this will add to the background sound level. Many marine animals rely, in part, on their acoustic sense for communication, social interaction, navigation, foraging, and predator avoidance. They emit sound over a broad range of frequencies from a few Hz to 200 kHz - depending on species. Sounds emitted by marine mammals have been described as whistles, songs, moans, grunts, barks, growls, knocks, pulses, clicks, etc. Such sounds take on a variety of functions, and some calls of some species have been linked to different types of behaviour, including travelling, resting, socializing, mother-calf contact, mating, nursing, foraging (coordinated group foraging as well as individual foraging), individual identification (signature whistles) and warning (alarm calls).

Underwater noise has the potential to interfere with sounds made by marine animals and with ambient sounds that animals listen to for successful navigation, foraging, and threat avoidance. Dolphins and toothed whales (*odontocetes*) emit mid- to high-frequency sonar signals and listen to the reflections for navigation and foraging. Many animals likely listen to environmental sounds such as surf for navigation. Many species can hear the sounds of prey as well as the sounds of predators or other potential threats. Underwater noise can mask these sounds to the point where they are no longer recognizable or detectable.

Underwater noise has also been shown to affect the behaviour of marine animals. While temporary noise will mostly cause only temporary effects, ongoing noise exposure can drive animals away from potentially critical habitat (*e.g.,* spawning/mating grounds, nursing grounds, feeding grounds).

In extreme cases, loud underwater noise can cause physiological damage to marine animals, such as the rupture of eggs, larvae, or gas-filled organs, and ear damage (hair cell damage in the inner ear).

Within deep oceanic waters far from shipping lanes, a sound level of 95 dB re 1 µPa can be assumed as ambient (Richardson *et al*. 1995) with considerably higher levels occurring closer to shipping lanes. Depending on proximity to shipping lanes, Urick (1983) gives

values for oceanic waters equivalent peak-to-peak noise levels of 75 to 95 dB re 1μPa. In coastal shipping and harbours where human activity is concentrated, ambient noise in shallow, continental shelf waters (< 200 m) has a higher variance. Normal peak levels of ambient noise range from 110 to 120 dB re 1μPa in shallow, continental shelf waters (Richardson *et al*. 1995) and is dependent on oceanographic conditions, shipping, and anthropogenic activities.

Background noise levels in the area of The Gully and Sable Bank have been reported by Desharnais and Collison (2001). At frequencies between 20 Hz and 50 Hz, mean noise levels range from 76 to 114 dB re 1 μPa2/Hz. At these frequencies, the ambient noise is influenced by vocalizing finback whales. At frequencies between 50 Hz and 200 Hz, which are dominated by shipping noise, mean noise levels range from 68 to 114 dB re 1 μPa2/Hz. At higher frequencies up to 1,000 Hz, which is dominated by wind stress on the ocean surface, noise levels range from 62 to 86 dB re 1 μPa2/Hz.

Dr. Jack Lawson at DFO (St. John's) deployed an autonomous recorder during the Husky Energy seismic program in 2010 and collected over 85,000 received sound level values from seismic shots in the Sydney Basin. The results of this monitoring exercise will be published in late 2011.

5.3 BIOLOGICAL ENVIRONMENT

5.3.1 Plankton

Plankton are defined as organisms that drift passively with ocean currents, and are a group that encompasses the domains *Archaea, Bacteria,* and *Eukarya* (Witman and Roy 2009). Prominent members of the plankton community include marine algae (phytoplankton), invertebrates (zooplankton), and the larval stages of certain fish species (ichthyoplankton). Plankton play a key role in marine ecosystems because they often form the basis of complex food webs, and changes in plankton communities can affect top predators and ultimately commercial fisheries via bottom-up regulation (Frederiksen *et al*. 2006). Plankton abundance is seasonally variable, with the summer months generally showing the highest numbers and diversity of species.

5.3.1.2 Phytoplankton

Phytoplankton are an autotrophic subset of plankton which derive their energy from sunlight. In addition to their role in marine food webs, phytoplankton also produce about half of the atmosphere's oxygen (Frajka-Williams and Rhines 2010). Phytoplankton production is limited by a number of physical, biological, and climatic factors, including water temperature, nutrient availability, irradiance (sunlight intensity), and the community of grazers. The Newfoundland and Labrador Shelf region, which encompasses the proposed Study Area, regularly experiences a large spring bloom and a smaller fall bloom of phytoplankton (Templeman 2010). In the North Atlantic Ocean, increases in phytoplankton abundances in the spring correspond to warming of surface waters (Colebrook 1979). Nutrient availability in the Labrador Sea can be affected by climatic variables such as strong winds that enable

nutrient mixing, such that storms can be followed by phytoplankton blooms during the summer (Wu *et al*. 2008).

Spring phytoplankton blooms begin when nutrients are mixed among layers and irradiance increases (Frajka-Williams and Rhines 2010). The timing of this bloom is especially important in the Labrador Sea because food chains in this region are short, such that higher predators depend almost exclusively on primary production (Frajka-Williams and Rhines 2010). Unlike in other areas where the timing of the spring phytoplankton bloom follows a latitudinal gradient, the north Labrador Sea (north of 60° N and east of the Labrador Shelf) has its bloom before the central Labrador Sea. These differences are due to the limiting factors in each region: in the north phytoplankton production is nutrient limited while in the central it is light limited. The Study Area is within the central Labrador Sea, where the phytoplankton bloom is likely to occur in June (Frajka-Williams and Rhines 2010). The schedule of the proposed work may therefore coincide with the phytoplankton bloom in the Study Area.

The highest levels of primary production within the region occur in the immediate nearshore areas, along the shelf edges where upwelling occurs, and in estuaries where nutrients are inputted from terrestrial sources (Templeman 2010). Annual primary production within the area is about 200 mg C m^{-2} y^{-1} (as cited in Templeman 2010) and it is considered a relatively productive area within the framework of the global oceans.

5.3.1.2 Zooplankton

Zooplankton are heterotrophic organisms that include small invertebrates such as copepods, and large invertebrates such as jellyfish. Also included amongst the zooplankton are the eggs and larval stages of many fish species.

Zooplankton reproduction at high latitudes either coincides with or closely follows phytoplankton blooms (Huntley *et al*. 1983). On the northern and southern Labrador Shelf, this means that zooplankton reproduction occurs around May, but because phytoplankton blooms are delayed in the central Labrador Sea, this period extends into June. In the Labrador Sea, high concentrations of the copepod *Calanus finmarchicus* have been reported (Head *et al*. 2003; Head and Pepin 2008). In the central Labrador Sea, this species produces a single generation annually (Head *et al*. 2000) but development proceeds at a much faster rate than in other nearby waters (Huntley *et al*. 1983). Diversity of zooplankton within the region is quite low, with communities usually dominated by less than 30 species (Huntley *et al*. 1983). Within the Labrador Sea, community composition of zooplankton is typically consistent within distinct geographical zones and within seasons (Head *et al*. 2003).

5.3.2 Marine Benthos

The benthic biome includes both epifaunal species (those living on the seafloor or other substrate) and infaunal species (those living within the substrate). These communities can be unique and can support a diverse array of organisms, and their structure is related to a suite of physical and biological characteristics (Templeton 2010). Benthic algal communities

are important because they provide a stable-year round source of food for invertebrates and fish at times when phytoplankton productivity is low (VBNC 1997).

The benthic communities within the Study Area are expected to vary with depth. Little is known about the broad spatio-temporal patterns of benthic invertebrates in Newfoundland and Labrador waters (Gilkinson 1986). Based on the known depth preferences of benthic species known to occur in the Newfoundland and Labrador region, species likely to occur in the shallower (0-500 m) portions of the Study Area include molluscs such as periwinkles (*Littorina* spp.), waved whelk (*Buccinum undatum*), ocean quahog (*Arctica islandica*), soft-shell clam (*Mya arenaria*), northern horse mussel (*Modiolus modiolus*), blue mussel (*Mytilus edulis*), Iceland scallop (*Chlamys islandica*), and sea scallop (*Placopecten magellanicus*); echinoderms such as orange-footed sea cucumber (*Cucumaria frondosa*; and polychaetes such as *Nereis* spp., red-lined worm (*Nephyts* spp.), and fan worm (*Myxicola infundibulum*) (as reviewed in Christian *et al*. 2010). Studies in the mid 1980's by Stewart *et al*. (1985) found that from a station in the north Labrador Sea, dominant molluscs were eroded turretsnail (*Tachyryhnchus erosus*) and inflated macoma (*Macoma loveni*), dominant polychaetes were bambooworm (*Maldane sarsi*) and *Chaetozone setosa* (no common name), and the dominant echinoderm was *Ophiura robusta* (no common name).

In terms of benthic plant life, data on distribution is generally limited to along the coastline, where the dominant macrophyte species include bladder, forked, and knotted wracks and winged and sugar kelps (Templeton 2010). Within the region, red algae species occur at the greatest depths (up to 100 m), so these species will most likely be encountered in the shallow portions of the Study Area. Less is known about the deep-sea benthic communities, although studies have explored the distribution of corals and sponges in the Labrador Sea area. Several echinoderms, including brittle- and sea-star species, are known to occur in the Labrador area and at depths of up to 1,500 m (Christian *et al*. 2010).

5.3.3 Corals and Sponges

The term coral refers to stony corals (scleractinians), sea anenomes (actinarians), soft/leather corals (alcyonaceans), horny corals (gogonaceans) and sea pens (pennatulaceans) (Gass 2003). Deep-sea corals are important aspects of benthic habitat because they provide shelter for smaller species, forage and nursery areas for young, and act as predation refugia for prey species (Templeton 2010). As such, corals act as frameworks around which diverse communities are established, and their presence may influence the local occurrence or abundance of other marine species (Campbell and Simms 2009). Edinger *et al*. (2007), for example, found that groundfish species richness was highest in areas containing small gorgonian corals. Coral habitats are sensitive to disturbance from fishing activities and can be damaged by bottom-trawling in particular (as cited in Gass and Willison 2005).

Coral ecology in the Newfoundland and Labrador region has been studied continuously by government biologists since 1997 (Campbell and Simms 2009). Within the Newfoundland and Labrador shelf area, at least 35 species of deep-water coral have been identified (as cited in Templeton 2010). A hotspot of coral species richness (Figure 5.10) has been

identified on an area of Labrador slope between Makkovik Bank and Belle Isle Bank within which 14 species were found (Wareham and Edinger 2007). Most corals in the region are found at depths greater than 200 m along the continental shelf edge and continental slope (Warehem and Edinger 2007). Due to their importance in structuring benthic marine habitats, an area approximately of 14,000 km^2 in NAFO Division 3O was established as a coral protection zone in 2007, within which all bottom-fishing activity is prohibited (Campbell and Simms 2009). An additional area of 12,500 km^2 in the northern Labrador Sea has been voluntarily designated a coral protection zone by the Groundfish Allocation Enterprise Council/Canadian Association of Seafood Producers (Campbell and Simms 2009) (see "Sensitive Areas, Section 5.5).

Sponges, like corals, are significant components of benthic habitats and are considered ubiquitous in marine habitats (Fuller 2011). These organisms can provide significant deep-sea habitat, enhance species richness and diversity, and influence local fauna communities (DFO 2010a). These organisms are sessile and attach to a variety of hard substrates on the sea-floor. In the Labrador Shelf area, large catches of sponges in the Order Astrophorida have been recorded at a depth stratum of 900-1250 m, and sponges appear to exist in large patches in this area (Fuller 2011). Like corals, sponges can be negatively affected by fishing activities and activities associated with the exploration for, and the production of, offshore petroleum resources (Campbell and Simms 2009).

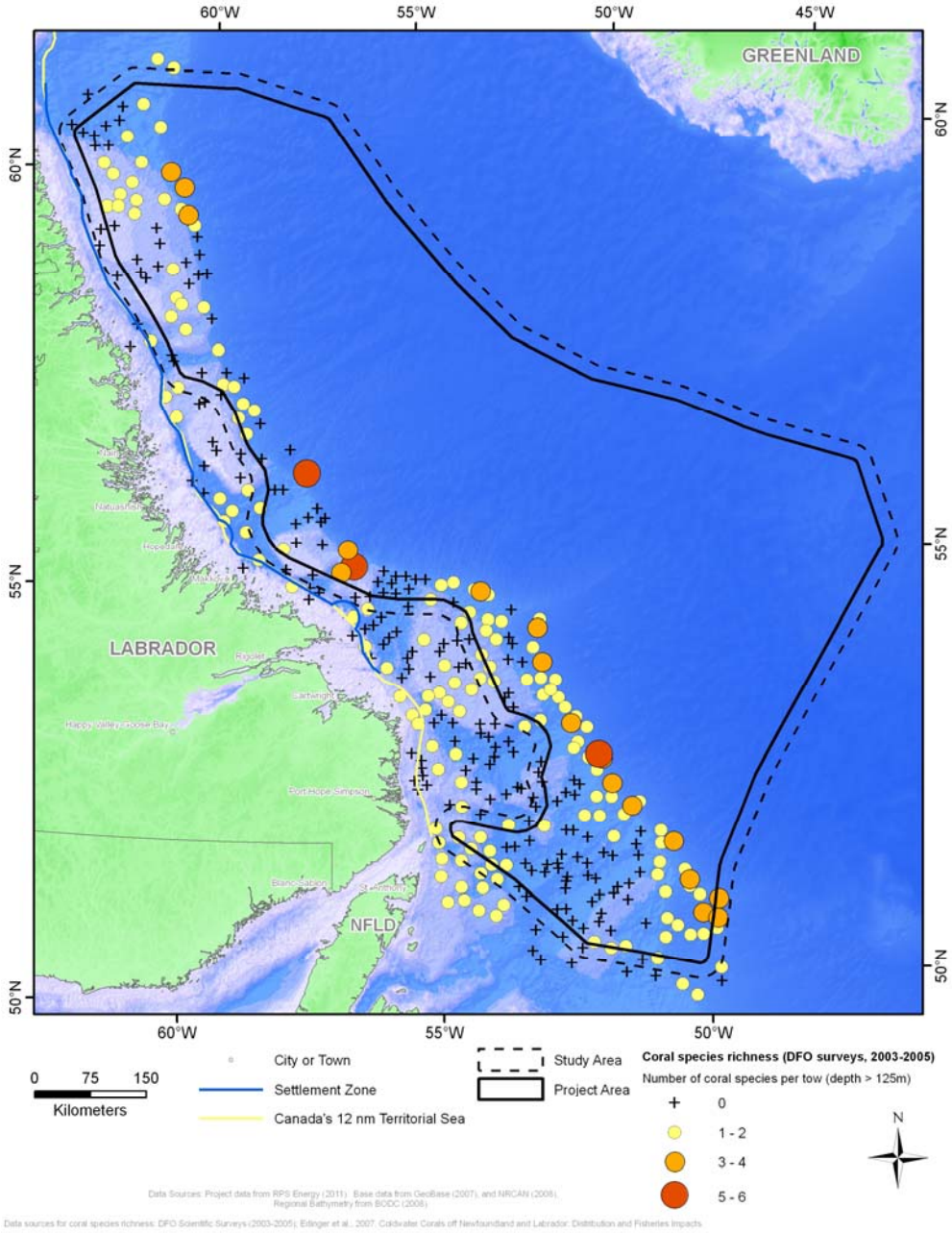

Figure 5.10 Coral Species Richness

5.3.4 Marine Fish

For discussion purposes, marine fish are divided into three groups: demersal (or groundfish), pelagic, and shellfish. The fish species that are present in the Labrador Shelf SEA Area may include American plaice, Arctic char, Atlantic cod, rock cod, capelin, snow crab, spider crab (toad crab), yellowtail flounder, Greenland halibut, roughhead grenadier, silver hake, Atlantic halibut, redfish, Iceland scallop, seal, porcupine crab, skate, witch flounder, northern shrimp, whelk, porbeagle shark, herring, lumpfish, sand lance, spiny dogfish, black dogfish, Atlantic

salmon, wolffish, shrimp, and haddock. Species that are SAR-listed or have a COSEWIC status are described in Section 5.4.

The choice of which species have been described in detail is based on overall distribution within the Labrador Sea, traditional importance, commercially exploited, and their role in the ecosystem. Species such as Atlantic halibut, haddock and yellowtail flounder may be found in the Labrador Shelf SEA Area but they are at the limit of their range and as such may represent stray fish or are limited to water of the Strait of Belle Island. Climate change may result in their expansion into the southern section of the Labrador Shelf SEA Area during warmer trends and retreating from the area during cooling trends. Thus they do not represent an indigenous population in the area.

5.3.4.1 Demersal Species

Demersal finfish species are fish that live near the seafloor for the majority of their adult lives. They are commonly referred to as groundfish and historically supported the largest fisheries in the western Atlantic.

Redfish

Redfish (*Sebastes* spp.) or ocean perch are benthic fish, inhabiting areas with rocky or clay-silt substrates along the slopes of banks and in deep channels at depths of 100 to 700 m and temperatures of 3°C to 8°C. They are distinguishable by their large eyes, a bony protrusion on the lower jaw and a fan of bony spines around the gill covers. They remain on or near the seabed during the day, rising into the water column at night to feed and are stratified by size, with smaller fish in shallow waters and larger fish deeper (McKone and LeGrow 1984; Scott and Scott 1988). The three species of redfish found in the Northwest Atlantic are *Sebastes fasciatus*, *S. marinus* and *S. mentella*. These species are nearly impossible to distinguish by appearance and are managed as a single fishery (Power and Mowbray 2000; Gascon 2003). *S. mentella* is found exclusively in subdivision 2GH, while both *S. mantella* and *S. fasciatus* may be found in subdivision 2J.

Populations of redfish are allopatric (separated geographically) for *S. mentella* and *S. fasciatus*. *S. mentella* is the northern range species off Labrador and Greenland. *S. fasciatus* is the southern range species on the Scotian shelf and the Gulf of Maine (Scott and Scott 1988; Gascon 2003). The ranges for *S. mentella* and *S. fasciatus* overlap in the Laurentian Channel and the Grand Banks (Gascon 2003).

In areas where *S. mentella* and *S. fasciatus* intermix, *S. mentella* is generally distributed deeper than *S. fasciatus* (Power and Mowbray 2000; Gascon 2003). The Gulf of St. Lawrence, the Laurentian Channel, Grand Banks, southern Labrador Sea and Flemish Cap comprised an area of symmetry separating the two allopatric zones. The introgression between the two species (*S. fasciatus* and *S. mentella*) is geographical limited to Unit 1 (redfish found in 4RST, 3Pn and 4Vn from January to May), Unit 2 (redfish from 3Ps,4Vs,4WFG and those in 3Pn4Vn from June to December) and the Flemish Cap where introgressed individuals persist with non-introgressed individuals of the two redfish species.

Redfish are a slow growing and long-lived species, with specimens having been aged at least to 75 years (Campana *et al.* 1990). S. fasciatus grows slower than S. mentella, with females of the species growing faster than males. Growth is usually faster in southern areas as compared to northern areas (Branton *et al.* 2003).

On the continental slopes of Labrador, redfish mature between 10 to 12 years, with mature females producing up to 40,000 eggs (DFO 2006e). Mating likely occurs during the late fall and early winter. Redfish are ovoviviparous with internal fertilization, which means that the fertilized eggs hatch inside the females and they give birth to live young (Scott and Scott 1988; Gascon 2003). Females carry developing embryos until spring (St. Pierre and de Lafontaine 1995; Gascon 2003; Morin *et al.* 2004). Following birth, larvae remain in shallow waters until they are approximately 25 mm, after which they move to deep waters over mud and rock substrates.

Redfish are pelagic or bathypelagic feeders, feeding primarily on zooplankton, including copepods, amphipods and euphausiids. Fish and crustaceans become more important in the diet as it increases in size. Feeding is believed to occur at night, when redfish rise off the bottom and feed on pelagic organisms in the water column (Scott and Scott 1988). Although this diel vertical migration is well documented, it is poorly understood (Gascon 2003). Redfish larvae feed almost exclusively on calanoid copepods (Runge and de Lafontaine 1996). Variability in the annual production cycle of these copepods can be an important factor in interannual differences in growth and survival of redfish larvae (Anderson 1994).

Redfish stock structure and resulting management strategies are complex due to the recognition of three species as well as the occurrence of introgressive hybridization individuals (Morin *et al.* 2004). The stock structure of redfish has recently been examined via parasite tagging and genetic analyses. The parasite tagging studies confirmed distinct redfish stocks occurred off Labrador and on the Flemish Cap (Marcogliese *et al.* 2003; Morin *et al.* 2004). The results of the parasite tagging studies are only partly supported by population genetic studies (Morin *et al.* 2004). Redfish species *S. mentella* has been placed on the Prioritized Candidate List by COSEWIC in October 2006 (COSEWIC 2006f).

American Plaice

American plaice (*Hippoglossoides platessoides*) is a bottom dwelling flatfish that resides on both sides of the Atlantic (DFO 2006f). American plaice that reside in the western Atlantic region range from the deep waters off Baffin Island and western Hudson Bay southward to the Gulf of Maine and Rhode Island (Scott and Scott 1988). In Newfoundland and Labrador waters, plaice occurs both inshore and offshore over a wide variety of bottom types (Morgan 2000). They are tolerant of a wide range of salinities and have been observed in estuaries (Scott and Scott 1988; Jury *et al.* 1994). Plaice are typically found at depths of approximately 90 to 250 m, but have been found as deep as 713 m. Most commercially harvested plaice are taken at depths of 125 to 200 m. They are a coldwater species, preferring water temperatures of 0°C to 1.5°C (Scott and Scott 1988). Tagging studies conducted on juvenile and adult plaice on the Grand Banks and in St. Mary's Bay showed that the species is sedentary, with most recaptures occurring within 48 km of release (Pitt

1969). However, older plaice have been known to move up to 160 km (Powles 1965). Migrations have been observed from Canadian waters to deeper offshore waters in the winter, returning to shallower water in the spring (Hebert and Wearing-Wilde 2002, in Johnson 2004).

In Newfoundland waters, American plaice spawn during the spring. The current age at sexual maturity for females in the area (2+3K) is approximately eight years with a length of maturity of approximately 30 cm (Busby *et al.* 2007). During spawning, large quantities of eggs (between 250,000 and 300,000) are released and fertilized over a period of days on the seabed (Johnson 2004). Eggs are buoyant and drift into the upper water column, where they are widely dispersed, allowing for some intermingling of stocks. Intermingling of adults is minimal. Hatching time is temperature dependent, occurring in 11 to 14 days at temperatures of 5°C (Scott and Scott 1988). Larvae are non-dorsally flattened and are 4 to 6 mm in length when they hatch. They begin to settle to the seabed when they reach 18 to 34 mm in length and their body flattens (Fahay 1983).

Larval plaice feed on phytoplankton and zooplankton while in the upper water column (Pitt 1989). When they have settled to the seabed, their diet changes as they grow, ingesting larger benthic organisms, depending on location. Small plaice (less than 30 cm) consume crustaceans and small echinoderms (Pitt 1973). Adult plaice generally consume large quantities of fish. Feeding intensity is highest during the spring and summer, likely to replenish energy stores lost during gonad development during the winter (Zamarro 1992).

American plaice has been placed on the Prioritized Candidate List by COSEWIC in October 2006 (COSEWIC 2006g).

Greenland Halibut

Greenland halibut (*Reinhardtius hippoglossoides*), commonly known as turbot, is a deep-water flatfish preferring temperatures of 0°C to 4.5°C (FAO 2007b). In the Northwest Atlantic, their range extends from Greenland to the Scotian Shelf and most are taken from depths greater than 450 m. Their depth range is from 90 to 1,600 m, with larger individuals occurring in deeper waters. Unlike most flatfishes, the Greenland halibut spends much of its time off the bottom, behaving as a pelagic fish (Scott and Scott 1988).

The spawning grounds of Greenland halibut (Boje 2002) are believed to be located southwest of Iceland (Sigurdsson 1979) and cover an extended area from Davis Strait, south of 67°N (Jensen 1935; Smidt 1969) to south of Flemish Pass off Newfoundland (Junquera and Zamarro 1994) between 800 and 2,000 m depths. Studies on the maturation and spawning of Greenland halibut have revealed a great deal of variability with the proportion of adult fish at size and age that maturation and spawning occurs exhibiting a high degree of geographic and temporal variation (Morgan and Bowering 1999). Large sized immature fish are common, fish in spawning condition over most months and fish skipping spawning seasons (Morgan *et al.* 2001). A study conducted by Morgan *et al.* (2001) found that variability in maturity estimates appears to be a feature common to all of the areas. Estimates of age and size at 50 % maturity were fairly similar across populations with the

exception of Division 2J3K which were higher (Morgan *et al.* 2001). The age and size at maturity estimated for the Div. 2J3K population are not unique as estimates from Russian surveys in the 1940's and 1960's of the northeast Arctic population were very similar (Kovtsova and Nizovtsev 1985).

Eggs tend to drift northward in the West Greenland current; however, those that get engulfed by the Arctic Current drift southwards along the coast of Baffin Island, Labrador and northeastern Newfoundland, colonizing continental banks and slopes along the way (Bowering 1982). The eggs are benthic, but upon hatching, the young move up into the water column and remain at depths near 30 m until they are approximately 70 mm in length. As they grow, young halibut move down the water column and are transported by the currents (Scott and Scott 1988). While maturing, Greenland halibut are thought to move to deep water and migrate north to the spawning area, suggesting a continuous stock throughout the range (Bowering 1982). Greenland halibut in the Northwest Atlantic are thought to be a relatively homogenous genetic stock; however, there is some evidence that genetic mixing does occur with stocks in the Gulf of St. Lawrence (Bowering 1982).

Sand Lance

Sand lance is a small fish found on sandy seabeds. It lives partially buried in the sand and occasionally rises into the water column to feed. It is found in the North Atlantic from Greenland to the Gulf of St. Lawrence and is typically found at depths of less than 91 m. The species of sand lance present in the Labrador Shelf SEA Area is the northern sand lance (*Ammodytes dubius)*; however, there is speculation about whether there are one or two species of sand lance in the SEA Area (DFO 2004b). It is generally accepted that the offshore, northern species is *A. dubius* and the inshore species *A. americanus* (= *A. hexapterus*), but the characteristics of the two species overlap (DFO 2004b). It co-occurs over much of its range with the American sand lance (*A. americanus*) (Scott and Scott 1988).

There is no information available regarding the time of spawning in the Labrador Shelf SEA Area, but in general, sand lance spawn during winter months in shallow waters (DFO 2004b). This species is not commercially fished, but is an important part of the marine food-web as it is a food source for marine mammals and several species of fish, including cod.

Arctic Cod

Arctic cod *(Boreogadus saida)* are circumpolar in distribution (DFO 2006h) and are found in Canadian waters of the Beaufort Sea, the Arctic Archipelago, Hudson Bay, Baffin Bay, along the Labrador coast, eastern Newfoundland coast, and the northern and eastern Grand Banks. Temperatures of 0°C to 4°C are believed to be optimal for the survival of Arctic cod, but they have usually been found in waters colder than 0°C and frequently near drifting ice (DFO 2006h). Off northern Labrador, the common length range of this fish is 25 to 30 cm with diminishing sizes in southern Labrador (10 to 25 cm) and off eastern Newfoundland (10 to 18 cm). These fish are found close to shore among ice floes and also offshore in depths greater than 900 m (DFO 2006h).

Both male and female Arctic cod are mature when about 20 cm long and three years of age. In northern Canadian waters, spawning is thought to occur in late autumn and winter (DFO 2006h). Fully mature, female Arctic cod produce eggs ranging from 1.5 to 1.9 mm in diameter, releasing 9,000 to 21,000 eggs (DFO 2006h). Spawning occurs under the Arctic ice cover and fertilization is external.

Arctic cod are the main consumers of plankton in the Arctic seas (DFO 2006h). Small Arctic cod, 4 to 6 cm long, feed mainly on the eggs and larvae of copepods and adult amphipods (DFO 2006h). Intermediate sized fish (8 to 12 cm) feed on copepods, amphipods, and euphausiids. Fish more than 12 cm in length feed on copepods, amphipods, and arrow worms. Large Arctic cod feed on plankton organisms and are cannibalistic, feeding on smaller members of their own kind (DFO 2006h).

The abundance of Arctic cod in the Canadian Arctic is unknown.

Rock Cod

Rock cod (*Gadus ogac*) (Greenland cod) is an Arctic to subarctic species whose distributions includes the Labrador Shelf SEA Area. They are found inshore at depths ranging from 0 to 200 m, but are rarely found in deeper water or offshore (FAO 2007c; Nielsen and Andersen 2001). While rock cod are tolerant of low salinities, there is no evidence that it enters freshwater (FAO 2007c).

Rock cod are relatively short lived, seldom living beyond nine years. Fish aged five to six years attain lengths of approximately 50 cm and rarely exceed 60 cm total length (FAO 2007c). It matures at approximately three to four years of age before spawning in shallow waters from February to May. After fertilization, eggs sink to substrate.

Rock cod spawn their demersal eggs in close proximity to nursery areas resulting in the larvae remaining in the area they were spawned (Laurel *et al.* 2003). As juveniles, rock cod associate with complex habitats and in particular eelgrass, for protection from predators (Laurel *et al.* 2003a). The structurally complex habitats impair the visual and swimming capabilities of predators, which in turn can reduce the effectiveness of encountering, attacking, and capturing prey (Laurel *et al.* 2003a). High densities of rock cod were found associated with eelgrass, suggesting it was the preferred nursery habitat (Laurel *et al.* 2004). Eelgrass often supports higher densities of food, namely in the form of pelagic and epiphytic zooplankton. Macrophytes also reduce the risk of predation for young fish from larger fish (Laurel *et al.* 2003a; Laurel *et al.* 2004).

Rock cod is an omnivorous opportunist (Nielsen and Andersen 2001) very similar to Atlantic cod. An adult diet is primarily comprised of capelin as well as other demersal species (Nielsen and Andersen 2001). Crustacea, polychaeta, mollusca, and echinodermata are important for juvenile and small rock cod and become less important as the fish grows (Neilsen and Andersen 2001).

Witch Flounder

Witch flounder (*Glyptocephalus cynoglossus*) are a deep water flatfish, also known as greysole, and occur in the Northwest Atlantic from Hamilton Inlet in Labrador (northern limits for this species) south to Cape Hatteras. They are plentiful in the Hawke Channel (DFO 2006i). Witch flounder prefer living in gullies where the bottom is usually of clay, muddy sand, or pure mud rather than the hard tops of the banks and inshore ground. In summer they usually move up onto the soft mud and in winter move down into the deeper gullies. They are usually found offshore, in moderately deep water, mainly at depths of 45 to 275 m, water temperatures of 2°C to 6°C and do not migrate (Scott and Scott 1988; Cargnelli *et al.* 1999). Witch flounder are a slow growing, long lived species that have been aged over 20 years old (Maddock-Parsons 2005).

The prey of witch flounder are marine worms as well as small crustaceans or shellfish similar in shape to shrimp (DFO 2006i). Small pieces of clam shells are also found in witch flounder stomachs and occasionally small fish are found in large witch founders (DFO 2006i).

The spawning is rather extensive throughout the Northwest Atlantic and occurs in late spring to late summer, depending upon the geographical area of the spawning grounds (DFO 2006i). Spawning usually takes place in deep waters where temperature conditions are rather high. The spawning period is less extensive in the north areas than in the south. The pelagic or midwater stage in the life history of witch flounder is longer than any other of the pleuronectine flatfishes and may continue anywhere from four months to one year (DFO 2006i). During this time, eggs and larvae from spawning grounds in the northern areas drift southward in the fast Labrador current over great distances to settle in water where temperatures are suitable for survival. Eggs and larvae on the southern banks probably do not drift far because of the slow currents, which move in a more circular fashion. On occasion, however, eggs have been found floating over oceanic depths (DFO 2006i).

Lumpfish

Lumpfish (*Cyclopterus lumpus*) are considered groundfish that range on both sides of the North Atlantic. In the Northwest Atlantic, lumpfish range from Greenland south to Chesapeake Bay (DFO 2006j).

The species is benthic, found on rocky substrates between 50 and 150 m, occasionally to 400 m. It may also occur in floating seaweed (MI 2007c). It is distinguished by its short stout body, which is covered by hard wart-like protrusions (tubercles) (MI 2007c). The caudal fin is broad based and square tipped. The pectorals, larger on males, are rounded and nearly meet on the throat (Bigelow and Schroeder 2002). The pelvic fins of the species are modified and united by a circular flap of skin, thus forming a sucking disc and enabling lumpfish to adhere to the bottom or to floating objects (MI 2007c), such as rocks, lobster traps, and other solid objects (DFO 2006j).

Lumpfish undergo a coastal migration for spawning, which takes place in May and June (DFO 2006j). Lumpfish feature sexual dimorphism, with male lumpfish considerably smaller than the females. Males arrive on the spawning grounds several weeks in advance of the

females to establish their territories. The females lay two to three egg masses at intervals ranging from 8 to 14 days. Once the eggs are deposited, females migrate back to deeper water, leaving the males to guard and fan the egg masses (DFO 2002c; 2006h). Egg mass may contain more than 100,000 to 130,000 eggs measuring 2 mm in diameter with one oil globule and light green to yellowish in colour. Juveniles are semi-pelagic, remaining in the top metre of the water column for their first year, during which they are often associated with floating algae.

The diet of lumpfish consists mainly of small shrimp and crustaceans, jelly fish, small fish, and worms (MI 2007c).

5.3.4.2 Skates

There are 13 known species of skate (Family Rajidae) found in the Northwest Atlantic; however, many are rare and do not make an important contribution to the fishery (MI 2007b). Of these 13 species, the two most abundant species are thorny (*Raja radiate*) and smooth (*Raja senta*) skate. These two species account for approximately 95 % of skate landings and are described in greater detail in the following sections (MI 2007b).

Thorny Skate

Thorny skate (*Raja radiate*) are a temperate to Arctic species, widely distributed in the North Atlantic from Greenland to South Carolina (Kulka *et al.* 2006). Thorny skate have been observed over a wide range of depths, from nearshore to 1,700 m, with most of its biomass noted to occur between 50 to 150 m (Kulka and Miri 2003a). They are observed on both hard and soft substrates (Kulka *et al.* 1996) and are primarily associated with muddy, sandy, and pebble substrates (Kulka and Miri 2003a).

The life span of the thorny skate has not been studied, but data from tagging studies indicate they may live for 20 years or more (DFO 2003a; Kulka and Miri 2003a). Information is lacking on most aspects of the population dynamics of thorny skate. Thus, it is not possible to undertake age-based analyses or estimate the spawning stock biomass with any certainty. Males have been found to mature at smaller sizes than females, with size at maturity increasing from north to south. Ovaries of sexually mature females hold 10 to 12 pairs of eggs in various developmental stages (Kulka and Miri 2003a). Thorny skate deposit 6 to 40 egg cases per year (DFO 2003a). Larger females produce larger egg cases, but it is not known if egg case size is related to survival rates (Kulka and Miri 2003a).

Thorny skate feed on a variety of invertebrates including polychaetes, crabs, and whelks (Kulka and Miri 2003a). The diets of larger skates include fish prey such as sculpins, redfish, sand lance, and small haddock. Considerable amounts of fish offal have been found in skate stomach and this, coupled with the ventral mouth location, suggests that thorny skate are opportunistic bottom feeders. There is limited information regarding thorny skate predation, suggesting they are prey to large predators such as seals, sharks and Atlantic halibut.

Thorny skate is currently under review by COSEWIC.

Smooth Skate

Smooth skate (*Malacoraja senta*) is found along the Atlantic coast of North America, ranging from the Gulf of St. Lawrence and Labrador shelf to South Caroline (Packer *et al.* 2003). They live on soft mud and clay bottom, often in deep troughs and basins (Scott and Scott 1988). It is found at depths ranging from 46 to 457 m, with greatest abundances noted below 110 m (Swain and Benoit 2001).

There is limited knowledge available on the life history of the smooth skate. Their diet is comprised of amphipods, mysiids, decopods, euphausiids, and fish species including yellowtail flounder (*Limanda ferruginea*), hake, witch flounder, and sand lance (Packer *et al.* 2003).

Smooth skate is currently under review by COSEWIC with the species schedule to be assessed in May 2008.

5.3.4.3 Demersal Sharks

Six species of small dogfish are resident in Canadian waters, with the spiny dogfish (*Squalus acanthius*) and black dogfish (*Centroscyllum fabricii*) the most abundant. Other demersal sharks in Canadian waters include the smooth dogfish (*Mustelus canis*), Portuguese shark (*Centroscymnus coelolepis*), deepsea cat shark (*Apristurus profundorum*) and great lantern shark (*Etmorpterus princes*).

Spiny Dogfish

The spiny dogfish is a widely distributed, boreal to warm temperate species distributed over continental and insular shelves and upper slopes of the Pacific and Atlantic Oceans (Kulka 2006). Their western Atlantic distribution ranges from Labrador to Florida, with their centre of abundance located between the southern Scotian Shelf and Cape Hatteras. Spiny dogfish concentrate at bottom depth of 10 to 200 m in water ranging between 7°C to 15°C. Thus, the spiny dogfish are at the northern limit of their distribution in Newfoundland and Labrador waters. Mature adults congregate in the warmest available water (>5°C).

Spiny dogfish distributions are patchy and they form dense aggregations, causing high variability in survey indices. The absence of young juveniles coupled with survey abundance variability suggests that the early life history stages (pupping and juveniles) occur elsewhere and, as such, the spiny dogfish on the Grand Banks are not independent stock.

The spiny dogfish is an omnivorous opportunistic feeder. The diet consists of small fish [capelin, cod, haddock, hake (*Urophycis tenuis*), and herring] and invertebrates (krill, crabs, polychaete worms, jellyfish, ctenophores, amphipods, squid, octopus) (Campana 2007). It is preyed upon by larger sharks and marine mammals (Grimm *et al.* 2004).

Spiny dogfish is currently under review by COSEWIC.

Black Dogfish

Black dogfish is distributed along the slopes of the Atlantic Ocean Basin, ranging from Greenland down to Cape Hatteras, possibly Florida and into the Gulf of Mexico (Kulka 2006). It is a bathydemersal species, resident in waters as shallow as 300 m but generally found in water deeper than 500 m. Black dogfish reside in the warmest available bottom temperatures (73.8°C).

Relative abundance estimates are problematic as large portions of the black dogfish occupy depths that exceed the range surveys (pre-1995) (Kulka 2006). Black dogfish exhibit a highly structured distribution with a degree of separation by life stage. Large pregnant females migrate to shallow waters in the Laurentian Channel, where pupping occurs. The young migrate in to deeper waters of the channel where, as they mature, they migrate out of the Laurentian Channel in to the slope waters. They may migrate considerable distances to the Labrador Shelf. As they continue to grow, they continue to move into deeper waters.

Black dogfish are primarily by-catch in Greenland halibut, crab, redfish, monkfish (*Lophius americanus*), and witch flounder fisheries and will not be discussed in the commercial and Traditional Fisheries section (6.7).

5.3.4.4 Pelagics

Atlantic Salmon

Atlantic salmon (*Salmo salar*) are anadromous fish, living in freshwater rivers for the first two years of life before migrating to sea. It is an iteroparous species, meaning it can spawn repeatedly, as opposed to most species of Pacific salmon (*Onchorhynchus* spp.), which are semelparous and die after one spawning (Schaffer 1974, in O'Connell *et al.* 2006; Flemming and Reynolds 2004, in O'Connell *et al.* 2006).

Atlantic salmon return annually to their natal river or tributary for spawning. Both post-smolt (juvenile) and adult salmon migrate from northeastern North America in the spring and summer to waters off Labrador to overwinter. While at sea, adult salmon were found spending a considerable amount of time in the upper portion of the water column (Reddin 2006). Tagging studies of post-smolts also showed them spending most of their time near the surface, but undergo deep dives, likely in search of prey (Reddin *et al.* 2006).

While still in the river, post-smolts mainly eat aquatic insect larvae, including caddisflies and blackflies. Adults at sea consume euphausiids, amphipods, and fish such as herring, capelin, small mackerel, sand Lance, and small cod. When salmon return to freshwater to spawn they do not eat (Scott and Scott 1988). Mortality sources of salmon while at sea are poorly known (Reddin 2006), but it is known that they are prey for seals, sharks, Pollock, and tuna (Scott and Scott 1988).

Atlantic salmon was placed on the prioritized candidate list by COSEWIC in October 2007 (COSEWIC 2007d).

Arctic Char

Arctic char (*Salvelinus alpinus*) have a circumpolar distribution in the northern hemisphere (DFO 2001a). They are either anadromous or resident freshwater fish, with a higher predominance of resident fish further south, while anadromous populations are common in northerly regions (DFO 2001a). In Labrador, anadromous populations increase in frequency with latitude as they are replaced by sea-run brook charr and Atlantic salmon in southern areas (DFO 2001a).

Seaward migration for northern Labrador Arctic char commences with spring runoff and ice break-up in coastal rivers (DFO 2001a). Migrations consist of both first-time and repeat migrants with first time migrants being between two to seven years and 10 to 20 cm in length. Seaward migration for Arctic char is short and irregular, with both juveniles and adults spending only one to four months at sea before returning to fresh water (DFO 2001a). Ocean migrations are also spatially limited, with few Arctic char moving less than 100 km from home rivers. The return migrations occur from July to September, with large mature charr returning first followed by non-mature adults then juveniles (DFO 2007e).

Northern Labrador Arctic char mature at younger ages and smaller sizes than other charr stocks from northern Canada (DFO 2001a). Spawning takes place in the fall, commencing by mid-October, and occurs in either lakes or streams and is not dependent on any particular substrate (DFO 2001a). Female's lay approximately 290 eggs per 100 g of body mass (DFO 2001a). Growth rates are slow during the freshwater stage of the life cycle, with the adult size-at-age being highly variable, dependent on age of first sea migration and the number of migrations the charr has taken (DFO 2001a). In Labrador, females begin to mature at approximately six years, with most spawning at least once by the age of nine (DFO 2001a).

Arctic char are opportunistic predators while at sea, with diet varying over spatial areas. Sand lance, capelin, sculpins and hyperiid amphipods are the four main species of prey for Arctic char within the Labrador Shelf SEA Area (DFO 2001a).

Capelin

Capelin (*Mallotus villosus*) is a small pelagic species that has a circumpolar distribution in the Northern Hemisphere (DFO 2006g). Although this Arctic-boreal species has evolved to live at the edge of Arctic waters exploiting the feeding opportunities, capelin require higher temperatures for successful reproduction (Rose 2005). Distributions in cold water are not free of risk as capelin have been observed to freeze to death off Labrador, presumably when they contact ice crystals in super-cooled water (Rose 2005).

They are members of the smelt family (Osmeridae), olive in colour, with an elongated body and exhibit pronounced sexual dimorphism during spawning. Capelin is found along the coasts of Newfoundland and Labrador and on the Grand Bank.

Migration towards the coast precedes spawning on beaches or in deeper waters (DFO 2006g). Capelin roll on sandy or fine gravel beaches in water temperatures ranging between 6°C to 10°C. Beach spawning is more prevalent at night. During spawning, the thermal

range of capelin typically shifts upwards (Rose 2005). Beach spawning occurs at 2°C to 10°C, but deepwater spawning is restricted to about 2°C to 7°C, most likely occurs from 2°C to 5°C (Rose 2005). Capelins are able to spawn at the age of two and males usually die following spawning. Spawning is typically in late June and early July, although it was somewhat later in the 1990s (Carscadden *et al.* 1997, 2001).

Eggs are red in colour, 1-mm diameter, and are attached to the substrate. Incubation varies with ambient temperature and lasts approximately 15 days at 10°C. Larval capelin is plankton and remains near the surface until the onset of winter.

Capelin is a major components in the marine ecosystem dynamics as they facilitate the transfer of energy between trophic levels, principally between primary and secondary producers to higher trophic levels (DFO 2006g). Capelin prey consists of planktonic organisms comprised of primarily euphausiids and copepods. Capelin feeding is seasonal with intense feeding late winter and early spring leading up to the spawning cycle when feed ceases. Feed recommences several weeks after cessation of spawning.

Capelin predators comprise most major fish species including Atlantic cod, haddock, herring, flatfish species, dogfish and others. Several marine mammal species, including minke whales (*Balaenoptera acutorostrata*), fin whales, harp and ringed seals (*Phoca hispida*), as well as a variety of seabirds, also prey on capelin.

In the 1990s capelin underwent dramatic changes in distribution, size, and maturity at age, and time and duration of spawning (Carscadden *et al.* 1997). Together, the changes represent biological responses to a colder, less favourable environment. The physical environment cooled throughout the 1980s, reaching a historical minimum in 1991 (Colbourne, 2000). Since 1991, the environment has been warming, returning to near-normal conditions by the mid-1990s with 1996 being one of the warmest years on record. Capelin avoid cold Arctic water in which the copepod fauna is dominated by Calanus hyperboreus and Metridia longa (Anderson *et al.* 2002). There appears to be a lag in the distributional response of capelin to improved environmental and feeding conditions (Anderson *et al.* 2002). In general as water temperatures rise, northward shifts in capelin distribution can be expected, with more southerly grounds abandoned (Rose 2005). Thus, changes in capelin distribution may be expected to have a direct impact on the many species that feed on them.

During the early 1990s, capelin exhibited large-scale changes in distribution within and outside their normal range that have been linked to colder ocean temperatures (Carscadden *et al.* 2002). During this period, capelin essentially disappeared from Div. 2J adjacent to the Labrador coast, to occupy an area to the south on the northern Grand Banks (Carscadden *et al.* 2001).

The primary cause of capelin mortality is associated with predation and as such, variations in capelin abundances are directly linked to natural causes (DFO 2006g). Capelin has a short life span (usually five years or less) and abundances are linked to a few age classes.

Management of capelin fisheries tends to be conservative because of the prominent role of capelin in the marine ecosystem.

Herring

Herring is a pelagic, schooling fish, usually occurring in shallow inshore waters. It also occurs offshore from the surface to depths of 200 m. There are a number of separate herring populations in the Northwest Atlantic and each has preferred spawning, feeding, and wintering grounds.

The time and location of spawning depends of the herring stock. Most stocks spawn in spring or fall (Scott and Scott 1988). Herring are demersal spawners, depositing their eggs on stable substrates in high energy environments with strong tidal currents (Iles and Sinclair 1982, in Stevenson and Scott 2005). Spawning can occur on offshore banks at depths of 40 to 80 m; however, most herring stocks spawn in shallow coastal waters at depths of less than 20 m. In Newfoundland waters, it appears that herring spawn in coastal waters only. For coastal spawning stocks, spring spawning usually occurs in shallower waters than fall spawning (LGL Limited 2005b). Tibbo (1956) found that the main spawning locations in Newfoundland waters are found at the heads of bays and deepwater inlets. Herring larvae are pelagic. The larval stage of fall-spawned herring is much longer than spring spawned herring, lasting through the winter months (Scott and Scott 1988). The larvae of some stocks have been shown to stay very close to where they were hatched, a result of the formation of tidally induced retention areas that prevent larvae from being dispersed by water currents (MI 2007a). The length of time it takes for larvae to metamorphose into juvenile herring is dependent on water temperature and the food availability (MI 2007a). Larvae are very light sensitive, seeking deeper waters on bright days (Scott and Scott 1988).

5.3.4.5 Shellfish

Commercially important shellfish of the Study Area include the Icelandic scallop (*Chlamys islandica*), northern shrimp (*Pandalus borealis*), snow crab (*Chionoecetes opilio*), toad crab, and whelk.

Iceland Scallops

The Iceland scallop (Chlamys islandica) is typically found at depths of 50-200 m in the waters off Newfoundland and Labrador, on hard substrates including gravel, stones, shells, and sand (DFO 2010d). In these waters, Iceland scallops prefer high salinity in areas with little wave energy. The species makes use of byssal threads which allow it to maintain its position in areas of strong currents. The Iceland scallop maintains separate sexes, with sexual maturation occurring at three to six years of age. Temperature variations initiate the onset of spawning in Newfoundland and Labrador in April-May, and larval forms have a planktonic stage persisting for up to ten weeks. Iceland scallops form aggregations of up to 100 individuals/m^2 in areas where currents allow larvae to settle together. Once settled, it can take an individual up to eight years to reach commercial size, but lifespans frequently exceed 25 years.

The spawning season for Iceland scallop is short, from April to August, and varies geographically (Wallace 1981; Crawford 1992). Sexes are separate, distinguishable by gonad colouration. Female fecundity is proportional to its size cubed (Pederson 1994). After fertilization, larvae are dispersed throughout the water column, with development taking approximately five weeks. Juveniles then attach to the seabed in proximity to the adults (DFO 2007d).

Snow Crab

Snow crab (*Chionoecetes opilio*) occurs over broad depths in the Northwest Atlantic, from Greenland to the Gulf of Maine. Distribution is widespread on the Newfoundland and Labrador shelves (DFO 2005b). Commercial-size crabs commonly occur on mud or sand substrates (DFO 2005b) at depths of 70 to 280 m (Elner 1985) at temperatures of -1°C to 5°C (Fisheries Resources Conservation Council [Fisheries Resources Conservation Council (FRCC)] 2005). Smaller crabs are also found on harder substrates (DFO 2002b). There are indications that snow crabs move from gravel bottom to mud bottom, usually in deeper waters, as they reach maturity (DFO 1993b). Snow crabs grow by moulting their shells in the spring. Females cease moulting upon achieving sexual maturity, between 40 to 95 mm carapace widths (CW). Conversely males may continue moulting until their terminal molt sometime in adulthood, between approximately 40 to 115 mm CW (DFO 2005b).

There is little or no information on the offshore snow crab migrations. Offshore mating is known to occur during the late winter or spring; however the actual area is unknown. Most females reach terminal moult sometime between December and April (FRCC 2005). M ost adolescent males reach terminal moult and maturity in the early spring but a small percentage does moult during the winter (FRCC 2005). First time mating generally takes place from February to mid-March, following the terminal moult (FRCC 2005). Mating by repeat spawners occurs later in the spring, sometime between April and June (FRCC 2005). It is believed that first-time spawners (primiparous) are less productive than the repeat (multiparous) spawners (FRCC 2005).

Depending on size, females lay between 20,000 to 150,000 eggs deposited on hairy appendages under the abdomen. Fertilized eggs are carried for approximately two years. During this period, the eggs change colour from bright orange to dark purple or black (DFO 1993). The eggs hatch in the late spring or early summer and larvae may spend two to eight months depending on temperature and planktonic food supply before settling to the seabed (DFO 2002b; FRCC 2005). Once on the bottom, snow crabs go through a series of moults, with growth of approximately 20 % between moults. It takes 5-10 years for male snow crab to reach legal size (95-mm carapace width). The full natural life cycle for snow crabs is approximately 15 years (FRCC 2005).

Snow crab feed on fish, clams, benthic worms, brittle stars, shrimps, and crustaceans, including smaller snow crabs. Feeding activity is apparently higher at night (DFO 1993b). Predators include various groundfish and seals (DFO 2002b).

Northern Shrimp

Northern or pink shrimp (*Pandalus borealis*) distributions in the Northwest Atlantic range from the Davis Strait to the Gulf of Maine. They occupy soft muddy substrates up to depths of 600 m in temperatures of 1°C to 8°C. Larger individuals generally occur in deeper waters (DFO 2006d). Shrimp undergo a diel vertical migration, moving off the bottom into the water column during the day to feed on small pelagic crustaceans. They migrate up the water column at night, feeding on pelagic copepods and krill (DFO 2006d). Female shrimp also undergo a seasonal migration to shallow water where spawning occurs (DFO 2006d). Northern shrimp are a protandric hermaphrodite, meaning that it first functions sexually as a male, undergoes a brief transitional period, and spends the rest of its life as a female (DFO 2006d). Eggs [2,400 for the average female (Haynes and Wigley 1969)] are laid in the summer and remain attached to the female until the following spring, when the female migrates to shallow coastal waters to spawn (Nicolajsen 1994, in Ollerhead et al. 2004). The hatched larvae float to the surface feeding on planktonic organisms (DFO 2006d).

As with most crustaceans, northern shrimp grow by moulting their shells. During this period, the new shell is soft, causing them to be highly vulnerable to predators such as Greenland halibut (turbot), cod (DFO 2006d), Atlantic halibut, skates, wolfish, and harp seals (*Phoca groventandica*) (DFO 2000b). Northern shirimp are vulnerable to these predators regardless of whether they have a soft shell.

Whelk

Whelks are gastropod molluscs, characterized by a spiral shell and large foot muscle. The species harvested in Newfoundland and Labrador waters is the waved or rough whelk (*Buccinum undatum*). It occurs in the Northwest Atlantic from the Arctic to New Jersey on a wide range of substrates and is very common on mud and sand (Newfoundland and Labrador Department of Fisheries and Oceans (NLDFA) 2006). Young are common in tide pools and shallow water. Adults can inhabit depths to 200 m and commonly grow to approximately 6.4 cm in length (Gosner 1978). They produce round egg masses that adhere to rocks and wash onshore during storms (Gosner 1978; Harvey-Clarke 1997).

Whelks are carnivorous. Fragments of polychaetes, bivalves and urchins found in whelk stomachs, suggesting they are active predators but also feed on opportunistic scavengers. Predatory behavior is almost never observed in the field. The suggestion that whelks are scavengers is based on their infrequent feeding, high mobility, and capacity to detect and locate dead animals on the seabed. They have been frequently observed approaching seastars feeding on bivalves, preying on the remains left by the seastars (Himmelman and Hamel 1993).

Toad Crab

Toad crab (spider crab) is comprised of two species *Hyas araneus* and *H. coarctatus*. Toad crab is common on all types of substrate, with *H. araneus* preferring soft bottom while *H. coarctatus* is more common on hard bottom (Squires 1990). Toad crab has an uneven carapace surface with four pairs of round, tubular walking legs. Their carapace is approximately $1^1/_3$ times longer than wide; up to a maximum carapace width of approximately 100 mm and a spread of 450 mm. Their maximum weight is approximately

0.7 kg. Toad crab is widespread on both sides of the north Atlantic; from low water to about 1650 m; in the Gulf of St. Lawrence, Bay of Fundy, Nova Scotia and Newfoundland and Labrador. They are very common at intermediate depths, overlapping rock crab and snow crab zones.

Porcupine Crab

The porcupine crab *(Neolithodes grimaldii*) is one of 79 members of the King Crab family, but only one of two species from this family that reside in waters off Atlantic Canada. It is a deep-water crab found on the seabed floor at depths between 800 to 2,000 m(Squires 1965). It is often found along the continental slope on both sides of the Atlantic Ocean ranging from North Carolina to Greenland in the western Atlantic and from Iceland and the British Isles to the Azores and Cape Verde Islands in the eastern Atlantic (Squires 1965). It is believed that the porcupine crab is carnivorous, feeding on snails and mussels (Squires 1965).

5.3.5 Marine Associated Birds

The avian biodiversity of marine Labrador is heavily influenced by the oceanic effects of the Labrador Current. Several species of seaducks and seabirds use the Labrador coast for breeding, overwintering, or as a migratory or moulting stopover. Many of the breeding marine species nest on the 4,000+ islands off the coast.

The sections that follow provide a general summary for bird species that are likely to occur within the Study Area. Species listed under *SARA* are discussed in Section 5.4. COSEWIC status species are discussed in Section 5.4.

5.3.5.1 Seabirds

During the summer, there are two main seabird communities in Labrador: the surface-feeding omnivorous gulls and the mostly fish-eating diving auks. The area is used by both communities for breeding in summer, as well as for migration, moulting, and, in a few cases, overwintering. Seabird observation locations are presented in Figure 5.11.

Fish is the primary food source for almost all of the seabirds in this area; however, diets also include crustaceans, cephalopods, copepods, amphipods and offal. Foraging strategies of seabirds within the Study Area include aerial plunge diving, using flight-like movements below the surface (*e.g.,* shearwaters), pursuit diving (typical of murres), dipping, or surface feeding (i.e. gulls and phalaropes), kleptoparasitism (*i.e.,* stealing food from other animals as done by jaegers and skuas) and surface plunging (*e.g.,* terns). Foraging strategies and diets of seabird species in the Labrador Shelf area are provided in Table 5.4.

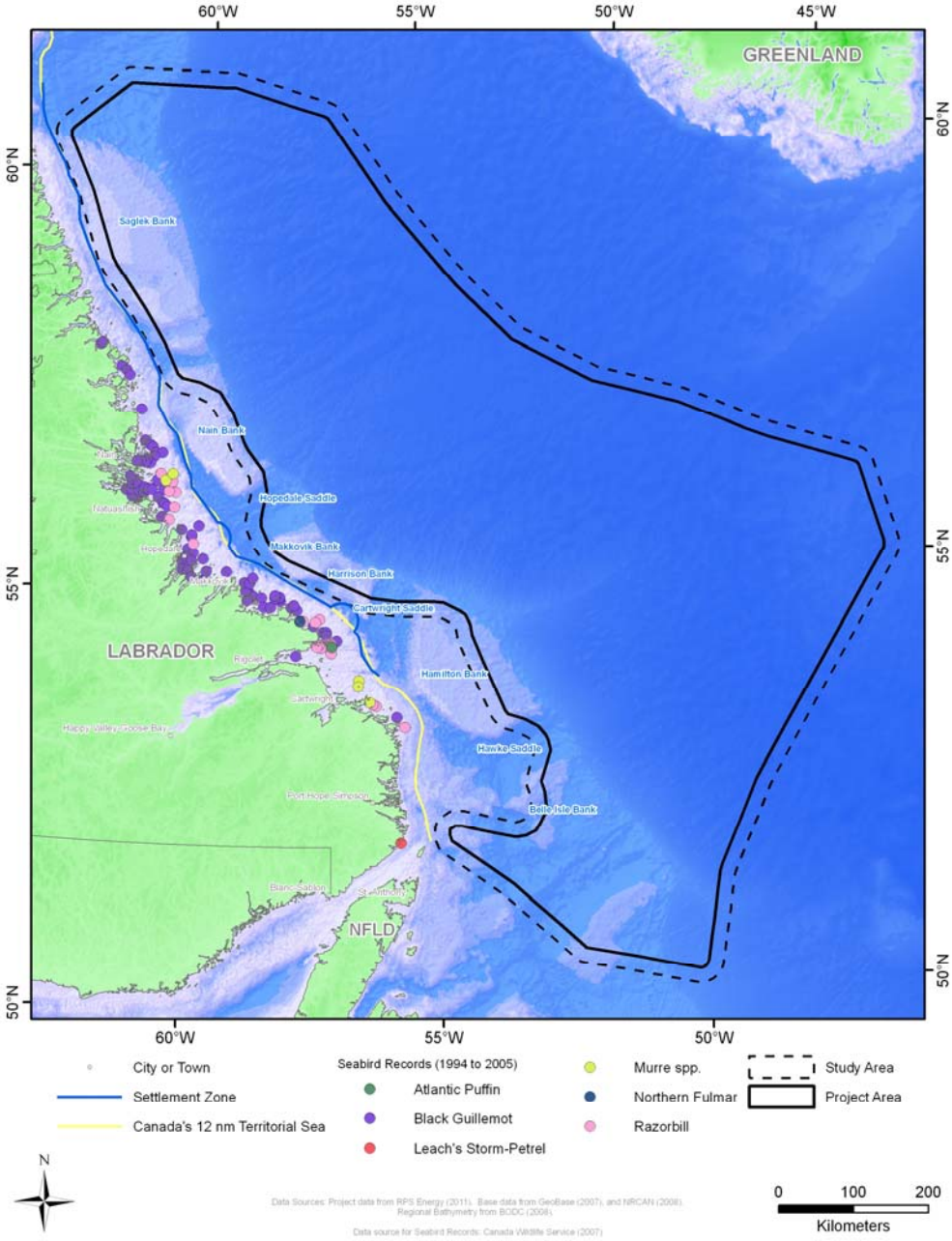

Figure 5.11 Seabird Observation Records 1994 to 2005

Table 5.4: Foraging Strategy and Diet for Seabirds Known on the Labrador Shelf Area

Species (Group)	Foraging Strategy	Diet
Procellariiformes		
Northern Fulmar	D	Fish, cephalopods, crustaceans, offal
Sooty Shearwater	D, PP	Fish, squid, crustaceans, offal
Leach's Storm-Petrel	D	Fish, amphipods
Wilson's Storm-Petrel	D	Fish, amphipods
Manx Shearwater	D, PP	Fish, squid, crustaceans
Pelecaniformes		
Double-crested Cormorant	PD	Fish, squid
Great Cormorant	PD	Fish, squid
Northern Gannet	AP	Fish, squid
Charadriiforms		
Black-legged Kittiwake	D	Fish, cephalopods, crustaceans, offal
Glaucous Gull	D, SC	Fish, cephalopods, crustaceans, offal
Great Black-backed Gull	D, SC	Fish, cephalopods, crustaceans, offal, eggs, chicks, birds
Herring Gull	D, SC	Fish, cephalopods, crustaceans, offal, eggs, chicks, birds
Ring-billed Gull	D, SC	Fish, cephalopods, crustaceans, offal
Iceland Gull	D, SC	Fish, cephalopods, crustaceans, offal
Ivory Gull	D, SC	Fish, cephalopods, crustaceans, offal
Long-tailed Jaeger	D, K, SC	Fish, invertebrates, offal, vertebrates, chicks
Parasitic Jaeger	D, K, SC	Fish, crustacean, invertebrates, offal, vertebrates, chicks
Pomarine Jaeger	K, SC	Fish, birds, vertebrates, chicks
Great Skua	K, SC	Fish, vertebrates, chicks
Red-necked Phalarope	D	Copepods, invertebrates, crustaceans
Terns	D, SP	Fish, crustaceans
Atlantic Puffin	PD	Fish, invertebrates
Black Guillemot	PD	Fish, invertebrates
Dovekie	PD	Amphipods, copepods
Common Murre	PD	Fish, invertebrates
Thick-billed Murre	PD	Fish, invertebrates
Razorbill	PD	Fish, invertebrates
Source: The Birds of North America Online (http://bna.birds.cornell.edu); CWS data; Sibley 2000. Foraging Strategy: D – Dipping (Surface Foraging); SP – Surface Plunging; PP – Pursuit Plunging; AP – Aerial Plunge Diving; K – Kleptoparasitism; PD – Pursuit Diving; SC – Scavenging		

Most of the seabirds in the Labrador Shelf area, including the Study Area, are colonial nesters, sharing breeding space with others of the same species and often with other species. Razorbill (*Alca torda*), Atlantic Puffin (*Fratercula arctica*), Common and Thick-billed

Murres (*Uria aalge* and *Uria lomvia*) and Black Guillemot (*Cepphus grille*) nest along islands along the Coast of Labrador.

The Labrador Shelf area features the highest breeding concentrations of Razorbills in North America (Chapdelaine *et al*. 2001). The largest colony of Razorbills in eastern North America, with an estimated 5,400 pairs (almost a third of the eastern North American population) is located on the Gannet Islands (North American Important Bird Areas 1999).

Northern Fulmars (*Fulmarus glacialis*) spend most of the year at sea, and are known to breed on the Gannet Islands. A study by Mallory *et al*. (2008) tracked five Northern Fulmars and found that the birds tended to remain in the Labrador Sea (between 50° and 55° N) from December to March. This suggests that the Labrador Sea is a key wintering area for fulmars from the high Arctic, which is inclusive of the Study Area.

Sooty Shearwater (*Puffinus griseus*) use the waters off the coast of Labrador during migration, as does the Leach's Storm Petrel (*Oceanodroma leucorhoa*) and the less common Wilson's Storm-Petrel (*Oceanites oceanicus*) (Brown 1988). Petrels are known to breed, albeit in low numbers, on islands off Labrador. Leach's Storm-Petrels are known to breed in a variety of habitats on marine islands, ranging from open grasslands to heavily-canopied coniferous forests (Huntington *et al*. 1996).

The Manx Shearwater (*Puffinus puffinus*) spends most of its life in the water, only coming ashore to breed at offshore nesting colonies (Lee and Haney 1996). The colony of Manx Shearwaters at Middle Lawn Island is the only known active breeding colony of this burrowing seabird in North America. However, recent research suggests that Manx Shearwaters also occur on multiple islands along the south coast of the Burin Peninsula (Roul 2010).

Great Cormorant (*Phalacrocorax auritus*) is known to winter along the coast of southern Labrador, while the Double-crested Cormorant will summer at the same location. There are also rare records of the Double-crested Cormorant around Hamilton Inlet (Chaulk *et al*. 2004).

Of the six major breeding colonies of the Northern Gannet (*Morus bassanus*) in North America, three exist on the Atlantic coast of Newfoundland, with the colony on Funk Island (50 km northeast of Cape Freels) being the closest to the Study Area. Northern Gannets breed in dense colonies on remote and relatively inaccessible coastal cliffs, stacks, and islands, or less frequently on precipitous inaccessible cliffs of mainland, within foraging distance of their principal prey (herring and mackerel). During breeding season, adult breeders and sub-adult non-breeders range extensively within the waters of the North Atlantic, having been reported from the Bay of Fundy, off of the Labrador coast, southwest of Greenland, regularly in the Strait of Belle Isle, and throughout the Gulf of St. Lawrence (Mowbray 2002).

Terns and gulls nest in small colonies along the coast in the Labrador Shelf (Figure 5.12). Common Tern (*Sterna hirundo*) and Arctic Tern (*Sterna paradisaea*) colonies are known to occur off the coast of Labrador. There are also occasional records of the less common Caspian Tern (*Sterna caspia*) (Chaulk *et al*. 2004). Terns usually nest in the interior and vegetated portions of offshore islands. Several gull species are known to occur off the coast of Labrador including Black-legged Kittiwake (*Rissa tridactyla*), Great Black-backed Gull (*Larus marinus*), Herring Gull (*Larus argentatus*), Ring-billed Gull (*Larus delawarensis*), and Glaucous Gull (*Larus hyperboreus*). The Black-legged Kittiwake nests particularly on cliffs, while the other species are capable of nesting anywhere on an island. Although Kittiwakes breed on the Gannet Islands, populations are quite small relative to the remainder of the North American range (tens of pairs compared to approximately 100,000 pairs in other areas in Nunavut and off Newfoundland/Quebec). This 'gap' in the range of Kittiwake is well known for Labrador.

Iceland Gull (*Larus glaucoides*), and Ivory Gull (*Pagophila eburnea*) do not nest in Labrador, but are non-breeding visitors moving down from Arctic breeding grounds. Sabine's Gull (*Xema sabini*) may also use the offshore Labrador for migration, although little documented evidence exists to support this assertion.

The following species also use the Study Area as part of the long-distance migration between northern breeding grounds and southern wintering areas: Long-tailed Jaeger (*Stercorarius longicaudus*), Parasitic Jaeger (*Stercorarius parasiticus)*, Pomarine Jaeger (*Stercorarius pomarinus*) (Wiley and Lee 1998; Wiley and Lee 1999; Wiley and Lee 2000), and the Red-necked Phalarope (*Phalaropus lobatus*) (Rubega *et al.* 2000).

Dovekie (*Alle alle*) breed predominantly in high-arctic regions, particularly Greenland, with a few small breeding assemblages in northeastern Canada and the Bering Sea. The species winters in the low-arctic waters of the Labrador Sea, Grand Banks, and coastal Newfoundland (Montevecchi and Stenhouse 2002).

Great Skua (*Catharacta skua*) have a limited range but population trends appear to be stable. The species breeds in Europe (Norway, Faroe Islands, Scotland) but small numbers winter on the Grand Banks off Newfoundland (del Hoyo *et al*. 1996, as cited by BirdLife International 2011). Great Skuas have also been documented off the Newfoundland coast in the spring, summer, and fall, but never in any abundance (Tuck 1971).

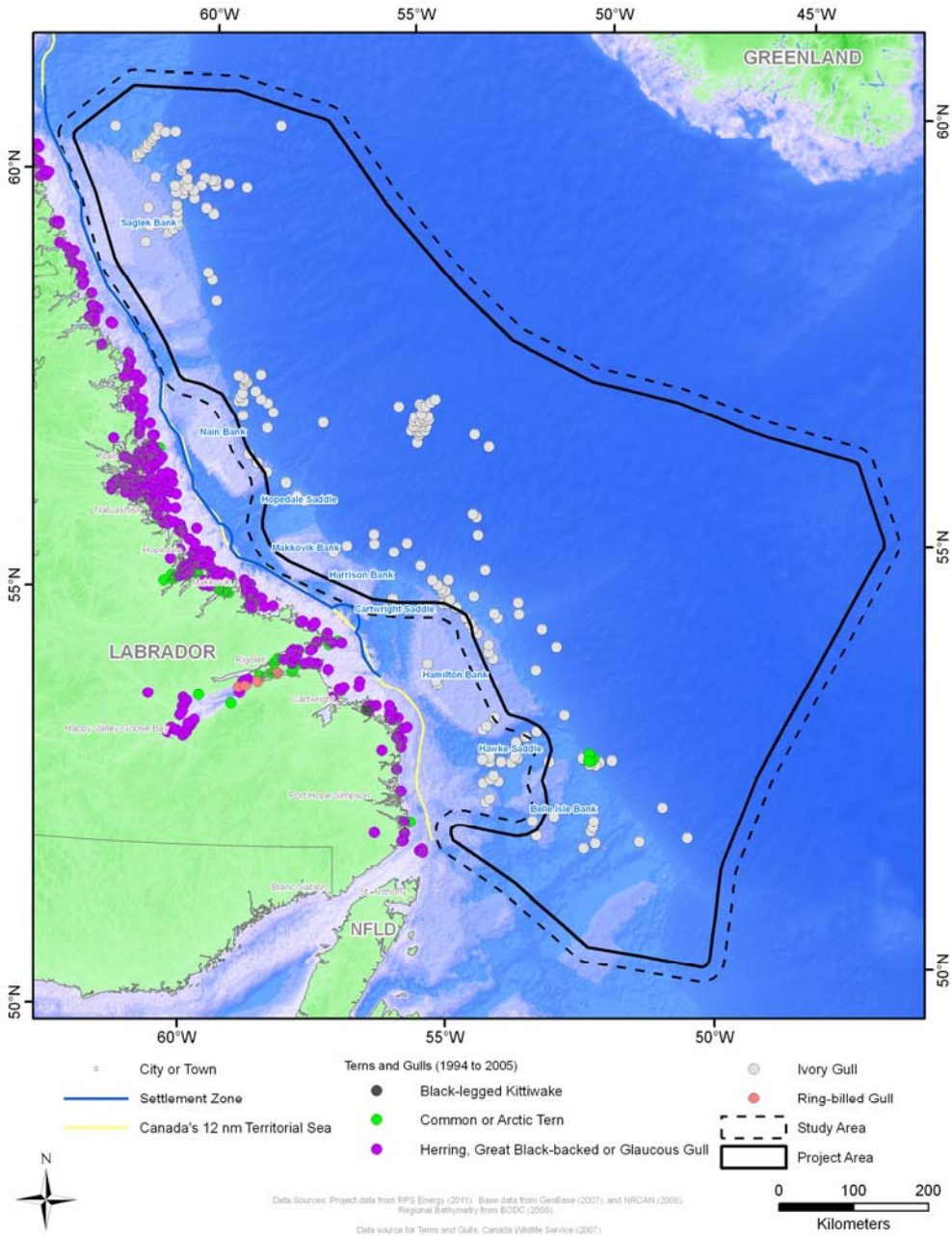

Figure 5.12 Tern and Gull Observation Records 1994-2005