4.0 Biological Environment

The biological environment in and near the Study Area has been recently described in the Labrador Shelf SEA (C-NLOPB 2008), the Eastern Newfoundland SEA (C-NLOPB 2014), the Southern Newfoundland SEA (C-NLOPB 2010), and four project-specific EAs (LGL 2014, 2015a,b, 2016). In addition to updated information, overviews of relevant information are presented in the following subsections for fish and fish habitat, fisheries, marine-associated birds, marine mammals, sea turtles, species at risk and sensitive areas. Data gaps identified in the three SEAs (C-NLOPB 2008, 2010, 2014) have also been examined for any change in status.

4.1 Ecosystem

An ecosystem is an inter-related complex of physical, chemical, geological, and biological components that can be defined at many different scales from a relatively small area that may only contain one primary habitat type (e.g., a shelf) to a relatively large regional area ecosystem which is topographically and oceanographically complex with shelves, slopes, valleys and several major water masses and currents (e.g., the NW Atlantic). This EA focuses on components of the ecosystem such as selected species and stages of fish, marine-associated birds and marine mammals that are important ecologically, economically, and/or socially, with potential to interact with the Project. This is the VEC approach (see § 2.4.1.2) to environmental assessment and this approach is described in § 5.0. The VECs and/or their respective groups are discussed in the following subsections.

4.2 Fish and Fish Habitat VEC

This subsection provides a description of the existing fish and fish habitat in the Study Area. Fish habitat is considered first, followed by a discussion of macro-invertebrates and fishes in the Study Area.

4.2.1 Fish Habitat

In this EA, 'fish habitat' includes physical and biological aspects of the marine environment used by macro-invertebrate and fish species in the Study Area. The physical and chemical nature of the water column (i.e., water temperature, depth, salinity) and bottom substrate (i.e., surficial sediment) are critical factors affecting the characterization of associated marine biological communities. Subsection 3.1 of this EA discusses both the bathymetry and the geology of the Study Area. The biological component of fish habitat refers to phytoplankton, zooplankton, and benthos (i.e., infaunal and epibenthic invertebrates, such as polychaetes and echinoderms, not typically harvested during commercial fisheries in the Study Area).

4.2.1.1 Plankton

Plankton is composed of free-floating organisms that form the basis of the pelagic ecosystem. Plankton constituents include bacteria, fungi, phytoplankton, and zooplankton (mostly invertebrates, but may also include eggs and larvae of fishes, known as ichthyoplankton). In simplest terms, phytoplankton species produce carbon compounds through the utilization of sunlight, carbon dioxide, and nutrients (e.g., nitrogen, phosphorus, silicon). This process is called primary production. Herbaceous zooplankton (e.g., calanoid copepods, the dominant component of NW Atlantic zooplankton) feed on phytoplankton, a growth process known as secondary production. The herbivores in turn are ingested by predators (i.e., tertiary production) such as predatory zooplankton (e.g., chaetognaths, jellyfish, etc.), all of which may be grazed by higher predators such as fish, marine-associated birds, marine mammals and sea turtles. This food web also links to the benthic ecosystem through bacterial degradation processes, dissolved and particulate carbon, and direct predation. An understanding of plankton production is important because areas of enhanced production and/or biomass are areas where fish, seabirds, and marine mammals congregate to feed.

Phytoplankton distribution, productivity, and growth regulation in high-latitude ecosystems constitute a complex system in which light, nutrients, and herbivore grazing are the principal factors limiting phytoplankton regulation (Harrison and Li 2008). In the NW Atlantic, there is generally a spring plankton bloom (May/June) which is typically followed by a smaller bloom in the fall (September/October). This general pattern likely applies to the Study Area. There are areas of enhanced production in the Study Area, similar to other slope areas that have been studied. For example, Moderate Resolution Imaging Spectroradiometer (MODIS) chlorophyll 'a' concentration images from 2015 and 2016 (DFO 2016a) indicate the highest chlorophyll 'a' concentrations in the southern portion of the Study Area occurred on the shelf and along the slope areas between April and June. A second peak, albeit less than the spring peak, occurred in October and November, primarily in slope areas. In the northern portion of the Study Area (i.e., off Labrador), the highest chlorophyll 'a' concentrations occurred on the shelf and along the slope areas between June and late August. A second smaller peak occurred in late September and October, primarily in slope areas. The spring/summer bloom of phytoplankton is typically the driving force of high-latitude marine ecosystem dynamics, at least in offshore areas. Sunlight has been considered the limiting factor for development of the spring bloom but other factors such as nutrients, latitude and water column stratification are also important (Wu et al. 2008).

Zooplankton reproduction is tied to the phytoplankton bloom and either coincides with or immediately follows the brief but intense phytoplankton blooms in the high latitudes (Huntley et al. 1983; Head et al. 2000; Head and Pepin 2008). Zooplankton is the foremost link between primary production and higher-level organisms in the offshore marine ecosystem. They transfer organic carbon from phytoplankton to fish, marine mammals, and seabirds higher in the food chain. Zooplankton, a food source for a broad spectrum of species, contribute carbon via faecal matter and dead zooplankton to benthic food chains. Pepin et al. (2011) noted that plankton distribution in the Study Area is primarily influenced by local advective transport and mixing processes, with several species of *Calanus* copepods acting as key contributors to the regional secondary production.

The information on plankton within the Study Area has been reviewed extensively in the Labrador Shelf SEA (§ 4.5 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.1.3 of C-NLOPB 2014), and the Southern Newfoundland SEA (§ 3.1.3 of C-NLOPB 2010), and is summarized briefly in this subsection. Some of the key points concerning the various components of planktonic communities for the eastern and southern Grand Banks as well as the Labrador Shelf area are highlighted below.

- In the North Atlantic, there is strong seasonal variability in primary production, typically characterized by a peak phytoplankton bloom in early spring (April or May) that is dissipated over the summer by the formation of a summer thermocline that prevents the movement of nutrients throughout the water column (Maillet et al. 2004; Harrison et al. 2013);
- Another smaller phytoplankton bloom is created when fall winds and cooler temperatures break down the thermocline, allowing nutrients to be circulated in the water column and utilized by phytoplankton (Maillet et al. 2004);
- Nitrate and silicate are considered limiting nutrients to phytoplankton and their relative abundance can affect community structure;
- In general, larger microplankton are dominated by diatoms (e.g., *Chaetoceros* sp.), but dinoflagellates (*Ceratium* spp.) become more abundant in fall/winter (Harrison et al. 2013);
- Copepods account for a majority of the zooplankton abundance, followed by cladocerans;
- The copepod *Calanus finmarchicus* is considered a keystone species in the region due to its importance to higher trophic levels;
- Euphausids, such as krill, are important prey for marine mammals and have the highest densities in slope waters and offshore regions;
- Spawning periods for many fish species are synchronized with plankton blooms to provide larvae access to seasonally abundant food supplies, thereby increasing survivorship;
- Microbiota consisting of bacteria, mould, and yeast are ubiquitous in the marine environment. These microflora occupy a unique niche in marine ecosystems in that they both serve as a food source and degrade organic matter (Bunch 1979). Typically, microflora are most abundant in the upper layers and their numbers decrease with depth (Li and Harrison 2001);
- Ichthyoplankton assemblages (fish eggs and larvae) on the Northeast Newfoundland Shelf are dominated by capelin (*Mallotus villosus*), sand lance (*Ammodytes* sp.), lanternfishes, and Arctic cod (*Boreogadus saida*);

- The vertical distributions of many zooplankton species exhibit diurnal variability, resulting in higher concentrations in the surface waters during the day;
- Arctic water masses that influence the Labrador Current are dominated by calanoid copepods (*Calanus finmarchicus*, *Calanus glacialis*, and *Calanus hyperboreus*) and the cyclopoid *Oithona similis* (Huntley et al. 1983);
- Sea ice biota are fauna and flora of all trophic levels that live in, on, or associated with sea ice during all or part of their life cycle. Some of these species become part of the plankton when the ice melts. Communities are found at the surface, interior, and bottom of the ice. There are different mechanisms for the formation of these communities depending on where the community is located within the ice (Horner et al. 1992);
- The spring bloom of phytoplankton is the driving force of high-latitude marine ecosystem dynamics and its initiation in the Labrador Sea is strongly regionally dependent (Wu et al. 2008). The spring bloom in the southern Labrador Sea starts in March as a continuation of the bloom that commences on the Grand Banks and spreads northward. In the northern Labrador Sea, the spring bloom starts in early April. The blooms occur earlier in both the north and south Labrador Sea areas compared to its initiation in the central Labrador Sea (Wu et al. 2008);
- The Labrador Shelf area is highly productive because of upwelling along the slopes of the offshore banks and channels and the outflow of nutrient rich water from the Hudson Strait (Drinkwater and Harding 2001; Breeze et al. 2002);
- The role of sea-ice dynamics with respect to phytoplankton dynamics in the Labrador Shelf area is significant in that the marginal ice zones release freshwater via melting, thereby strengthening stratification and affecting salinity and temperature distributions of the upper mixed layer. Retreat of the sea ice also influences the timing and magnitude of the phytoplankton bloom (Wu et al. 2007);
- The areas within the Southern NL SEA Study Area, where primary production was highest at certain times during 2008 (based on chlorophyll-a concentration), included the coastal region of the southwest coast of Newfoundland, the western edge of St. Pierre Bank/Laurentian Channel, and both the slope and shelf of the southwest Grand Bank; and
- Nitrates, important in the growth of diatoms, are limited in the Eastern NL SEA Study Area relative to other areas of the NW Atlantic.

The Atlantic Zone Monitoring Program (AZMP) was implemented by DFO in 1998 in order to better understand, describe and forecast the state of the marine ecosystem. A critical element of the AZMP is an observation program designed to assess the variability in nutrients, phytoplankton and zooplankton (DFO 2016a). The AZMP findings in relation to oceanographic conditions in the Study Area for 2015 are summarized below.

- In the southern regions of the zone, sea-surface temperatures were above normal in January and February of 2015, and generally near normal until June across the zone. The sea-surface temperatures for Labrador and the Newfoundland shelf were below normal to normal, and normal to above normal everywhere else in the zone for the remainder of the year. Bottom temperatures were generally normal or above normal across the zone;
- Nitrate inventories in deep waters were below normal on the Newfoundland Shelf in 2015, continuing a pattern that began in 2008–2009;
- Overall abundance of coepepods throughout much of the Atlantic Zone has increased compared to levels observed in 2014;
- Chlorophyll ‘a’ inventories were near or above normal throughout much of the Atlantic Zone except for the Newfoundland Shelf where they have continued to remain low since 2011;
- Timing indices of the spring bloom was substantially delayed on the northern Labrador and northeast Shelf compared to those in the Flemish Pass and Flemish Cap area (Pepin et al. 2015);
- The abundance of *Calanus glacialis* and *Calanus hyperboreus* has shown long-term declines in abundance on the Flemish Cap and southeast Grand Bank (Pepin et al. 2015);
- High abundance levels of non-copepod zooplankton (e.g., larval stages of benthic invertebrates and carnivores that feed on other zooplankton) were observed on the Newfoundland Shelf and Grand Banks in 2014; and
- The abundance of zooplankton *Pseudocalanus* spp. was above normal throughout the Newfoundland Shelf while abundance of *Calanus finmarchicus* has been below normal levels throughout much of the Atlantic Zone, except for the Flemish Cap.

Planktonic organisms are so ubiquitous and abundant, and typically have such rapid generation times, that there will be negligible effect on planktonic communities from the proposed seismic program. Therefore, no further assessment of the potential effects of the Project on phytoplankton and zooplankton will be discussed here. However, planktonic stages of commercial invertebrates (e.g., northern shrimp *Pandalus borealis*, snow crab *Chionoecetes opilio* and fishes (e.g., Atlantic cod *Gadus morhua*) are described in the following subsections because of their VEC status.

More information on phytoplankton within and around the Study Area is available in the Labrador Shelf SEA (C-NLOPB 2008) Eastern Newfoundland SEA (C-NLOPB 2014), the Southern Newfoundland SEA (C-NLOPB 2010), and relevant project-specific EAs (LGL 2014, LGL 2015a,b, 2016).

4.2.1.2 Benthic Invertebrates

Benthic invertebrates are bottom-dwelling organisms that can be classified into three categories: (1) infaunal organisms; (2) sessile organisms; and (3) epibenthic species (Barrie et al. 1980). Infaunal organisms live on or are buried in soft substrates and include bivalves, polychaetes, amphipods, sipunculids, ophiuroids, and some gastropods. Sessile organisms live attached to hard substrates and include barnacles, tunicates, bryzoans, holothurians, and some anemones. The epibenthic organisms are active swimmers that remain in close association to the seabed and include mysiids, amphipods, and decapods.

Benthic invertebrate communities can be spatially variable because of variability associated with physical habitat characteristics such as water depth, substrate type, currents, and sedimentation. The primary factors affecting the structure and function of such communities in high latitude communities are water mass differences, sediment characteristics, and ice scour (Carey 1991). The wide range of these characteristics within the Study Area ensures a variety of benthic communities. The structure and metabolism of benthic communities can also be directly affected by the rate of sedimentation of organic detritus in shelf and deeper waters (Desrosiers et al. 2000). The seasonality of phytoplankton can influence production in benthic communities, adding temporal variability to a highly heterogeneous community.

The benthic invertebrate communities of portions of the Study Area have been described in the Labrador Shelf SEA (§ 4.6 and 4.7 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.1.5 of C-NLOPB 2014), Southern Newfoundland SEA (§ 3.1.4 of C-NLOPB 2010), and four project-specific EAs (§ 4.2 of LGL 2014, 2015a,b, 2016). It is important to note that beyond the Canadian 200 nm limit, excluding the Nose and Tail of the Grand Banks, the Flemish Pass and the Flemish Cap, there is a substantial deficiency in data related to the benthos. The information presented in this subsection pertains to studies completed on the continental shelf and slope of the Study Area.

- There have been a limited number of benthic studies conducted in the waters off Labrador, particularly in areas where water depth >200 m. The studies described in the Labrador Shelf SEA (C-NLOPB 2008) largely concern benthic organisms and communities occurring in waters shallower than 200 m;
- Some of the key deep subtidal invertebrate species in the Eastern Grand Banks area include snow crab (*Chionoecetes opilio*), Iceland scallops (*Chlamys islandica*), sea scallops (*Placopecten magellanicus*), northern shrimp (*Pandalus borealis*), striped pink shrimp (*P. montagui*), Atlantic surf clams (*Spisula solidissima*), propeller clams (*Cyrtodaria silique*), pale sea urchin (*Strongylocentrotus pallidus*), hooded shrimp (Cumacea), and whelks (*Buccinum* sp.);
- Characteristic deep subtidal invertebrate species in the Southern Grand Banks area include lobster (*Homarus americanus*), snow crab, toad crab (*Hyas* sp.), rock crab (*Cancer* sp.), Iceland scallops, sea scallops, northern shrimp, Stimpson's surf clams

(*Mactromeris polynyma*), propeller clams (*Cyrtodaria siliqua*), ocean quahogs (*Arctica islandica*) and sea urchins;
- The Sydney Basin SEA and the Laurentian Sub-basin SEA both described benthic invertebrate communities reported by Hutcheson et al. (1981) and Nesis (1965) in deep subtidal areas of the Grand Banks. Reported invertebrate groups included echinoderms, polychaetes, crustaceans, bivalve molluscs and benthic colonial organisms such as bryozoans, hydrozoans, sponges and corals;
- Many benthic communities in the Eastern Newfoundland SEA Study Area are quite diverse compared to higher trophic levels and can be expected to vary over time and with changing environmental conditions;
- A number of research studies have characterized benthic communities on the Grand Banks (Schneider et al. 1987; Kenchington et al. 2001; Gale 2013; Gilkinson 2013) and associated slopes (Houston and Haedrich 1984);
- Schneider et al. (1987) reported observing epifaunal communities of the northeastern part of the Grand Banks that were dominated by bivalves and echinoderms such as brittlestars, urchins, and sand dollars;
- Trawling impact studies conducted by Prena et al. (1999) and Kenchington et al. (2001) using video grabs and benthic sled and trawl bycatch sampling characterized benthic communities on the northeast slope of the Grand Banks within the Study Area over a three year period. Kenchington et al. (2001) documented 246 benthic taxa which were primarily echinoderms, polychaetes, crustaceans, and molluscs;
- In contrast to other survey types, DFO research vessel (RV) trawl survey catches are often dominated by relatively large taxa such as sponges, anemones, shrimp, crab and urchins. Other taxa included echinoids such as sand dollars, sea stars, brittle stars and basket stars (LGL 2012, 2013); and
- Infaunal invertebrates collected at Lewis Hill (southwestern Grand Banks) were dominated by polychaetes, followed by nemertean worms, amphipods and sea cucumbers. The invertebrate community found at Lewis Hill was very similar to those found in similar surficial sediment types elsewhere on the Grand Banks (Husky 2003a,b).

Stewart et al. (1985) surveyed benthic invertebrates at stations on the continental shelf and slope of southeastern Baffin Island, in Ungava Bay, and on the northern Labrador Shelf. Water depths ranged from 106 to 970 m while bottom temperatures ranged from -0.7 to 4.3°C. Stations deeper than 600 m had fine sand-silt substrate while shallower stations generally had a sand substrate. Stewart et al. (1985) identified 492 species of molluscs, echinoderms, crustaceans, and polychaetes. Many of the species were present in low abundances at a small number of stations. The data indicate that the groupings of the marine benthic organisms were more commonly associated with particular water masses and temperature distribution than with substrate distribution.

Two stations examined by Stewart et al. (1985) were located on the northern Labrador shelf in water depths of 180 m (bottom temp. = 3.0°C; sand substrate) and 621 m (bottom temp. = 4.0°C; silt and clay substrate). The dominant species at the shallower site, in terms of standing crop and abundance, were the molluscs *Tachyrhynchus erosus* and *Macoma loveni*, the polychaetes *Rhodine gracilior*, *Maldane sarsi,* and *Chaetozone setosa*, the echinoderm *Ophiura* robusta, and the crustacean *Unciola leucopis*. The deeper site was dominated by the molluscs *Yoldiella lucida*, *Thyasira gouldi*, and *Dentalium occidentale*, the polychaetes *Glycera capitata*, *Ophelina cylindrocaudatus*, *Lumbrineris impatiens*, and an unidentified species, and the echinoderms *Amphipholis squamata* and *Amphiura fragilis*. The dominant crustaceans at the deeper site included *Ischyrocerus megacheir*, *Ampelisca gibba*, *Ampelisca amblyops*, *Haploops tubicola*, and *Byblis crassicornis*. At the shallower site, the water mass was influenced by mixing between the Labrador Current water and deeper, warmer Atlantic Intermediate water. The deeper site occurred under the Irminger Atlantic water mass.

Gilkinson (2013) provided summary data related to benthos caught during DFO RV survey trawling in North Atlantic Fisheries Organization (NAFO) Divisions 3LNO between 2006 and 2010. Figure 1 in Gilkinson (2013) indicates that the trawl-caught benthos biomass was dominated by sponges, sea anemones, snow crab and echinoderms. Catches of sponges and shrimp in 3L were larger than those in 3NO. Also, sponge catches tended to be higher in 2J compared to 3K while sea anemone catch biomass was greater in 3K. During the DFO NEREUS grab sampling program, from 2008 to 2010, a total of 455 benthic macrofaunal taxa were identified from 22,000 specimens representing 12 phyla. The average sampling depth was 92 m (range 58–157 m). Overall, 51% of samples collected were composed of pure sand. The majority (77%) of samples were collected from the mid-depth zone (>50–100 m) of which 46% contained pure sand. The percentage sand increased to 61% in the deep zone. The three phyla that dominated the grab samples included Annelida, Arthropoda, and Mollusca. These three phyla comprised 86% of all recorded taxa. Annelida was the most species rich phylum (39% of all species) with polychaetes accounting for 99% of all annelid taxa. Amphipods accounted for 60% of arthropod taxa, while gastropods and bivalves accounted for 51% and 43% of mollusc taxa, respectively. Dominance in species richness by these three phyla is typical of NW Atlantic continental shelves that are characterized primarily by sandy seabeds (Gilkinson et al. 2005, and Kenchington et al. 2001 *in* Gilkinson 2013). Some of the main species collected in grab samples included the annelids *Glycera capitata, Prionospio steenstrupi, Terebellides stroemi, Nothria conchylega, Nothria conchylega,* and *Pectinaria granulate*, the arthropods *Hyas coarctatus, Unciola irrorata,* and *Unciola leucopis*, and the molluscs *Antalis entails, Crenella decussate, Arctica islandica, Liocyma fluctuosa*, and *Chlamys islandicus*.

During a study conducted by Houston and Haedrich (1984), grab samples were taken in the vicinity of Carson Canyon (continental edge and slope) on the southeastern Grand Banks. Faunal communities in these grab samples were dominated by polychaetes, hooded shrimp, sipunculid worms, amphipods, echinoderms, isopods and bivalves. The relative dominance of these taxa depended on substrate type, although polychaetes were among the top four taxa, in terms of abundance, in each of sand, gravel and silt (Houston and Haedrich 1984).

A recent study (Murillo et al. 2016) provided information on the epibenthic invertebrate assemblages that occur beyond the Canadian 200 nm limit on the Tail and southern Nose of the Grand Bank, and in the Flemish Cap area. Sampling was conducted with bottom trawls. Twelve spatially coherent epibenthic megafaunal assemblages were identified, nested within three major regional-scale faunal groups: (1) the continental shelf of the Tail of the Grand Bank, typified by the sea cucumber (*Cucumaria frondosa)* and the sand dollar (*Echinarachnius parma*); (2) the upper slope of the Grand Bank and the top of the Flemish Cap, typified by the sponges *Radiella hemisphaerica* and *Iophon piceum*, and the sea star *Ceramaster granularis*; and (3) the lower slope of the Grand Bank and Flemish Cap, typified by the sea urchin *Phormosoma placenta*, and the sea pens *Anthoptilum grandiflorum* and *Funiculina quadrangularis*. Statistical analysis concluded that faunal group 1 is most closely associated with shallow depth (i.e., <200 m), coarse sediments, and cold fresh water associated with the Labrador Current, while faunal group 3 is most closely associated with greater depth (i.e., 500–600 m), muddy sediments, and warmer, more saline water. An extensive comprehensive list of epifauna collected during the bottom trawl surveys is presented in Table A.1 *in* Murillo et al. (2016). This study fills a knowledge gap in these areas.

There is a substantial deficiency in data related to the benthos that occurs in the portion of the Study Area beyond the Canadian 200 nm, excluding the Nose and Tail of the Grand Banks, the Flemish Pass and the Flemish Cap.

For more information on the life history and biology of some of the key benthic species in the Study Area see Table 4.58 of the Eastern Newfoundland SEA (C-NLOPB 2014).

Deep-water Corals and Sponges

A variety of coral groups occur in Newfoundland and Labrador waters. These include scleractinians (solitary stony corals), antipatharians (black wire corals), alcyonaceans (large and small gorgonians, soft corals), and pennatulaceans (sea pens) (Wareham and Edinger 2007; Wareham 2009). Corals are largely distributed along the edge of the continental shelf and slope off Newfoundland and Labrador (Edinger et al. 2007; Wareham and Edinger 2007). Typically, they are found in canyons and along the edges of channels (Breeze et al. 1997), at depths greater than 200 m. Soft corals are distributed in both shallow and deep waters, while horny and stony corals (hard corals) are restricted to deep water only in this region. Dense congregations of coral off Labrador are referred to as coral “forests” or “fields”. Most grow on hard substrate (Gass 2003), including the large gorgonian corals (Breeze et al. 1997). Others, such as small gorgonians, cup corals, and sea pens, prefer sand or mud substrate (Edinger et al. 2007). The distribution of various corals along the continental shelf and slope regions of the Study Area based on data collected by fisheries observers, are provided in Figure 3 of Wareham and

Edinger (2007) and Map 1 of Wareham (2009). In total, thirty species of corals were documented, including two antipatharians (black wire corals), 13 alcyonaceans (large gorgonians, small gorgonians, and soft corals), four scleractinians (solitary stony corals), and 11 pennatulaceans (sea pens). The authors noted that corals were more widely distributed on the continental edge and slope.

Several studies present information on the ecology of deep cold-water corals of Newfoundland and Labrador waters, including information on biogeography, life history, biochemistry, and their relation to fishes (e.g., Gilkinson and Edinger 2009; Kenchington et al. 2010a,b; Baillon et al. 2012; Baker et al. 2012). Wareham (2009) updated deep-sea coral distribution data for the Newfoundland and Labrador and Arctic Regions to partially fill information gaps previously identified by Wareham and Edinger (2007). Their study area encompassed the continental shelf, edge, and slope ranging from Baffin Bay to the Grand Banks, including the Labrador Shelf (NAFO Divisions 2GHJ). Distributional maps were compiled by Wareham (2009) using DFO Newfoundland and Labrador Region multispecies surveys (2000 to 2007), DFO Arctic multispecies surveys (2006 to 2007), a northern shrimp survey (2005), and information provided by fisheries observers aboard commercial fishing vessels (2004 to 2007). The maps in Wareham (2009) show the distribution of several coral groups occurring along the continental edge and slope from Baffin Bay to the Grand Banks. The groups profiled include antipatharians, alcyonaceans, scleractinians, and pennatulaceans. Six previously undocumented coral species, composed of one alcyonacean, two scleractinians, and three pennatulaceans, were identified in the Newfoundland and Labrador and Arctic Regions (Wareham 2009).

According to distribution maps included in Wareham (2009), there are numerous species of corals occurring within or adjacent to the Study Area. The species identified include large gorgonians (*Keratoisis ornata*, *Paragorgia arborea*, *Primnoa resedaeformis*, and *Paramuricea* spp.), small gorgonians (*Acanthogorgia armata*, *Acanella arbuscula, Radicipes gracilis*, and *Anthothela grandiflora*), and soft corals (*Anthomastus grandiflorus*, *Duva florida*, *Gersemia rubiformis*, and *Nephtheid* spp.). Also noted were scleractinian species (*Flabellum alabastrum, Javania cailleti, Dasmosmilia lymani, Vaughanella margaritata* and *Flabellum macandrewi*) and several pennatulacean species (*Protoptilum carpenteri*, *Anthoptilum grandiflorum, Halipteris finmarchica, Pennatula grandis, Pennatula phosporea, Distichoptilum gracile*, *Funiculinia quandrangularis* and unspecified sea pen species). Antipatharian species were also observed within the Study Area along the Flemish Pass, NE Newfoundland shelf, and Labrador shelf. The majority of coral species observed occurred on the continental slope, with the exception of several soft corals (*Gersemia rubiformis* and *Nephtheid* spp.) found distributed on the shelf. Map 1 in Wareham (2009) indicates a continuous coral distribution within the Study Area primarily on the edges of the continental shelf and slope of the Grand Banks. In another deep-water coral distribution study within the eastern region of the Study Area, it was determined that the Flemish Cap supported the greatest species diversity of deep-water corals (Murillo et al. 2011). They observed 34 species on the Flemish Cap, followed by 22 species in the Flemish Pass and on the Nose of the Grand Banks.

The patterns of association between deep-sea corals, fish, and invertebrate species, based on DFO scientific surveys and ROV surveys, are discussed by Edinger et al. (2009). Although there were no dramatic relationships between corals and abundance of the ten groundfish species studied, there was a weak but statistically significant positive correlation between coral species richness and fish species richness. For various sample segment lengths and depth ranges in the southern Grand Banks, Baker et al. (2012) found significant positive relationships between the presence and/or abundance of roundnose grenadier (*Coryphaenoides rupestris*) with that of large skeletal corals and cup corals, of roughhead grenadier (*Macrourus berglax*) with large gorgonians/antipatharians and soft corals, and of marlin-spike grenadier (*Nezumia bairdii*) with small gorgonians. Baillon et al. (2012) determined that several types of coral, particularly sea pens (e.g., *Anthoptilum grandiflorum*) were hosts to eggs and/or larvae of two redfish species (*Sebastes fasciatus* and *S. mentella*), a lanternfish (*Benthosema glaciale*) and greater eelpout (*Lycodes esmarkii*) in the Laurentian Channel and southern Grand Banks. This suggests that habitats that support diverse corals may also support diverse assemblages of fishes. Although relationships between corals and groundfish or invertebrates are not obligate and may result from coincidence, conservation areas established for corals may effectively protect populations of groundfish, including some commercial species (Edinger et al. 2009). By increasing the spatial and hydrodynamic complexity of habitats, deep-sea corals may provide important, but probably not critical, habitat for a wide variety of fishes. Effects of deep-sea corals on fish habitat and communities may include higher prey abundance, greater water turbulence, and resting places for a wide variety of fish size classes (Auster et al. 2005, Costello et al. 2005 *in* Edinger et al. 2009).

Sponges also provide significant deep-sea habitat, enhance species richness and diversity, and cause clear ecological effects on other local fauna. Sponge grounds and reefs support increased biodiversity compared to structurally-complex abiotic habitats or habitats that do not contain these organisms (Beazley et al. 2013). Kenchington et al. (2013) noted the association of several demersal fish taxa with Geodia-dominated sponge grounds on the Grand Banks and Flemish Cap. Beazley et al. (2013) determined that deep-water sponge grounds in the NW Atlantic were characterized by a significantly higher biodiversity and abundance of associated megafauna compared to non-sponge habitat.

Morphological forms such as thick encrustations, mounds, and branched, barrel- or fan-like shapes influence near-bottom currents and sedimentation patterns. They provide substrate for other species and offer shelter for associated fauna through the provision of holes, crevices, and spaces. Siliceous hexactinelid sponges can form reefs as their glass spicules fuse together. When the sponge dies, the skeleton remains. This skeleton provides settlement surfaces for other sponges, which in turn form a network that is subsequently filled with sediment (DFO 2010a).

Although some of the siliceous spicules of non-reef-forming species dissolve quickly, there is some accumulation of shed spicules forming a thick sediment-stabilizing mat, which constitutes a special bottom type supporting a rich diversity of species. Organisms commonly associated with sponges and sponge grounds include species of marine worms and bryozoans, as well as fauna of higher trophic levels. Live glass sponge reefs have been shown to provide nursery habitat for juvenile rockfish, and high-complexity reefs are associated with higher species richness and abundance (DFO 2010a).

In a recent DFO report by Guijarro et al. (2016), sponge and coral distributions based on research vessel survey data and associated environmental data contributed to the development of a species distribution modelling approach called "random forest" to identify significant benthic areas and predict the probable occurrence of sponges, sea pens (*Pennatulacea*), large gorgonians, and small gorgonians within the entire Newfoundland and Labrador region. Random forest modelling can be used to predict the probability of species occurrence in an unsampled area. Data were collected from DFO research vessel multispecies trawl surveys, DFO/industry northern shrimp surveys, and Spanish research vessel groundfish trawl surveys. All tows followed a stratified random trawl design using Campelen trawl gear. Data concerning sponges were drawn from trawl data conducted from 1995 to 2015 and from 2003 to 2015 for all other species. Figures 5, 20, 35, and 50 *in* Guijarro et al. (2016) display the probability of species' distributions in unsampled areas overlaying known presence/absence of species from survey tows for sponges, sea pens, large gorgonians, and small gorgonians. This modelling approach is useful for filling data gaps in survey coverage and extrapolating probable significant benthic areas for unsampled areas.

Since 2008, the NAFO Scientific Council has been identifying various areas of significant coral and sponge concentrations within the NAFO Regulatory Area. These areas that have been closed to fishing with bottom gear are shown in § 4.7, Sensitive Areas (NAFO 2017).

DFO has recently published a report that discusses its coral and sponge conservation strategy for Eastern Canada (DFO 2015a). The report includes discussion of the current status of coral and sponge conservation in Eastern Canada, research on corals and sponges in Eastern Canada, and other aspects of corals and sponges in both Canadian and international contexts.

DFO RV survey data collected in the Study Area during May–November 2014, indicate that corals and sponges were caught primarily in the slope areas of the Grand Banks and off Labrador although some were also caught on the shelf, particularly in the northern part of the Study Area (see Figures 4.32 and 4.34 *in* § 4.3.7).

4.2.2 Fish

For the purposes of this EA, 'fish' includes macro-invertebrates that are targeted in the commercial fisheries and all fishes, either targeted in the commercial fisheries or otherwise. The focus is on key commercially- and ecologically-important fishes.

4.2.2.1 Principal Macro-invertebrates and Fishes Commercially Harvested

This subsection describes the principal macroinvertebrate and fish species that are typically harvested in the Study Area during commercial fisheries. These include both targeted species (e.g., snow crab, northern shrimp and Greenland halibut *Reinhardtius hippoglossoides*) and other species caught incidentally (e.g., wolffishes [*Anarhichas* spp]).

Snow crab, northern shrimp and Greenland halibut have dominated directed commercial fishery landings for the Study Area in recent years. Some of the 'incidental catch' species and key ecologically-important fishes are also discussed in this subsection.

Macroinvertebrates

Snow Crab

Aspects of the snow crab life history, including information on distribution, are discussed in § 4.2.2.1 of LGL (2014, 2015a,b, 2016). Subsections 4.8.2 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.5 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.2.1.1 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on snow crab.

Snow crab landings in NAFO Div. 2HJ have been low since 2011, with less than 2000 t landed annually. Fishing effort has been substantially reduced in recent years. While recruitment increased dramatically in 2014, it was assessed at a much lower level in 2015. Landings in the offshore of NAFO Div. 3K have declined by 50% since 2008 (7,200 t in 2015), the lowest level in two decades. Effort in this area has also been near its lowest level for the last three years. Snow crab landings in the offshore of NAFO Div. 3LNO have increased slightly since 2009 to a historic high of 28,750 t in 2015. Effort has increased slightly in the past three years (DFO 2016b). Long-term recruitment prospects in these NAFO Divisions are considered unfavourable based on a recent warming oceanic regime and a low abundance of young crabs in the past decade (DFO 2016b).

There are two fishery closure areas that occur in the Project Area: (1) Hawke Channel; and (2) Funk Island Deep (see Figure 4.40); both created to offer protection to snow crab (DFO 2016b). More details on these closure areas are provided in § 4.7, Sensitive Areas.

In the commercial fishery conducted within the Study Area during May–November 2015, snow crab harvesting was conducted along the southeastern, eastern and northeastern shelf and upper slope of the Grand Banks, on the shelf south of the Avalon and Burin Peninsulas, on the shelf immediately east of the Avalon Peninsula, and the area off northeastern Newfoundland and southeastern Labrador (see Figure 4.12 in § 4.3.3.2). Distributions of fishing effort for snow crab within the Study Area during 2013-2014 are provided in Figure 4.13 in § 4.3.3.2 of LGL (2016).

Northern Shrimp

Aspects of the northern shrimp life history, including information on distribution, are discussed in § 4.2.2.1 of LGL (2014, 2015a,b, 2016). Subsections 4.8.3 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.5 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.1.4.1 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on northern shrimp.

The northern shrimp fishery in NAFO Div. 3LNO within the Study Area has seen a reduction in shrimp catch and declining Total Allowable Catch (TAC) levels in recent years. TACs increased from 6,000 t in 2000 to 30,000 t in 2009 and 2010 but declined to 4,300 t in 2014 due to continued declines in survey and commercial fishery indices. Small and large Canadian fishing fleets have altered their fishing patterns in response to low catch rates by fishing along the border to 3K. The number of countries fishing for shrimp in 3L decreased, from as many as 16 in 2006 to only one country in 2013. The majority (>92.7%) of total shrimp biomass in NAFO Div. 3LNO caught during either spring or fall surveys has come from 3L, while 3N accounted for only 0.2–8.1%, and 3O accounted for less than 1% (Orr and Sullivan 2014). Northern shrimp have also been significantly increasing in biomass and abundance in NAFO Div. 3M since 2014, with biomass and abundance increasing by 70% and 117% respectively in 2015 from the previous year (Casas 2015). The fishable biomass in Shrimp Fishing Area (SFA) 4 (NAFO Div. 2G) decreased by 13% in 2015 relative to 2014. The fishable biomass in this area is estimated at 91,000 t. The fishable biomass in SFA 5 (NAFO Div. 2HJ) has been relatively stable since 2010, having an estimated biomass of 148,000 t in 2015. Fishable biomass in Shrimp Fishing Area (SFA) 6 (NAFO Div. 3K) decreased by 41% in 2015 relative to 2014. The fishable biomass in SFA 6 is estimated at 138,000 t (DFO 2016c).

In the commercial fishery conducted within the Study Area, northern shrimp harvesting during May–November 2015 was prosecuted primarily in the area off northeastern Newfoundland and southeastern Labrador, and at various slope areas off Labrador (see Figure 4.9 in § 4.3.3.2). Fishing effort distributions for northern shrimp within the Study Area during 2013–2014 are provided in Figure 4.10 in § 4.3.3.2 of LGL (2016). In addition to catch locations for northern shrimp in the Study Area during DFO RV surveys in May–November 2014 reflecting the pattern observed with the commercial fishery data, shrimp was also harvested along the northeastern, southeastern and southwestern slopes of the Grand Banks (see Figure 4.27 in § 4.3.7).

Note that the portion of NAFO Div. 3L where water depth <200 m is closed to commercial shrimp fishing during 2017 due to the decline of the stock (NAFO 2017).

Cockles

Life history aspects of the cockle, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015b).

Figures 4.27 and 4.28 in § 4.3.3.2 of LGL (2015b) show the locations of cockle harvesting in the Study Area during May–November between 2005 and 2012. Cockle harvesting is concentrated on the eastern shelf of the Grand Banks in the general vicinity of Lilly Canyon and Carson Canyon.

Stimpson's Surf Clam

Life history aspects of the Stimpson's surf clam, including distribution information, are presented in § 4.2.2.1 of LGL (2014) and LGL (2015b). Subsection 3.1.4.1 of the Southern Newfoundland SEA (C-NLOPB 2010) also provides life history information on this bivalve.

The fishery for Stimpson's surf clam takes place on Banquereau Bank and the Grand Banks using factory freezer fishing vessels equipped with hydraulic clam dredges. The fishery was established in 1986 (Roddick et al. 2011). Although there are four licenses for offshore vessels in this fishery, only two vessels are currently active. The stock, which does not have a high exploitation rate, is thought to be relatively healthy. The fishery typically takes place in areas with water depths of 45 to 65 m (Roddick 2013).

Fishes

Greenland Halibut (Turbot)

Life history aspects of Greenland halibut, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015a, 2016). Subsections 4.8.6 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on Greenland halibut.

In the commercial fishery conducted within the Study Area during May–November 2015, Greenland halibut harvesting was prosecuted primarily along the northeastern slope of the Grand Banks, the slope region off southern Labrador and secondarily along the slope region of the Southern Grand Banks (see Figure 4.15 in § 4.3.3.2). Distributions of fishing effort for Greenland halibut within the Study Area during 2013 and 2014 are provided in Figure 4.16 in § 4.3.3.2 of LGL (2016). Most catch locations for Greenland halibut in the Study Area during DFO RV surveys in May–November 2014, were distributed along the slope of the Grand Banks, the shelf and slope areas off northeastern Newfoundland, and the shelf and slope area off Labrador (see Figure 4.30 in § 4.3.7).

Atlantic Halibut

Life history aspects of Atlantic halibut (*Hippoglossus hippoglossus)*, including distribution information, are presented in § 4.2.2.1 of LGL (2015a, 2016). Subsections 4.8.22 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.2 and 4.2.1.5 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on Atlantic halibut.

In the commercial fishery conducted within the Study Area during May–November 2015, Atlantic halibut harvesting was conducted along the northeastern slope of the Grand Banks, the slope region of the Southern Grand Banks and on the Southeast Shoal (see Figure 4.21 in § 4.3.3.2). Distributions of fishing effort for Atlantic halibut within the Study Area during recent years are provided in Figures 4.48–4.51 in § 4.3.3.2 of LGL (2015b) and Figure 4.21 in § 4.3.3.2 of LGL (2016).

Atlantic Cod

Life history aspects of Atlantic cod (*Gadus morhua*), including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015a,b, 2016). Subsections 4.8 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on Atlantic cod.

A recent study by Rose and Rowe (2015) discusses the comeback of northern cod. Using data collected during acoustic-trawl surveys of the main pre-spawning and spawning components of the stock, they show that biomass has increased from tens of thousands of tonnes to >200 thousand tonnes during the last decade. The increase was first signalled by the observation of massive schooling behaviour in late winter in 2008 in the southern range of the stock (i.e., Bonavista Corridor) after a 15-year absence. In the spring of 2015, large increases in cod abundance and size composition were observed for the first time since 1992 in the more northerly spawning groups of the stock complex (i.e., outer Notre Dame Channel, southern Hamilton Bank and Hawke Channel).

The latest DFO stock assessments indicate that the “Northern” cod stocks in NAFO Divs. 2J3KL have increased considerably over the past decade. Overall biomass increased between 2005 and 2012 but has remained stable in recent years. DFO continues to manage the stock using the precautionary principle, keeping removals at the lowest possible level until assessments indicate the stock has cleared the critical zone (DFO 2016d).

In the commercial fishery conducted within the Study Area during May–November 2015, Atlantic cod were harvested along the northeastern slope of the Grand Banks, the slope region of the Southern Grand Banks and on the Southeast Shoal (see Figure 4.19 in § 4.3.3.2).

Distributions of fishing effort for Atlantic cod within the Study Area during 2013 and 2014 are provided in Figure 4.20 in § 4.3.3.2 of LGL (2016). DFO RV data collected in the Study Area during May–November 2014 indicated Atlantic cod catches in the shelf and slope areas of most of the Study Area except for the extreme northern portion (see Figure 4.29 in § 4.3.7).

American Plaice

Life history aspects of American plaice (*Hippoglossoides platessoides*), including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015a,b, 2016). Subsections 4.8.5 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.7.1 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on American plaice.

In the commercial fishery conducted within the Study Area during May–November 2015, American plaice were harvested primarily on the shelf of the Southern Grand Banks but also along the slope of the northeastern Grand Banks (see Figure 4.22 in § 4.3.3.2). Distributions of fishing effort for American plaice within the Study Area during 2013 and 2014 are provided in Figure 4.21 in § 4.3.3.2 of LGL (2016). DFO RV data collected in the Study Area during May–November 2014 indicated American plaice catches primarily throughout the shelf areas of the Study Area as well as some slope areas of the Grand Banks (see Figure 4.28 in § 4.3.7).

Yellowtail Flounder

Life history aspects of yellowtail flounder (*Pleuronectes ferruginea)*, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015a,b, 2016). Subsections 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on yellowtail flounder.

In the commercial fishery conducted within the Study Area during May–November 2015, yellowtail flounder harvesting was prosecuted primarily in the Southeast Shoal area of the Southern Grand Bank with some harvesting also occurring on St. Pierre Bank (see Figure 4.18 in § 4.3.3.2). Fishing effort distribution for yellowtail flounder within the Study Area during 2013 and 2014 are provided in Figure 4.19 in § 4.3.3.2 of LGL (2016). Catch locations for yellowtail flounder in the Study Area during DFO RV surveys in May–November 2014, were distributed across the shelf of the Northern and Southern Grand Banks (see Figure 4.26 in § 4.3.7).

White Hake

Life history aspects of white hake (*Urophycis tenuis*), including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015b, 2016). Subsections 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on white hake.

White hake biomass and abundance estimates for NAFO Divs. 3NOPs have been at stable low levels since 2003. The abundance of white hake in these areas are above the recovery target set under current conditions and fishing rates. Current harvesting levels are not expected to negatively affect the recovery of the stocks (DFO 2016e).

Redfishes

Life history aspects of redfishes, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015a,b, 2016). Subsections 4.8.4 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on redfishes.

In the commercial fishery conducted within the Study Area during May–November 2015, redfish harvesting was conducted primarily along the slope area of the northeastern Grand Bank and the southern Grand Bank (see Figure 4.20 in § 4.3.3.2). Fishing effort distribution for redfishes within the Study Area during 2013 and 2014 are provided in Figure 4.20 in § 4.3.3.2 of LGL (2016). Catch locations for deepwater redfish in the Study Area during DFO RV surveys in May–November 2014, were distributed along the slope of the Northern and Southern Grand Banks, and on the shelf and upper slope off northeastern Newfoundland and southern Labrador (see Figure 4.25 in § 4.3.7).

4.2.2.2 Other Fishes of Note

Capelin

Life history aspects of capelin, including distribution information, are presented in § 4.2.2.2 of LGL (2015a). Subsections 4.8.10 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.2.2.3 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on capelin.

In the latest DFO CSAS document for capelin, landings in 2013 and 2014 were determined to be 23,755 and 23,173 t, respectively, with a Total Allowable Catch (TAC) in Divs. 2J3KL of 22,771 t. Fish harvesters reported increased abundance and distribution for capelin in all NAFO areas, including those that did not support a commercial fishery in 2014. Capelin were noted to be longer, heavier and have higher fat levels (DFO 2015b).

Wolffishes

Three species of wolffish (i.e., northern *Anarhichas denticulatus*, spotted *A. minor*, and Atlantic *A. lupus)* have statuses under Schedule 1 of *SARA*. The northern and spotted wolffishes have *threatened* statuses under Schedule 1 of *SARA* and under COSEWIC. The Atlantic wolffish has *special concern* status under Schedule 1 of *SARA* and under COSEWIC.

Profiles for northern and spotted wolffishes are included in § 4.6, Species at Risk. The profile for Atlantic wolffish is provided below.

Atlantic Wolffish

Life history aspects of Atlantic wolffish, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015b) and § 4.2.2.2 of LGL (2015a). Subsections 4.2.3 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.7.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on Atlantic wolffish.

DFO RV data collected in the Study Area during May–November 2014 indicated that Atlantic wolffish were caught in the shelf and slope areas of the Northern and Southern Grand Banks, as well as on the shelf area off southern Labrador (see Figure 4.33 in § 4.3.7).

Arctic Cod

Life history aspects of Arctic cod (*Boreogadus saida*), including distribution information, are presented in § 4.2.2.1 of LGL (2014) and 4.8.12 of the Labrador Shelf SEA (C-NLOPB 2008).

Swordfish

Life history aspects of swordfish (*Xiphias gladius*), including distribution information, are presented in § 4.2.2.1 of LGL (2015b). Subsection 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provides life history information on swordfish.

Anadromous Fishes

The two predominant anadromous fish species that occur within the Study Area are Atlantic salmon (*Salmo salar*) and Arctic char (*Salvelinus alpinus*). Subsection 4.2.2.1 of LGL (2014) provides life history information for both species. Subsections 4.8.7 and 4.8.8 of the Labrador Shelf SEA (C-NLOPB 2008) also provide life history information on Atlantic salmon and Arctic char. Subsection 3.2.2.8 of the Southern Newfoundland SEA (C-NLOPB 2010) discusses the Atlantic salmon populations that occur in the southern portion of the Study Area.

4.2.2.3 Macroinvertebrate and Fish Reproduction in the Study Area

Temporal and spatial details of macroinvertebrate and fish reproduction within the Study Area are provided in Table 4.1.

Table 4.1 Reproduction Specifics of Macroinvertebrate and Fish Species Likely to Spawn within or near the Study Area.

Species	Locations of Reproductive Events	Times of Reproductive Events	Duration of Planktonic Stages
Northern Shrimp	On banks and in channels over the extent of its distribution	Spawning in late summer/fall Fertilized eggs carried by female for 8 to 10 months and larvae hatch in the spring	12 to 16 weeks
Snow Crab	On banks and possibly along some upper slope regions over the extent of its distribution	Mating in early spring Fertilized eggs carried by female for 2 years and larvae hatch in late spring/early summer	12 to 15 weeks
Greenland Cockle	Eastern Grand Banks	Uncertain	Uncertain
Stimpson's Surf Clam	Eastern Grand Banks	Fall	4 to 8 weeks
Greenland Halibut	Spawning grounds extend from Davis Strait (south of 67°N) to south of Flemish Pass between 800 m and 2,000 m depth	Spring/summer or winter months	Uncertain
Yellowtail Flounder	Shallower sandy areas – typically <100 m water depth – at bottom	May to September, typically peaking in June/July Both eggs and larvae are planktonic.	Pelagic larvae are brief residents in the plankton
Witch Flounder	Throughout the Grand Banks, particularly along slopes >500 m	Late spring to late summer/early fall	Uncertain
Thorny Skate	Throughout distribution range	Year-round Eggs deposited in capsule (one egg per capsule), possibly on bottom	None
Roundnose Grenadier	Uncertain	Year-round Eggs are free-floating	Uncertain
Roughhead Grenadier	Likely along southern and southeastern slopes of Grand Banks	Winter/early spring	Uncertain
Capelin	Spawning generally on beaches or in deeper waters	Late June to early July	Several weeks
Atlantic Halibut	Uncertain	Likely spawns between January and May Both eggs and larvae are planktonic	6 to 8 weeks
American Plaice	Spawning generally occurs throughout the range the population inhabits.	April to May	12 to 16 weeks
Redfish	Primarily along edge of shelf and banks, in slope waters, and in deep channels	Mating in late winter and release of young between April and July (peak in April)	No planktonic stage
Atlantic Cod	Spawn along outer slopes of the shelf in depths from tens to hundreds of metres	March to June	10 to 12 weeks
Atlantic Salmon	Spawn in freshwater	October to November	Several weeks in freshwater
Wolffishes	Along bottom in deeper water, typically along continental slope	Summer to early winter (species-dependent)	Uncertain
Swordfish	NW Atlantic population believed to spawn in the Caribbean Sea, Gulf of Mexico, and off Florida	Year-round	Uncertain
Porbeagle Shark	Very little known about the location of the pupping grounds; likely southern Grand Banks	Mating in late-summer/fall and pupping between early-April and early-June	Uncertain
Arctic Char	Spawn in freshwater	October to November	Several weeks in freshwater
Cusk	Uncertain	May to August	Presumed to be 4 to 16 weeks
Sandlance	On sand in shallow water of the Grand Banks	November to January	Several weeks

4.2.3 Fish and Fish Habitat Data Gaps Identified in Relevant SEAs

The following data gaps associated with the Fish and Fish Habitat VEC were identified in the Labrador Shelf SEA (§ 4.8.21 of C-NLOPB 2008).

- There is a lack of regional specific data related to species life history (e.g., spawning locations, abundance, distribution), particularly with respect to non-commercial species;
- Data related to species movements are limited; and
- There is a lack of knowledge about how climate variations affect species and ecosystem interactions.

The following data gap associated with the Fish and Fish Habitat VEC was identified in the Eastern Newfoundland SEA (§ 6.1.6 of C-NLOPB 2014).

- Limited data regarding fish and fish habitat in deep water beyond the continental slope, particularly for species that are not commercially important at this time.

The following data gaps associated with the Fish and Fish Habitat VEC were identified in the Southern Newfoundland SEA (§ 3.1.6 and 3.2.6 of C-NLOPB 2010).

- Data regarding the spatial and temporal distributions of macroinvertebrate eggs and larvae, and ichthyoplankton are deficient. Some spawning areas have been identified but little work has been done on the passive movements of the eggs and larvae of macroinvertebrates and fishes. More knowledge of drift routes would also provide more perspective on nursery areas;
- Data regarding benthos are quite dated and are primarily related to specific coastal areas and/or restricted time periods;
- Data regarding benthic community composition are limited, most resulting from species-specific studies;
- Data regarding the life histories of many macroinvertebrates and fishes are deficient;
- Data regarding the population size and structure of several macroinvertebrate and fish species are deficient; and
- Data regarding many pelagic fishes are deficient.

All of the data gaps indicated above still exist. The collection of temporal and spatial data with regards to species life history (e.g., spawning locations, abundance, distribution, areas of high productivity) for data-deficient and lesser known non-commercial species would be valuable when considering environmental effects assessments and fisheries resource management. Similarly, addressing these data gaps would aid in assessing cumulative effects from multiple industrial activities, especially in terms of mitigating possible marine ecosystem impacts. Gaps in our knowledge of marine ecosystems are significant and these deficiencies make it difficult to determine the extent to which humans have influenced and affected marine ecosystems, particularly with the current expansion and intensification of anthropogenic activities. The interaction between climate change and ecosystem/species specific impacts is a developing research area that will most likely help fill existing data gaps and provide new data on climate change. As stated in § 6.2 of the Eastern Newfoundland SEA (C-NLOPB 2014): "The C-NLOPB, in consultation with advisory agencies within governments and with relevant stakeholders, will promote the planning, prioritizing and undertaking of research (e.g., through research organizations such as the Environmental Studies Research Funds). In addition, Operators may be required to collect data as part of their program operations, either opportunistically during program operations or prior to the start of program activities. The requirement and nature of the latter will be determined during project-specific assessment."

4.3 Fisheries VEC

The Fisheries VEC of the Study Area has been previously described in the Labrador Shelf SEA (§ 4.10 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.3.4 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.3 of C-NLOPB 2010), and four project-specific EAs (§ 4.3 of LGL 2014, 2015a,b, 2016). An overview of the fisheries of the Study Area, based on information within these documents and new information, is provided below. Relevant data gaps identified in the three SEAs are also discussed in terms of current status.

This subsection describes the commercial fishery in the Study Area during 2010–2015. The Study Area overlaps portions of NAFO Divisions 0B, 1EF, 2GHJ, 3KLMNOPs, 4VnVs and 6H (Figure 4.1).

This subsection also briefly describes historical, recreational and traditional fisheries, aquaculture activity and fisheries research surveys in the Study Area. New information regarding the biology and status of the principal macro-invertebrates and fishes discussed in this section was included in § 4.2, Fish and Fish Habitat.

4.3.1 Information Sources

NAFO catch weight data are used to describe domestic and foreign fisheries conducted beyond the 200 nm EEZ. Much of the Study Area is located outside of the 200 nm limit (Figure 4.1). The NAFO data were obtained from the STATLANT21A dataset for 2010–2015. The STATLANT reporting system of questionnaires data are described in § 4.3.1 of LGL (2015a). The data analyses in this EA quantify harvesting in NAFO Divisions 0B, 1EF, 2GHJ, 3KLMNOPs, 4VnVs and 6H (Figure 4.1).

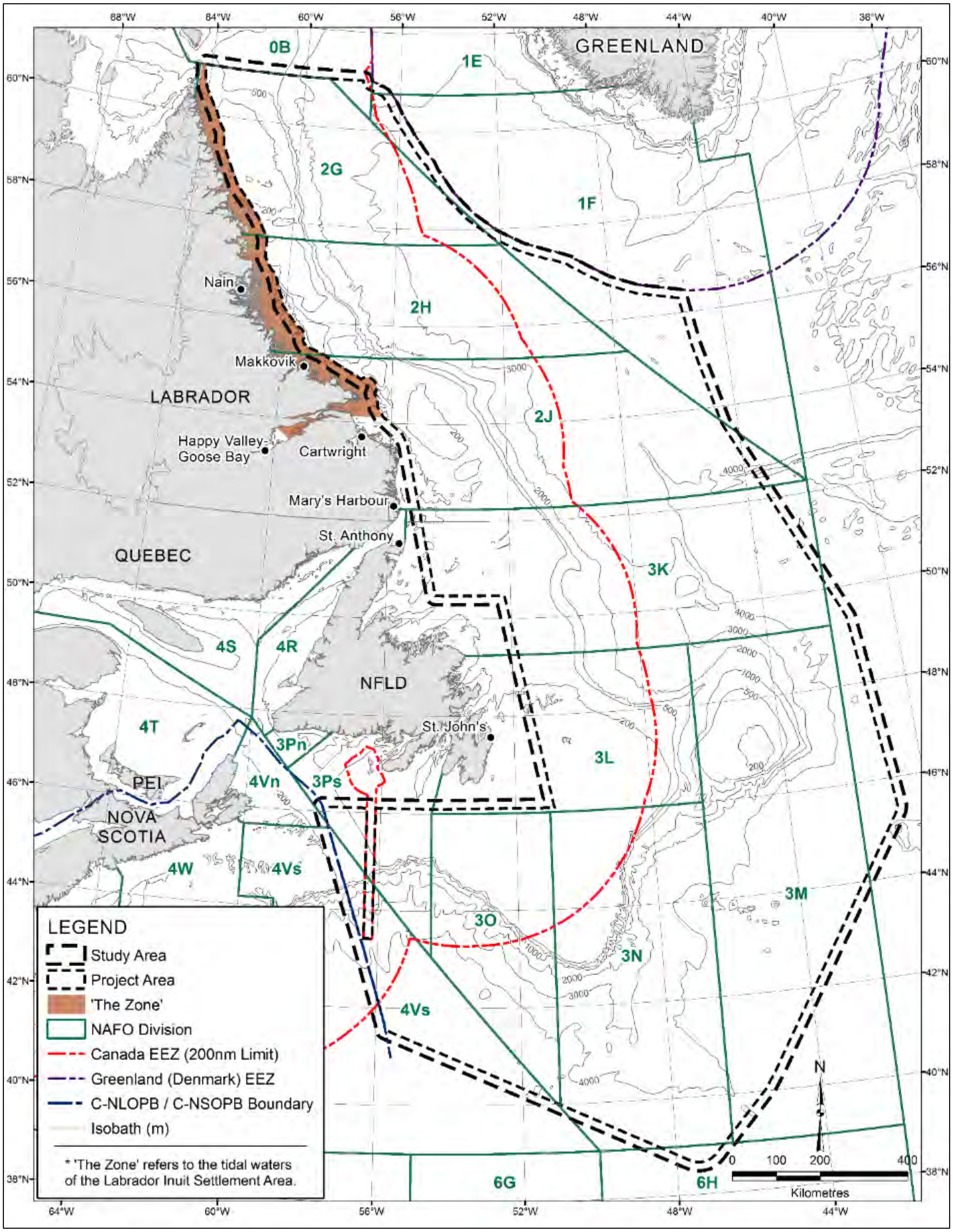


Figure 4.1 Study Area and Project Area in Relation to Regional Fisheries Management Areas (NAFO Divisions).

The primary fisheries data analyses use all DFO Atlantic Regions georeferenced landings data for the 2010 time period, as well as gridded cell landings for 2011–2015. The DFO datasets, analyses and georeferencing/grid methodology of pre- and post-2010 DFO data are described in § 4.3.1 of LGL (2015a). References to figures in the Labrador Shelf SEA (C-NLOPB 2008), the Eastern Newfoundland SEA (C-NLOPB 2014), the Southern Newfoundland SEA (C-NLOPB 2010), and four project-specific EAs (LGL 2014, 2015a,b, 2016) are provided for commercial harvest locations prior to 2015. Other sources used for this assessment include DFO species management plans, DFO stock status reports and other internal documents.

4.3.2 Regional NAFO Fisheries

The stocks and species managed by NAFO are described in § 4.3.2 of LGL (2015a). During the 2010–2015 period, commercial harvesting within the Study Area beyond the 200 nm EEZ, in terms of catch weight, was dominated by northern shrimp (27% of total catch weight; primarily in NAFO Division 3K), snow crab (17%; primarily in 3L), Atlantic cod (7%; primarily in 3M), Atlantic redfish (7%; primarily in 3MO), Greenland halibut (7%; primarily in 0B and 3L), Capelin (6%; primarily in 3KL), and surf clam (6%; primarily in 4Vs). Proportional catch weights in the Study Area during the six year period, in descending order of magnitude, were 20% in NAFO Division 3L, 19% in 3K, 10% in 4Vs, 8% in 2J, 7% in 3M and 3Ps, and ≤6% in the remaining NAFO Divisions that overlap the Study Area.

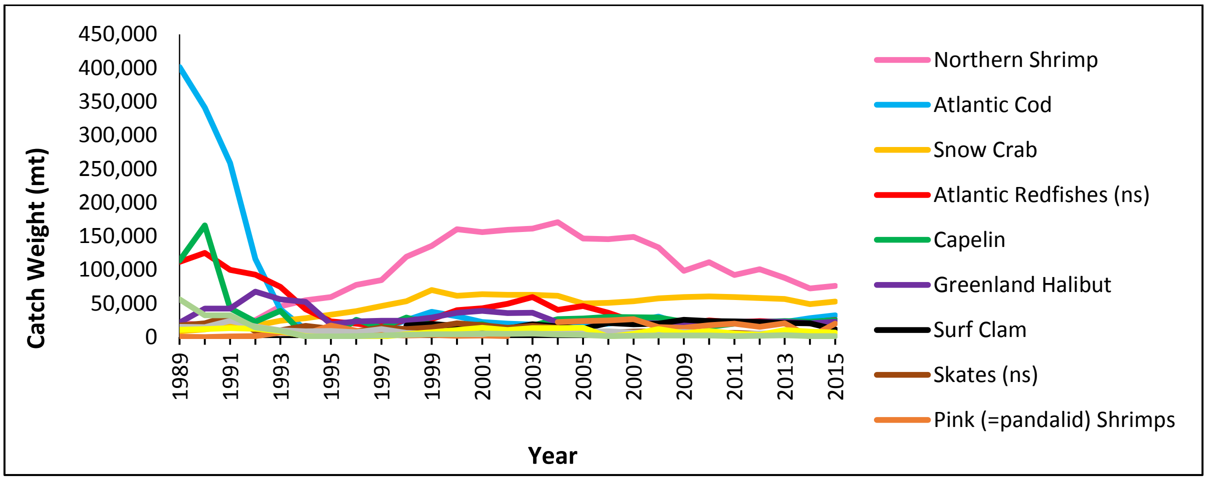
Canadian vessels accounted for 79% of the commercial catch weight reported for this area during 2010–2015. While Canadian vessels accounted for the majority of catches in most of the NAFO Divisions which overlap the Study Area, foreign vessels dominated catches in Divisions 1EF and 3M (>99% of total catch weight within these Divisions). Catches in Division 1E were dominated by northern shrimp and Atlantic cod, in 1F by Atlantic cod, beaked deep-water redfish and northern shrimp, and in 3M by Atlantic cod, Atlantic redfish and great blue shark. Canadian and foreign vessels captured ~40% and 60%, respectively, of the total catches in Division 3N, and ~30% and 70%, respectively, in Division 3O. The primary species captured included yellowtail flounder, skate sp. and snow crab in 3N, and Atlantic redfish, snow crab and yellowtail flounder in 3O.

4.3.3 Domestic Fisheries

The following subsection provides an overview of the commercial fisheries within and/or adjacent to the Study Area. Traditional historical fishing activity during the last 20 years, including abundance data for historically principal species, are presented. Statistical summaries of the commercial catch data specific to the Study and Project Areas, based on the georeferenced (lat/long) data for 2010 and annual gridded cell (6' x 6') data for 2011–2015, are also provided in this subsection.

4.3.3.1 Historical Fisheries

A historical overview of fisheries was given in § 4.3.4.2 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 4.3.3.1 of LGL (2014, 2015a,b, 2016). In the late 1980s, fishes such as Atlantic cod, capelin and Atlantic redfish were the primary species harvested in NAFO Divisions 0B, 1EF, 2GHJ, 3KLMNOPs, 4VnVs and 6H. These fisheries were considerably reduced in the early 1990s during the moratorium, after which crustaceans such as northern shrimp and snow crab became the predominant target species (Figure 4.2). Much lower quotas have been allocated in recent years, based on scientific advice and other relevant considerations (see § 4.3.3.1 of LGL [2015a] for a description of Integrated Fisheries Management Plans for priority groundfish species).

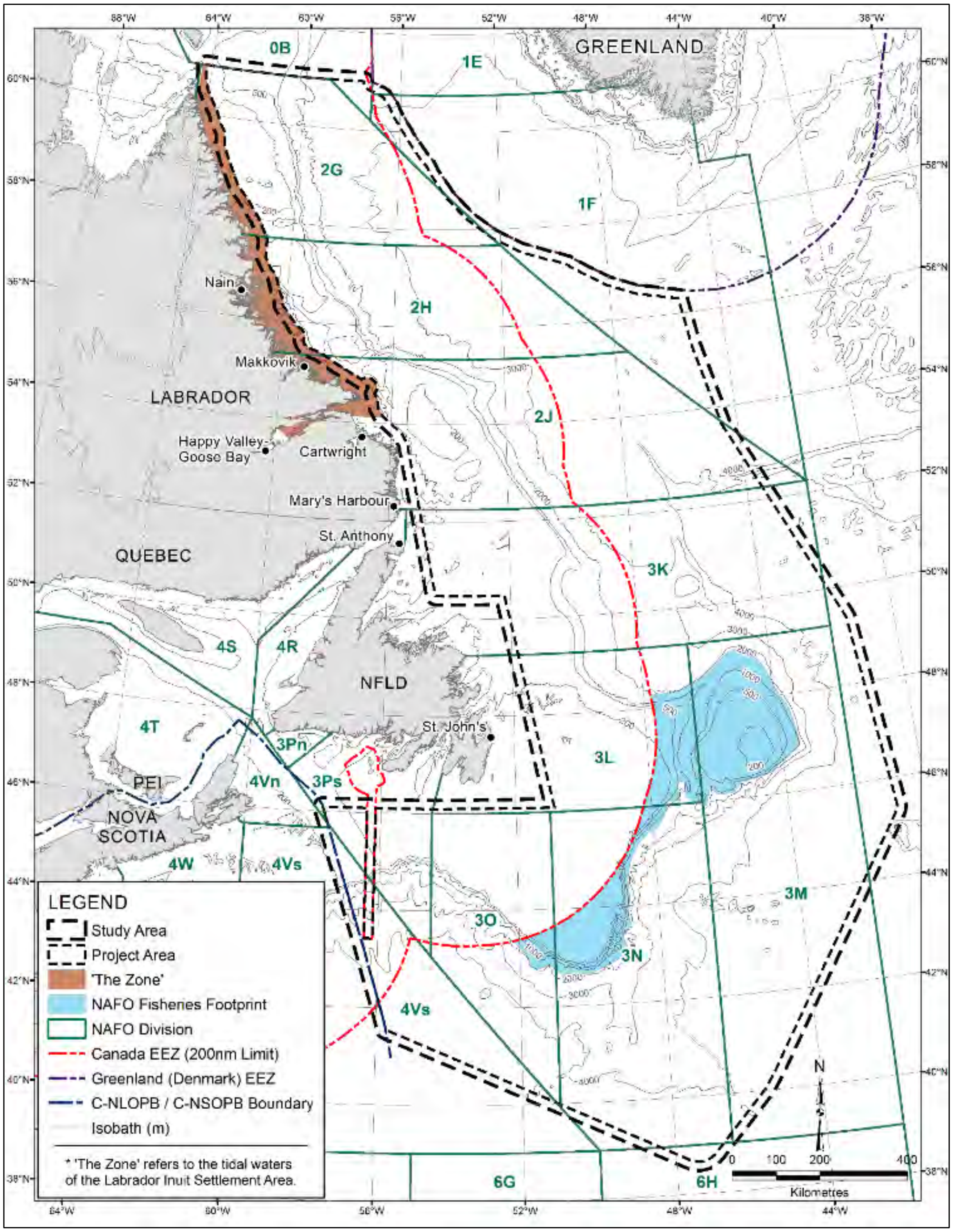


Source: NAFO STATLANT21A Data Extraction Tool.

Figure 4.2 Historical Catch Weights for Predominant Species in the Commercial Fisheries in NAFO Divisions 0B, 1EF, 2GHJ, 3KLMNOPs, 4VnVs and 6H, All Countries, 1989–2015.

Northern shrimp stocks have recently declined (see § 4.3.3.1 of LGL 2015a), resulting in a shrimp fishing moratorium in Division 3L since 2015 (NAFO 2015b,d *in* LGL 2016; NAFO 2017a). Cod and redfish stocks on the Flemish Cap in Division 3M appear healthy, with relatively high recruitment levels since 2005. The Total Allowable Catch (TAC) remained unchanged for cod and redfish in 3M during 2016 and 2017, and redfish TAC in 3LN was increased for 2017 (NAFO 2017b,c). In a continued effort to improve stocks, fishing moratoria remain in place for 2017 for several fish species, including Atlantic cod in 3LNO, American plaice in 3LMNO, witch flounder in 3L, and capelin in 3NO (NAFO 2017b,c).

NAFO's bottom fishing footprint was described in § 4.3.3.1 of LGL (2015a). The footprint lies entirely within the Project Area (Figure 4.3).



Source: NAFO 2017d.

Figure 4.3 Location of the NAFO Bottom Fisheries Footprint, 1987–2007.

4.3.3.2 Study Area Catch Analysis, 2010–2015

Information on domestic harvests in the Study and Project Areas during May–November 2010 are shown in Table 4.2, and in the Study Area during May–November 2011–2015 in Tables 4.3–4.7. The principal fisheries in 2010, in descending order of catch weight magnitude, targeted northern shrimp, snow crab and Greenland halibut, accounting for ~86% of the total annual catch weight (125,166 mt; see Figure 4.4). Other notable species harvested in the 2010 commercial fisheries in the Study Area include yellowtail flounder, Atlantic cod, redfish, Atlantic halibut and American plaice. During May–November,2011–2015, the sum of quartile catch ranges in the Study Area decreased by about 16% between 2011 and 2013, followed by a 30% decrease in 2014, and then remained relatively steady in 2015 (see Figure 4.4).

During May–November 2010, <0.1% of the Study Area catch weight was harvested within St. Pierre et Miquelon waters. The principal fisheries in St. Pierre et Miquelon waters during this time period, in descending order of catch weight magnitude, targeted redfish, Atlantic cod, whelk and Atlantic halibut, accounting for >99% of the total annual catch weight (50 mt; see Table 4.2). Other notable species harvested in St. Pierre et Miquelon waters during 2010 included Atlantic halibut and American plaice.

Commercial Harvest Locations in the Study Area

Georeferenced harvest locations for all species, May–November 2005–2010 for offshore Labrador and eastern/southern Newfoundland are shown in Figure 4.3 of LGL (2014) and Figure 4.5 of LGL (2015a,b), respectively. Gridded harvest locations (6' x 6' cells) during May–November 2011-2013 for offshore Labrador and eastern/southern offshore Newfoundland are shown in Figures 4.4–4.5 of LGL (2014) and Figures 4.6–4.8 of LGL (2015a,b), respectively. Year-round harvest locations are indicated in Figure 4.32 of the Labrador Shelf SEA (C-NLOPB 2008), Figures 4.123–4.124 of the Eastern Newfoundland SEA (C-NLOPB 2014) and Figure 3.18 of the Southern Newfoundland SEA (C-NLOPB 2010). Figure 4.5 shows gridded harvest locations for all species within the Study Area, May–November 2015. Minimal fish harvesting occurred in the eastern portion of the Study Area. Most harvesting occurred on the shelf and slope of the Grand Banks out to the 1,000 m isobath. These locations are quite consistent from year to year.

Table 4.2 Study Area and Project Area Annual Catch Weight and Value by Species, May–November 2010 (also includes summary of catches in the Saint Pierre et Miquelon waters within the Study Area).

Species	Study Area				Project Area				Saint-Pierre-et-Miquelon			
	Quantity		Value		Quantity		Value		Quantity		Value	
	mt	% of Total	$	% of Total	mt	% of Total	$	% of Total	mt	% of Total	$	% of Total
Northern Shrimp	73,382	59	107,295,400	48	72,184	60	105,070,811	50	0	0	0	0
Snow Crab	29,904	24	89,098,378	40	26,990	23	80,391,782	38	0	0	0	0
Yellowtail Flounder	4,880	4	1,267,407	1	4,880	4	1,267,407	1	0	0	0	0
Greenland Halibut	4,776	4	11,269,299	5	4,774	4	11,264,491	5	0	0	0	0
Whelk	3,898	3	3,434,568	2	3,820	3	3,366,315	2	6	11	4,859	14
Redfish sp.	2,939	2	1,515,810	1	1,386	1	681,498	0.3	28	56	11,625	34
Atlantic Cod	1,340	1	1,354,219	1	1,312	1	1,321,916	1	16	32	15,677	46
Striped Shrimp	1,122	1	2,411,766	1	1,117	1	2,401,456	1	0	0	0	0
American Plaice	828	1	309,698	0.1	826	1	308,036	0.1	0.1	0.2	99	0.3
White Hake	423	0.3	152,259	0.1	419	0.4	147,449	0.1	<0.1	<0.1	17	<0.1
Atlantic Halibut	313	0.2	2,226,815	1	289	0.2	2,053,629	1	0.4	1	1,908	6
Pollock	255	0.2	176,771	0.1	253	0.2	174,494	0.1	0	0	0	0
Monkfish	219	0.2	237,616	0.1	219	0.2	236,935	0.1	<0.1	<0.1	9	<0.1
Hagfish	162	0.1	125,138	0.1	162	0.1	125,138	0.1	0	0	0	0
Cockle	146	0.1	173,359	0.1	146	0.1	173,359	0.1	0	0	0	0
Witch Flounder	128	0.1	43,259	<0.1	128	0.1	43,226	<0.1	0	0	0	0
Skate sp.	122	0.1	33,120	<0.1	110	0.1	30,807	<0.1	0.1	0.1	17	<0.1
Stimpson's Surf Clam	56	<0.1	86,277	<0.1	54	<0.1	83,075	<0.1	0	0	0	0
Atlantic Haddock	53	<0.1	46,179	<0.1	52	<0.1	43,626	<0.1	0	0	0	0
Atlantic Herring	40	<0.1	8,149	<0.1	40	<0.1	8,149	<0.1	0	0	0	0
Bluefin Tuna	37	<0.1	392,079	0.2	37	<0.1	392,079	0.2	0	0	0	0
Roughhead Grenadier	37	<0.1	24,287	<0.1	37	<0.1	24,287	<0.1	0	0	0	0
Mackerel	32	<0.1	14,226	<0.1	32	<0.1	14,226	<0.1	0	0	0	0
Capelin	28	<0.1	3,346	<0.1	28	<0.1	3,346	<0.1	0	0	0	0
Swordfish	25	<0.1	133,338	<0.1	21	<0.1	114,733	0.1	0	0	0	0
Sea Scallop	8	<0.1	12,682	<0.1	8	<0.1	12,682	<0.1	0	0	0	0
Cusk	7	<0.1	4,720	<0.1	7	<0.1	4,151	<0.1	<0.1	<0.1	6	<0.1
Porbeagle Shark	2	<0.1	2,219	<0.1	2	<0.1	1,660	<0.1	0	0	0	0
Roundnose Grenadier	1	<0.1	848	<0.1	1	<0.1	848	<0.1	0	0	0	0
Atlantic (striped) Wolffish	1	<0.1	322	<0.1	0.4	<0.1	207	<0.1	0	0	0	0
Mako Shark	0.3	<0.1	844	<0.1	0.3	<0.1	777	<0.1	0	0	0	0
Bigeye Tuna	0.1	<0.1	1,250	<0.1	0.1	<0.1	1,250	<0.1	0	0	0	0
Flounder sp.	0.04	<0.1	51	<0.1	0.04	<0.1	51	<0.1	0	0	0	0
Yellowfin Tuna	0.04	<0.1	307	<0.1	0.04	<0.1	307	<0.1	0	0	0	0
Shark sp.	0.03	<0.1	10	<0.1	0.02	<0.1	6	<0.1	<0.1	<0.1	4	<0.1
Albacore Tuna	0.01	<0.1	18	<0.1	0.01	<0.1	18	<0.1	0	0	0	0
Totals	**125,166**	**100**	**221,856,033**	**100**	**119,334**	**100**	**209,764,226**	**100**	**50**	**100**	**34,220**	**100**

Source: DFO commercial landings database, All Atlantic Regions (2010).

Table 4.3 Commercial Catch Weights and Values in the Study Area, May–November 2011 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] attributed to each species).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts [b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Northern Shrimp	721	1,103	1,478	1,583	982	1,270	1,465	1,168	4,885
Snow Crab	760	1,273	1,511	259	530	1,107	1,469	697	3,803
Greenland Halibut	180	356	257	62	130	371	281	73	855
Redfish sp.	77	155	185	78	148	149	145	53	495
Atlantic Halibut	138	165	116	54	147	232	84	10	473
Atlantic Cod	97	111	125	86	144	161	92	22	419
American Plaice	45	92	114	60	123	109	62	17	311
Witch Flounder	39	87	115	57	90	89	75	44	298
Whelk	14	35	74	70	34	46	85	28	193
Atlantic Haddock	32	52	55	47	67	68	45	6	186
Skate sp.	22	83	64	9	42	89	37	10	178
Yellowtail Flounder	23	59	63	32	80	67	24	6	177
Roughhead Grenadier	29	56	62	17	21	54	65	24	164
White Hake	43	56	46	18	48	74	40	1	163
Monkfish	21	63	48	17	42	72	31	4	149
Striped Shrimp	5	18	30	51	6	20	29	49	104
Pollock	9	25	21	33	27	27	30	4	88
Bluefin Tuna	42	10	3	7	23	28	7	4	62
Swordfish	39	16	1	0	23	29	4	0	56
Cusk	28	17	4	3	7	37	8	0	52
Mako Shark	15	9	1	0	9	13	3	0	25
Hagfish	1	2	9	2	3	9	2	0	14
Cockle	1	5	1	3	3	4	0	3	10
Roundnose Grenadier	5	3	0	0	0	8	0	0	8
Sea Cucumber	0	0	1	7	0	1	5	2	8
Bigeye Tuna	5	2	0	0	4	3	0	0	7
Porbeagle Shark	4	2	0	0	2	3	1	0	6
Stimpson's Surf Clam	0	2	0	3	0	2	0	3	5
Winter Flounder	2	0	1	1	2	1	1	0	4
White Marlin	2	0	1	0	1	1	1	0	3
Yellowfin Tuna	3	0	0	0	2	1	0	0	3
Sea Scallop	2	0	0	1	2	0	1	0	3
Atlantic (striped) Wolffish	3	0	0	0	2	1	0	0	3
Capelin	0	1	1	0	1	0	1	0	2
Atlantic Rock Crab	2	0	0	0	2	0	0	0	2
Shark sp.	1	0	0	1	1	0	1	0	2
Mahi Mahi (dolphinfish)	2	0	0	0	2	0	0	0	2
Mackerel	0	1	1	0	0	2	0	0	2
White Marlin	1	0	0	0	1	0	0	0	1
Groundfish sp.	1	0	0	0	1	0	0	0	1
Total	**2,414**	**3,859**	**4,388**	**2,561**	**2,752**	**4,148**	**4,094**	**2,228**	**13,222**

Source: DFO commercial landings database, All Atlantic Regions (2011).

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2011 quartile ranges: 1 = 0 – 2,377 kg, 2 = 2,378 – 11,045 kg, 3 = 11,046 – 45,183 kg, 4 = ≥ 45,184 kg.

[b] Quartile ranges provided by DFO (Quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2011 quartile ranges: 1 = \$0 – \$7,281, 2 = \$7,282 – \$32,789, 3 = \$32,790 – \$126,294, 4 = ≥ \$126,295.

[c] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 4.4 Commercial Catch Weights and Values in the Study Area, May–November 2012 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] attributed to each species).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts [b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Northern Shrimp	572	1,017	1,220	1,412	854	1,023	1,187	1,157	4,221
Snow Crab	700	1,229	1,138	259	549	1,039	1,226	512	3,326
Greenland Halibut	181	307	250	45	169	299	262	53	783
Atlantic Halibut	173	161	111	42	180	197	98	12	487
Redfish sp.	89	148	174	57	137	128	164	39	468
Atlantic Cod	94	98	112	64	146	123	86	13	368
White Hake	50	85	65	22	71	92	53	6	222
American Plaice	46	56	74	28	94	53	40	17	204
Whelk	17	38	59	57	35	44	72	20	171
Monkfish	29	77	49	13	57	72	38	1	168
Witch Flounder	25	33	75	25	39	32	66	21	158
Skate sp.	26	73	51	5	41	65	47	2	155
Striped Shrimp	10	24	48	70	9	23	47	73	152
Atlantic Haddock	27	35	51	28	47	53	37	4	141
Yellowtail Flounder	39	34	38	15	75	36	13	2	126
Roughhead Grenadier	23	32	49	19	21	39	44	19	123
Pollock	9	40	44	20	39	37	33	4	113
Cusk	35	19	17	18	21	38	24	6	89
Swordfish	23	37	5	2	10	39	18	0	67
Bluefin Tuna	44	7	11	3	34	16	15	0	65
Mako Shark	11	24	3	2	5	20	15	0	40
Porbeagle Shark	22	4	0	0	8	15	3	0	26
Hagfish	1	5	9	0	4	6	5	0	15
Roundnose Grenadier	11	3	0	0	6	6	2	0	14
White Marlin	8	4	0	1	4	7	2	0	13
Bigeye Tuna	7	5	0	1	5	5	3	0	13
Winter Flounder	3	2	2	5	5	2	4	1	12
Mahi Mahi (dolphinfish)	4	5	0	0	3	3	3	0	9
Sea Cucumber	0	0	1	6	0	1	4	2	7
Capelin	0	0	5	1	5	0	1	0	6
White Marlin	0	6	0	0	0	3	3	0	6
Iceland Scallop	3	2	0	0	3	2	0	0	5
Yellowfin Tuna	3	0	0	0	2	1	0	0	3
Flounder sp.	0	1	2	0	0	1	2	0	3
Atlantic (striped) Wolffish	0	1	1	1	0	1	2	0	3
Sea Scallop	2	0	1	0	2	1	0	0	3
Shark sp.	0	1	0	1	0	1	1	0	2
Stimpson's Surf Clam	0	1	0	0	1	0	0	0	1
Atlantic Rock Crab	1	0	0	0	1	0	0	0	1
Mackerel	0	1	0	0	1	0	0	0	1
Total	**2,288**	**3,615**	**3,665**	**2,222**	**2,683**	**3,523**	**3,620**	**1,964**	**11,790**

Source: DFO commercial landings database, All Atlantic Regions (2012).

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2012 quartile ranges: 1 = 0 – 2,618 kg, 2 = 2,619 – 12,233 kg, 3 = 12,234 – 47,739 kg, 4 = ≥ 47,740 kg.

[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2012 quartile ranges: 1 = $0 – $8,240, 2 = $8,241 – $35,022, 3 = $35,023 – $130,732, 4 = ≥ $130,733.

[c] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 4.5 Commercial Catch Weights and Values in the Study Area, May–November 2013 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] attributed to each species).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts [b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Northern Shrimp	576	902	1,163	1,328	937	891	1,116	1,025	3,969
Snow Crab	468	1,063	1,108	292	390	864	1,058	619	2,931
Greenland Halibut	161	327	235	36	185	305	224	45	759
Atlantic Halibut	210	173	148	48	192	209	148	30	579
Atlantic Cod	103	165	177	56	147	182	151	21	501
American Plaice	56	158	126	54	142	120	100	32	394
Redfish sp.	90	113	121	28	115	105	106	26	352
Witch Flounder	64	107	123	42	105	94	105	32	336
Yellowtail Flounder	48	127	99	42	119	104	78	15	316
Whelk	26	56	100	31	51	81	73	8	213
White Hake	69	61	26	1	83	64	9	1	157
Atlantic Haddock	34	60	44	16	65	56	29	4	154
Striped Shrimp	12	28	39	38	11	24	38	44	117
Roughhead Grenadier	33	33	33	5	36	31	27	10	104
Skate sp.	25	34	28	6	44	25	20	4	93
Cusk	45	12	3	0	29	30	1	0	60
Pollock	18	27	14	1	38	21	1	0	60
Monkfish	14	23	17	5	30	22	7	0	59
Bluefin Tuna	2	1	12	0	1	5	9	0	15
Hagfish	0	7	7	0	3	10	1	0	14
Swordfish	7	4	0	0	3	6	2	0	11
Stimpson's Surf Clam	0	2	7	1	0	6	3	1	10
Sea Cucumber	0	0	3	7	0	3	3	4	10
Mako Shark	5	3	0	0	1	6	1	0	8
Sculpin sp.	6	1	0	0	6	1	0	0	7
Mahi Mahi (dolphinfish)	3	3	0	0	0	4	2	0	6
Cockle	0	2	3	0	0	4	1	0	5
Dogfish sp.	2	3	0	0	2	0	2	1	5
Flounder sp.	1	0	2	2	1	2	2	0	5
Roundnose Grenadier	2	3	0	0	2	0	2	1	5
Capelin	0	1	2	1	3	1	0	0	4
Porbeagle Shark	3	0	0	0	2	1	0	0	3
Sea Scallop	3	0	0	0	3	0	0	0	3
Propeller Clam	0	0	2	1	0	2	0	1	3
Atlantic (striped) Wolffish	0	1	0	0	0	1	0	0	1
Mackerel	0	0	1	0	0	1	0	0	1
White Marlin	0	1	0	0	0	0	1	0	1
Toad Crab	0	0	1	0	0	1	0	0	1
Atlantic Herring	1	0	0	0	1	0	0	0	1
Total	**2,087**	**3,501**	**3,644**	**2,041**	**2,747**	**3,282**	**3,320**	**1,924**	**11,273**

Source: DFO commercial landings database, All Atlantic Regions (2013).

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2013 quartile ranges: 1 = 0 – 2,565 kg, 2 = 2,566 – 11,872 kg, 3 = 11,873 – 48,585 kg, 4 = ≥ 48,586 kg.

[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2013 quartile ranges: 1 = $0 – $8,934, 2 = $8,395 – $35,699, 3 = $35,700 – $125,728, 4 = ≥ $125,729.

[c] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 4.6 Commercial Catch Weights and Values in the Study Area, May–November 2014 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] attributed to each species).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts [b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Snow Crab	444	832	869	258	320	747	879	457	2,403
Northern Shrimp	335	482	536	670	458	450	519	596	2,023
Greenland Halibut	85	217	197	56	99	229	166	61	555
Atlantic Halibut	188	149	115	48	169	192	106	33	500
Atlantic Cod	101	147	129	58	142	175	103	15	435
American Plaice	46	76	82	35	89	85	55	10	239
Yellowtail Flounder	41	71	68	32	81	75	52	4	212
White Hake	82	61	44	9	95	82	18	1	196
Redfish sp.	56	62	46	30	77	63	33	21	194
Atlantic Haddock	26	44	50	20	48	54	34	4	140
Whelk	32	34	55	12	50	49	31	3	133
Striped Shrimp	7	20	42	60	10	19	35	65	129
Skate sp.	45	27	22	8	57	30	11	4	102
Witch Flounder	15	21	24	25	21	19	21	24	85
Swordfish	38	25	8	0	21	29	19	2	71
Pollock	8	27	29	4	35	28	5	0	68
Atlantic (striped) Wolffish	2	17	24	12	10	25	18	2	55
Cusk	30	14	3	0	22	22	3	0	47
Mako Shark	20	20	7	0	12	19	14	2	47
Monkfish	9	15	10	8	20	13	9	0	42
Roughhead Grenadier	2	13	11	9	2	16	12	5	35
Bluefin Tuna	13	7	7	6	10	12	8	3	33
Argentine	4	14	8	4	6	19	4	1	30
Porbeagle Shark	19	2	0	0	8	13	0	0	21
Sea Scallop	2	3	9	4	3	5	6	4	18
Mahi Mahi (dolphinfish)	7	6	2	0	4	5	5	1	15
Sea Cucumber	0	0	3	8	0	3	8	0	11
White Marlin	5	4	1	0	3	2	4	1	10
Albacore Tuna	3	3	2	0	1	2	4	1	8
Bigeye Tuna	2	3	1	0	1	2	3	0	6
Groundfish sp.	0	4	0	0	0	1	3	0	4
Iceland Scallop	3	0	0	0	3	0	0	0	3
Capelin	0	0	2	0	2	0	0	0	2
Stimpson's Surf Clam	0	1	1	0	0	1	1	0	2
Propeller Clam	0	1	1	0	0	1	1	0	2
Cockle	0	1	1	0	0	1	1	0	2
Blue Marlin	2	0	0	0	1	1	0	0	2
Mackerel	0	0	1	0	0	1	0	0	1
Quahaug Clam	0	0	1	0	0	0	1	0	1
Total	**1,672**	**2,423**	**2,411**	**1,376**	**1,880**	**2,490**	**2,192**	**1,320**	**7,882**

Source: DFO commercial landings database, All Atlantic Regions (2014).

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2014 quartile ranges: 1 = 0 – 2,421 kg, 2 = 2,422 – 10,786 kg, 3 = 10,787 – 42,872 kg, 4 = ≥ 42,873 kg.

[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2014 quartile ranges: 1 = \$0 – \$8,851, 2 = \$8,852 – \$38,076, 3 = \$38,077 – \$140,695, 4 = ≥ \$140,696.

[c] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 4.7 Commercial Catch Weights and Values in the Study Area, May–November 2015 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] attributed to each species).

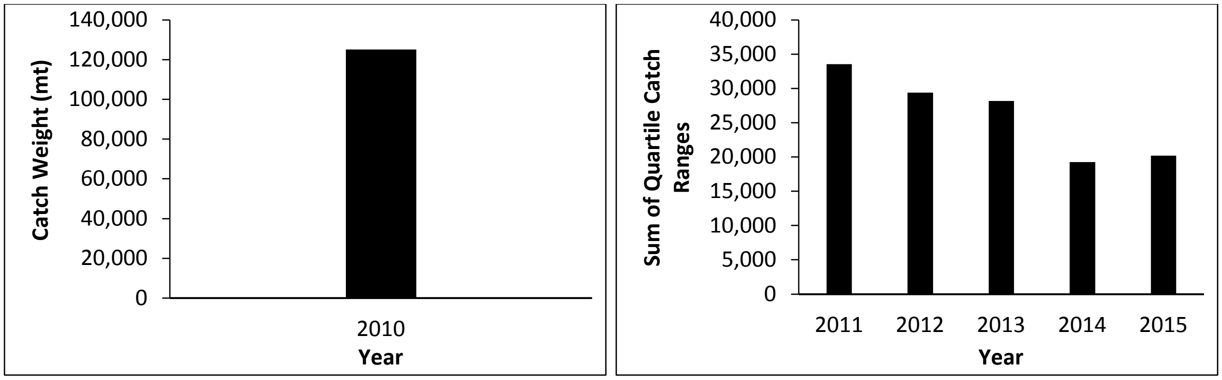
Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts [b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Snow Crab	523	779	817	287	423	711	752	520	2,406
Northern Shrimp	307	499	571	758	327	451	498	859	2,135
Greenland Halibut	88	250	200	41	103	230	203	43	579
Atlantic Halibut	165	173	120	59	178	180	126	33	517
Atlantic Cod	79	129	127	56	108	159	102	22	391
Redfish sp.	68	90	89	41	112	80	63	33	288
American Plaice	38	85	98	48	99	94	54	22	269
Yellowtail Flounder	40	82	76	34	99	81	43	9	232
White Hake	88	77	51	4	117	81	21	1	220
Striped Shrimp	16	40	68	65	18	40	53	78	189
Witch Flounder	22	54	67	26	47	55	43	24	169
Whelk	20	35	45	22	39	36	34	13	122
Atlantic Haddock	30	35	37	14	48	40	23	5	116
Cusk	50	37	16	2	50	46	9	0	105
Monkfish	25	36	24	9	56	24	11	3	94
Pollock	10	20	27	3	27	26	7	0	60
Swordfish	21	15	10	1	16	10	14	7	47
Mako Shark	10	11	10	1	7	8	11	6	32
Skate sp.	7	14	8	1	14	11	4	1	30
Bluefin Tuna	4	5	12	6	5	6	9	7	27
Roughhead Grenadier	0	10	7	3	0	2	14	4	20
Porbeagle Shark	6	9	1	2	2	11	4	1	18
Atlantic (striped) Wolffish	3	12	1	1	2	12	2	1	17
Albacore Tuna	8	3	3	1	7	2	4	2	15
Sea Cucumber	1	1	4	9	2	3	5	5	15
Bigeye Tuna	2	3	6	1	1	1	5	5	12
Arctic Skate	2	5	0	0	2	5	0	0	7
Silver Hake	1	1	2	0	2	1	0	1	4
Capelin	0	3	1	0	4	0	0	0	4
Sea Scallop	2	0	0	1	2	0	1	0	3
Yellowfin Tuna	0	2	1	0	0	1	1	1	3
Shark sp.	0	1	2	0	0	1	2	0	3
Mahi Mahi (dolphinfish)	1	0	1	0	1	0	0	1	2
Stimpson's Surf Clam	0	1	1	0	0	2	0	0	2
Hagfish	0	0	1	0	0	1	0	0	1
Porcupine Crab	0	1	0	0	0	0	1	0	1
Iceland Scallop	0	1	0	0	0	1	0	0	1
Propeller Clam	0	0	1	0	0	1	0	0	1
Total	**1,637**	**2,519**	**2,505**	**1,496**	**1,918**	**2,413**	**2,119**	**1,707**	**8,157**

Source: DFO commercial landings database, All Atlantic Regions (2015).

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2014 quartile ranges: 1 = 0 – 2,253 kg, 2 = 2,254 – 9,535 kg, 3 = 9,536 – 40,703 kg, 4 = ≥ 40,704 kg.

[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2014 quartile ranges: 1 = \$0 – \$9,539, 2 = \$9,540 – \$37,526, 3 = \$37,527 – \$134,094, 4 = ≥ \$134,095.

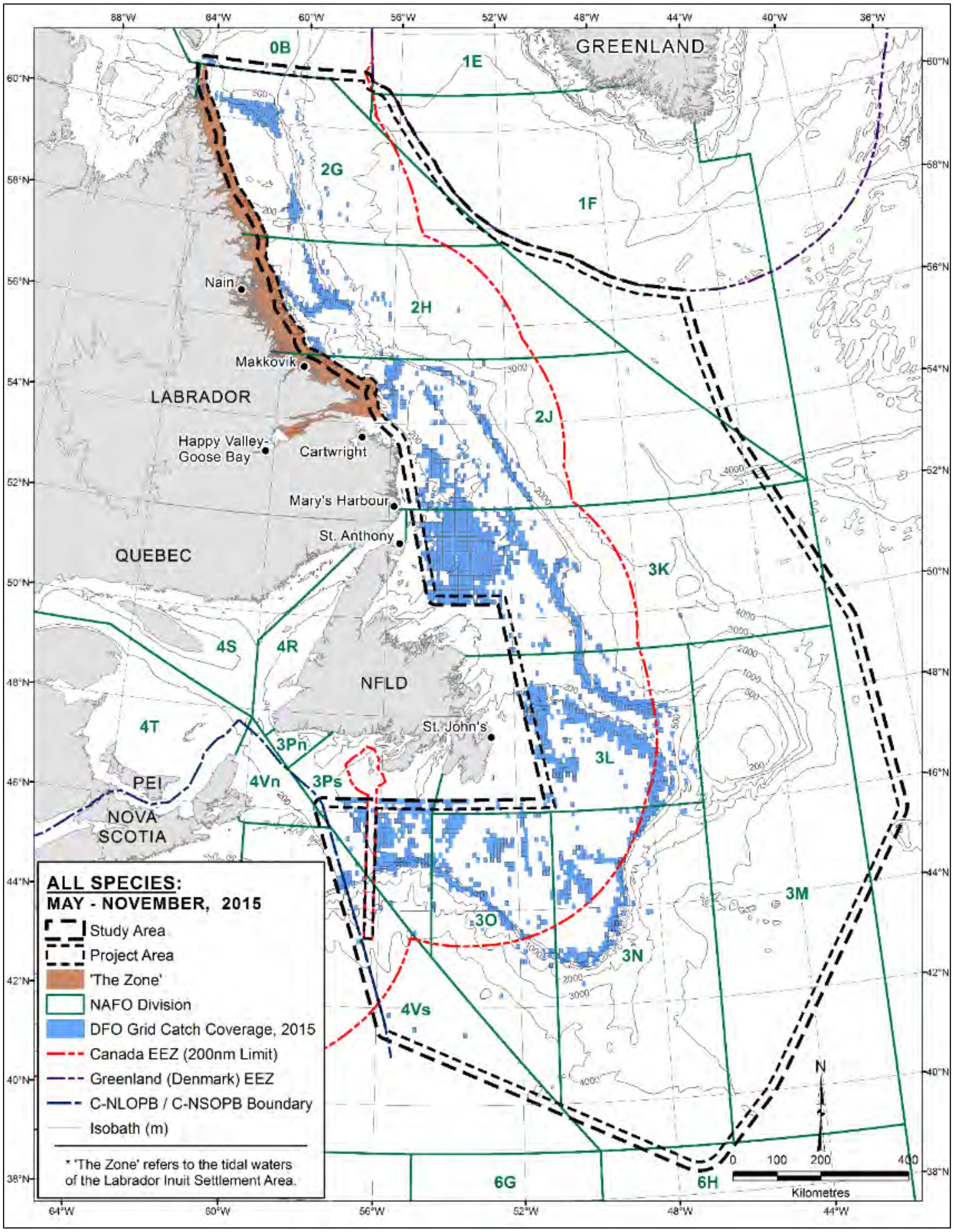
[c] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.



Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.4 Total Catch Weight, May–November 2010 (left), and Annual Total Catch Weight Quartile Codes, May–November 2011–2015 (right) (all species within the Study Area).



Source: DFO commercial landings database, 2015.

Figure 4.5 Distribution of Commercial Harvest Locations, All Species, May–November 2015.

Fishing Gear Used in the Study Area

A variety of fishing gear types were used in the Study Area during May–November 2010–2015. These include trawls (northern shrimp, Greenland halibut, redfish, American plaice, yellowtail flounder and Atlantic halibut), pots (snow crab, Greenland halibut, redfish, American plaice, Atlantic cod and Atlantic halibut), and longlines (Greenland halibut, redfish, American plaice, yellowtail flounder, Atlantic cod and Atlantic halibut) (Tables 4.8 and 4.9). Atlantic cod were also harvested using hand-line (baited) and rod and reel. Shrimp trawls (mobile gear) accounted for about 59% of the total catch weight of all species in the Study Area during 2010. Pots (fixed gear) accounted for ~24% of the total catch weight during this period. Overall, mobile and fixed gears each accounted for ~68% and 32%, respectively (Table 4.8).

Fishing gears and harvest locations by gear type typically used in the Study Area are provided in § 4.10.2.3 of the Labrador Shelf SEA (C-NLOPB 2008), Table 4.119 and Figure 4.137 of the Eastern Newfoundland SEA (C-NLOPB 2014) and Table 3.5 and Figures 2.19–3.20 in the Southern Newfoundland SEA (C-NLOPB 2010). As described in § 4.3.3.2 of LGL (2016), the fixed gears have greater potential to interact with Project activities than the mobile gears.

Mobile and fixed gear harvest locations in Labrador waters during 2005–2010 are shown in Figures 4.6–4.7 of LGL (2014). Figures 4.9–4.12 of LGL (2015a) and Figures 4.138–4.139 of C-NLOPB (2014) show similar information for the eastern Newfoundland offshore during May–November 2008–2012. Figures 4.9–4.12 of LGL (2015b) show similar information for the southeastern/southern Newfoundland offshore during May–November 2005–2013. Fixed and mobile gear harvest locations in the Study Area during May–November 2013-2014 are shown in Figures 4.6–4.7 of LGL (2016). Figure 4.6 shows fixed and mobile gear catch locations in the Study Area during May–November 2015.

Harvest Timing in the Study Area

Total monthly catch weights of all species within the Study Area during May–November 2010 and total sum of monthly catch weight quartile codes for May–November 2011–2015 are indicated in Figure 4.7. Monthly catch weights were highest during the May–August period and lowest during the fall. Note that the timing of harvesting can vary from year to year depending on resource availability, fisheries management plans and enterprise harvesting strategies.

Table 4.8 Total Study Area Catch Weight by Gear Type, May–November 2010.

Species	Fixed Gear		Mobile Gear	
	mt	% of Total	mt	% of Total
Northern Shrimp	0	0	73,382	86
Snow Crab	29,904	75	0	0
Yellowtail Flounder	0.2	<0.1	4,880	6
Greenland Halibut	3,085	8	1,692	2
Whelk	3,898	10	0	0
Redfish sp.	199	0.5	2,740	3
Atlantic Cod	1,133	3	207	0.2
Striped Shrimp	0	0	1,122	1
American Plaice	23	0.1	804	1
White Hake	420	1	2	<0.1
Atlantic Halibut	293	1	20	<0.1
Pollock	248	1	7	<0.1
Monkfish	219	1	0.4	<0.1
Hagfish	162	0.4	0	0
Cockle	0	0	146	0.2
Witch Flounder	3	<0.1	125	0.1
Skate sp.	120	0.3	2	<0.1
Stimpson's Surf Clam	0	0	56	0.1
Atlantic Haddock	31	0.1	22	<0.1
Atlantic Herring	5	<0.1	35	<0.1
Bluefin Tuna	1	<0.1	36	<0.1
Roughhead Grenadier	37	0.1	0	0
Mackerel	0	0	32	<0.1
Capelin	0	0	28	<0.1
Swordfish	25	0.1	0	0
Sea Scallop	0	0	8	<0.1
Cusk	7	<0.1	0.1	<0.1
Porbeagle Shark	2	<0.1	0	0
Roundnose Grenadier	1	<0.1	0	0
Atlantic (striped) Wolffish	1	<0.1	<0.1	<0.1
Mako Shark	0.3	<0.1	0	0
Bigeye Tuna	0.1	<0.1	0	0
Flounder sp.	0	0	<0.1	<0.1
Yellowfin Tuna	<0.1	<0.1	0	0
Shark sp.	<0.1	<0.1	0	0
Albacore Tuna	<0.1	<0.1	0	0
Subtotal	**39,819**	**100**	**85,346**	**100**
Grand Total (mt)	**125,166**			

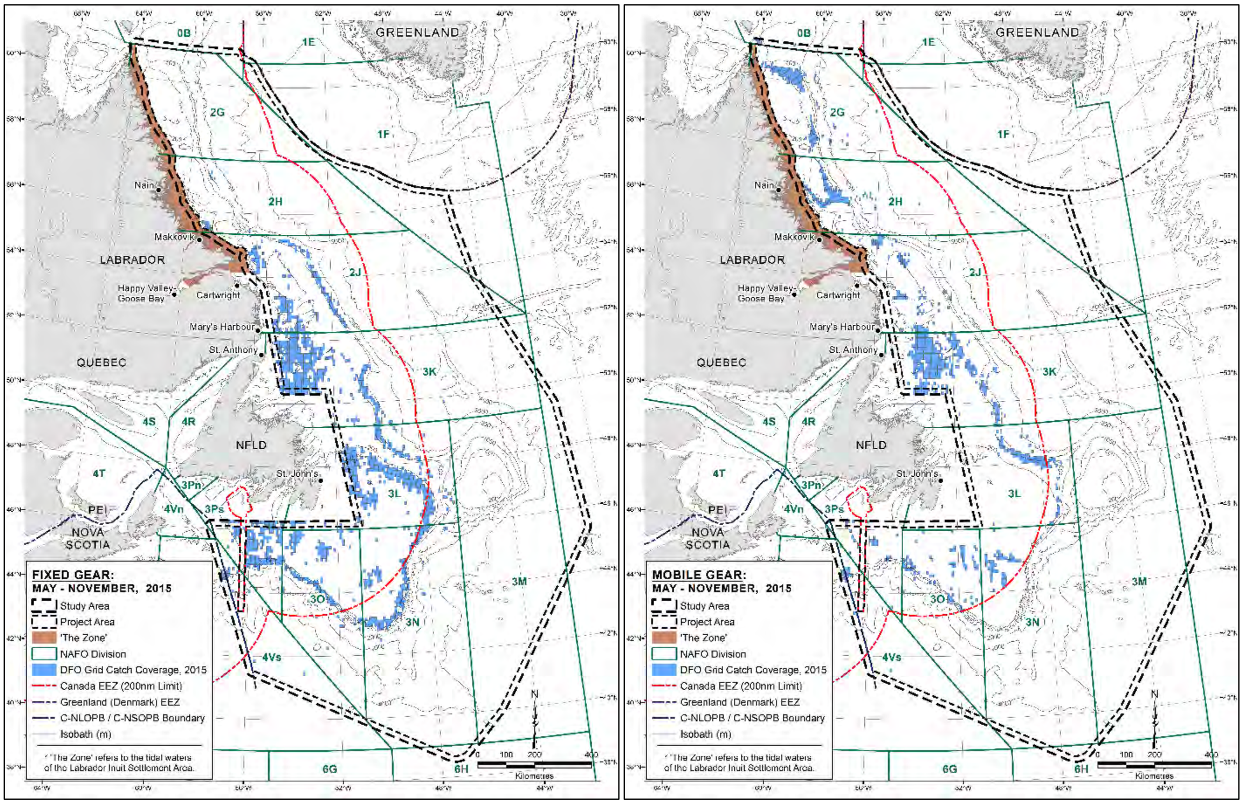
Source: DFO commercial landings database, 2010.

Table 4.9 Summary of Gear Type Used and Timing of the Commercial Fishery in the Study Area, May–November 2010–2015.

Species	Month Caught						Gear Type	
	2010	2011	2012	2013	2014	2015	Fixed	Mobile
Northern Shrimp	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	-	Trawl
Snow Crab	May-Sep; Nov	May-Aug	May-Aug	May-Aug	May-Aug	May-Aug	Pot	-
Greenland Halibut	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	Gillnet; Longline; Pot	Trawl
Redfish sp.	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	Gillnet; Longline; Pot	Trawl
American Plaice	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	May-Jun; Aug-Nov	Gillnet; Longline; Pot	Trawl
Yellowtail Flounder	May-Nov	May-Jul; Sep-Nov	May-Jun; Oct-Nov	May-Jul; Sep-Nov	May-Aug; Oct-Nov	May-Jun; Aug-Nov	Gillnet; Longline	Trawl
Atlantic Cod	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	Gillnet; Longline; Pot	Trawl; Hand-line (baited); Rod and Reel
Skate sp.	May-Nov	May-Nov	May-Nov	May-Aug; Oct-Nov	May-Sep; Nov	May-Nov	Gillnet; Longline	Trawl
Atlantic Halibut	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	Gillnet; Longline; Pot	Trawl
Whelk	May-Aug	May-Aug	May-Aug	May-Oct	May-Oct	May-Oct	Pot	-
Roughhead Grenadier	May-Nov	Jun-Aug; Oct-Nov	May-Oct	May-Nov	May-Aug	Jun-Sep	Gillnet	Trawl
Witch Flounder	May-Nov	May-Sep; Nov	May-Nov	May-Nov	May-Nov	May-Jun; Aug-Nov	Gillnet	Trawl
White Hake	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	May-Nov	Gillnet; Longline	Trawl
Atlantic Haddock	May-Nov	May-Nov	Jun-Nov	May-Nov	May-Nov	May-Nov	Gillnet; Longline; Pot	Trawl
Pollock	May-Nov	Jun-Nov	May-Nov	May-Aug; Oct-Nov	May-Nov	Jun-Nov	Gillnet; Longline	Trawl
Monkfish	May-Nov	Jun-Nov	May-Nov	May-Aug; Oct-Nov	May-Nov	May-Nov	Gillnet; Longline	Trawl
Capelin	May-Nov	Jul	Jul	Jul	Jul	Jul	Trap Net	Trawl; Seine
Striped Shrimp	May; Jul-Nov	Sep-Nov	May-Nov	May; Jul-Nov	May; Aug-Nov	May-Nov	-	Trawl
Cusk	May-Nov	May-Nov	May-Nov	May-Nov	May-Aug; Nov	May-Nov	Gillnet; Longline	Trawl
Bluefin Tuna	Sep-Nov	Jul-Nov	Jul-Nov	Jul; Sep	Aug-Nov	Aug-Nov	Longline	Troller Lines; Rod and Reel; Electric Harpoon
Atlantic (striped) Wolffish	Jun-Aug	Jun-Jul	Jun-Jul	Jul	May-Jul	Jun-Aug	Gillnet; Longline	Trawl
Hagfish	Sep-Nov	Sep-Oct	Sep-Nov	Jun; Aug-Oct	-	May	Hagfish Barrel; Trap Net	-

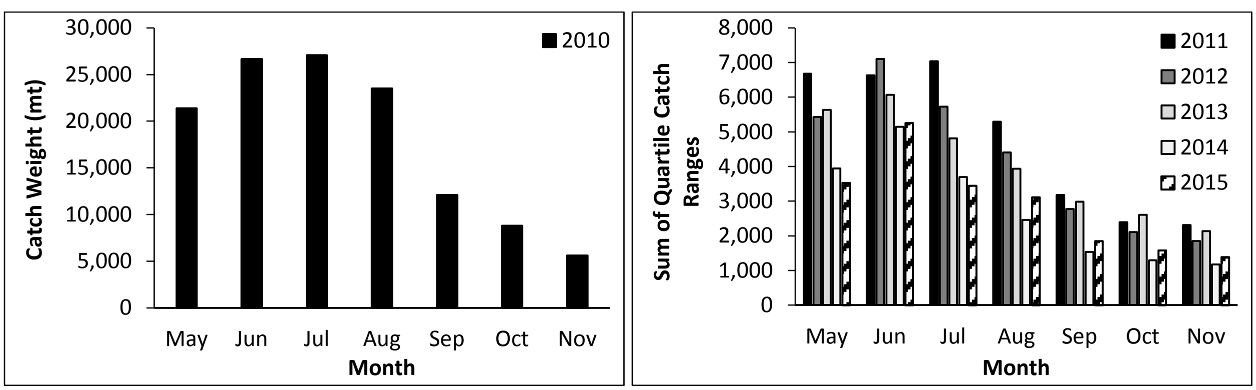
Species	Month Caught						Gear Type	
	2010	2011	2012	2013	2014	2015	Fixed	Mobile
Shark sp.	Jul-Oct	Oct	Nov	-	-	Aug-Sep	Gillnet; Longline	Trawl
Swordfish	Aug-Nov	Jul-Nov	Jul-Nov	Jul-Aug; Oct	Aug-Oct	Aug-Oct	Longline	Trawl
Mako Shark	Jun-Oct	Jul-Oct	Jul-Nov	Jul-Aug	Jun; Aug-Oct	Aug-Oct	Gillnet; Longline	-
Stimpson's Surf Clam	May-Oct	Oct	Jun	Jun-Nov	May; Aug	May; Oct	-	Dredge
Porbeagle Shark	May-Jun; Aug; Oct-Nov	Jun-Aug; Nov	May-Jun; Nov	Jun	May-Jul; Sep-Oct	May-Jul; Sep	Gillnet; Longline	-
Cockle	Jul	Oct	-	Jun; Aug-Nov	May; Aug	-	-	Dredge
Atlantic Herring	Jun-Jul; Sep; Nov	-	-	May	-	-	Gillnet	Trawl; Seine
Roundnose Grenadier	Jun-Jul	Jul-Aug	Jun	Nov	-	-	Longline	-
Sea Scallop	Jun-Nov	May; Sep	Jul-Aug; Nov	May; Jul	Jul-Sep	Jul-Aug	-	Dredge
Flounder sp.	Nov	-	Sep	Aug; Nov	-	-	Gillnet	Trawl
Bigeye Tuna	Sep-Oct	Jul-Sep; Nov	Jul-Sep; Nov	-	Sep-Oct	Aug-Oct	Longline	-
Mackerel	Sep-Oct	Sep-Oct	Sep	Oct	Oct	-	-	Seine
Albacore Tuna	Aug	Jul-Sep	Jul-Sep; Nov	Jul	Aug-Oct	Aug-Oct	Longline	-
Yellowfin Tuna	Oct	Jul-Aug; Oct	Aug-Sep	-	-	Sep	Longline	-
Sea Cucumber	-	Aug-Nov	Jul-Oct	Aug-Oct	Sep-Nov	Jun-Oct	-	Dredge; Drag Rake; Unspecified
Winter Flounder	-	Sep	Jul; Sep	-	-	-	Gillnet	Trawl
Atlantic Rock Crab	-	Sep-Oct	Aug	-	-	-	Pot	-
Mahi Mahi (dolphinfish)	-	Jul-Aug	Jul-Aug; Oct	Jul-Aug	Aug-Sep	Aug; Oct	Longline	-
White Marlin	-	Jul	Aug	-	Aug-Sep	-	Longline	-
Groundfish sp.	-	Jul	-	-	Nov	-	Longline	-
Iceland Scallop	-	-	Aug	-	Jul-Aug; Oct	Sep	-	Dredge
Sculpin sp.	-	-	-	Oct	-	-	-	Trawl
Dogfish sp.	-	-	-	Nov	-	-	Longline	-
Propeller Clam	-	-	-	Jun-Jul	May; Aug	May	-	Dredge
Toad Crab	-	-	-	Aug	-	-	Pot	-
Argentine	-	-	-	-	Aug	-	-	Trawl
Blue Marlin	-	-	-	-	Sep	-	Longline	-
Quahaug Clam	-	-	-	-	May	-	-	Dredge
Arctic Skate	-	-	-	-	-	Jul	Longline	-
Silver Hake	-	-	-	-	-	Oct	-	Trawl
Porcupine Crab	-	-	-	-	-	Jul	Gillnet	-

Source: DFO commercial landings database, 2010–2015.



Source: DFO commercial landings database, 2015.

Figure 4.6 Distribution of Fixed (left) and Mobile (right) Gear Commercial Harvest Locations, All Species, May–November 2015.



Source: DFO commercial landings database, 2010–2015.

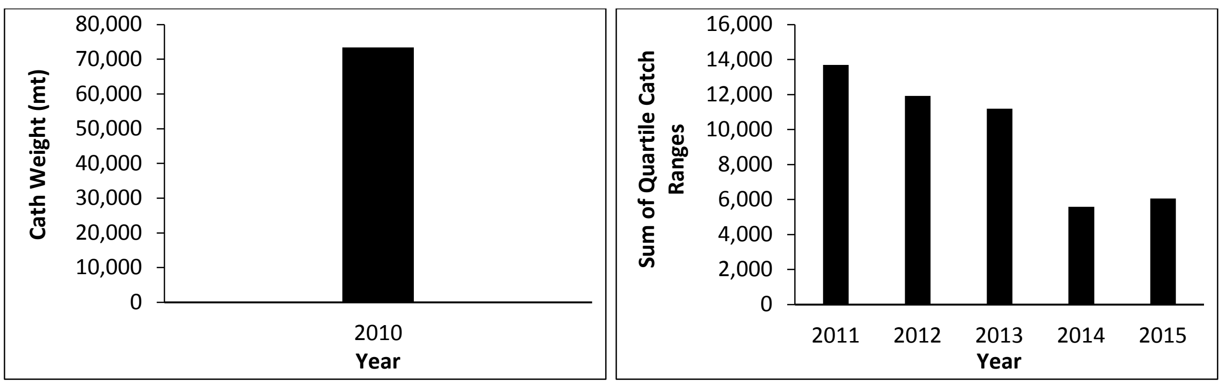
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.7 Total Monthly Catch Weight during May–November 2010 (left) and Total Monthly Sum of Catch Weight Quartile Codes, May–November 2011–2015 (right) (all species within the Study Area).

Principal Species in the Study Area

__Northern Shrimp__

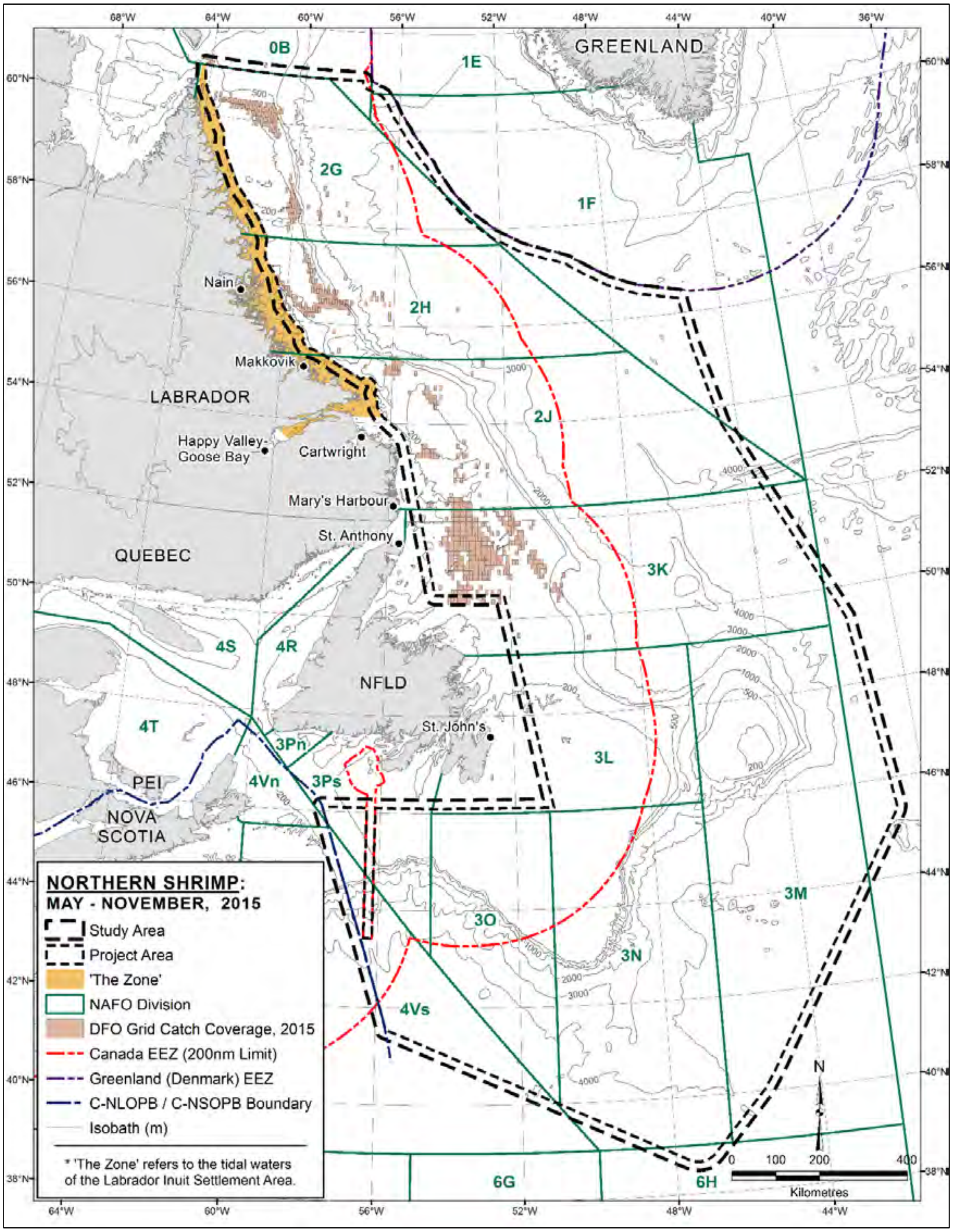
Based on both quantity and value, northern shrimp was the most important commercial species in the Study Area during May–November 2010–2013, and the second most important during May–November 2014–2015. The total annual catch weight (2010) and total annual catch weight quartile codes (2011–2015) for northern shrimp in the Study Area during May–November are shown in Figure 4.8. Shrimp harvest locations in the Study Area during 2005-2014 are provided in recent EAs (LGL 2014, 2015a,b, 2016). Harvest locations during May–November 2015 are shown in Figure 4.9. The majority of northern shrimp were harvested in the central-western and northwestern portions of the Study and Project Areas, between the 200 and 500-m isobaths. An indication of total monthly northern shrimp harvests in the Study Area during the May–November 2010–2015 period is shown in Figure 4.10. Most of the northern shrimp was harvested between June and August.



Source: DFO commercial landings database, 2010–2015.

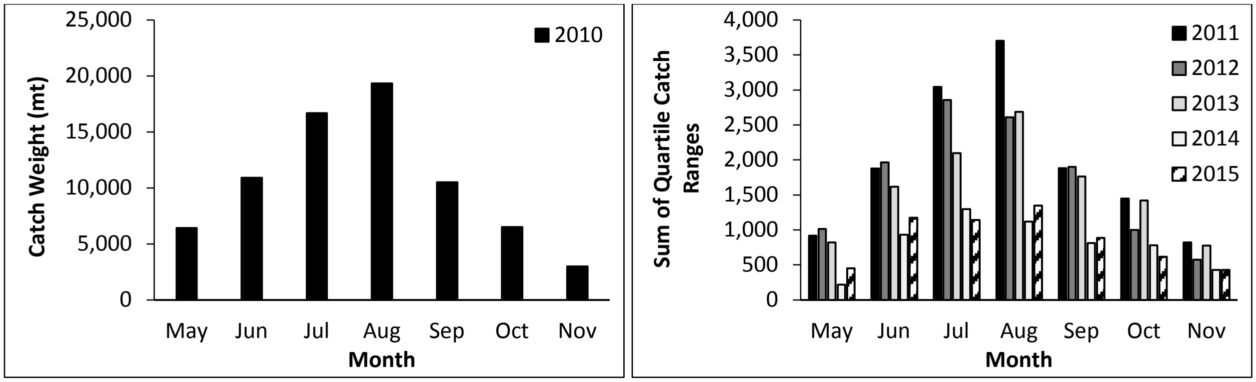
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.8 Total Annual Catch Weight, May–November 2010 (left) and Total Annual Catch Weight Quartile Codes, May–November 2011–2015 (right) for Northern Shrimp in the Study Area.



Source: DFO commercial landings database, 2015.

Figure 4.9 Distribution of Commercial Harvest Locations for Northern Shrimp, May–November 2015.



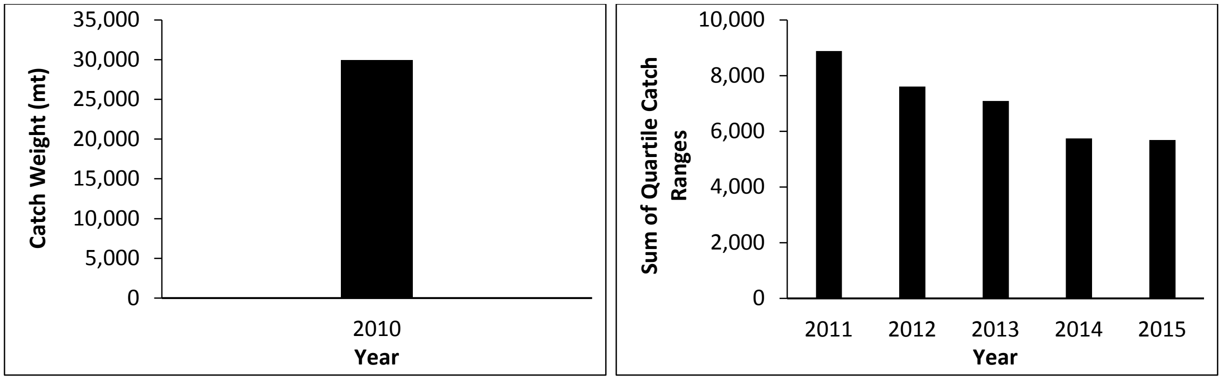
Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.10 Total Monthly Catch Weights, May–November 2010 (left) and Total Monthly Catch Weight Quartile Codes, May–November 2011–2015 (right) for Northern Shrimp in the Study Area.

Snow Crab

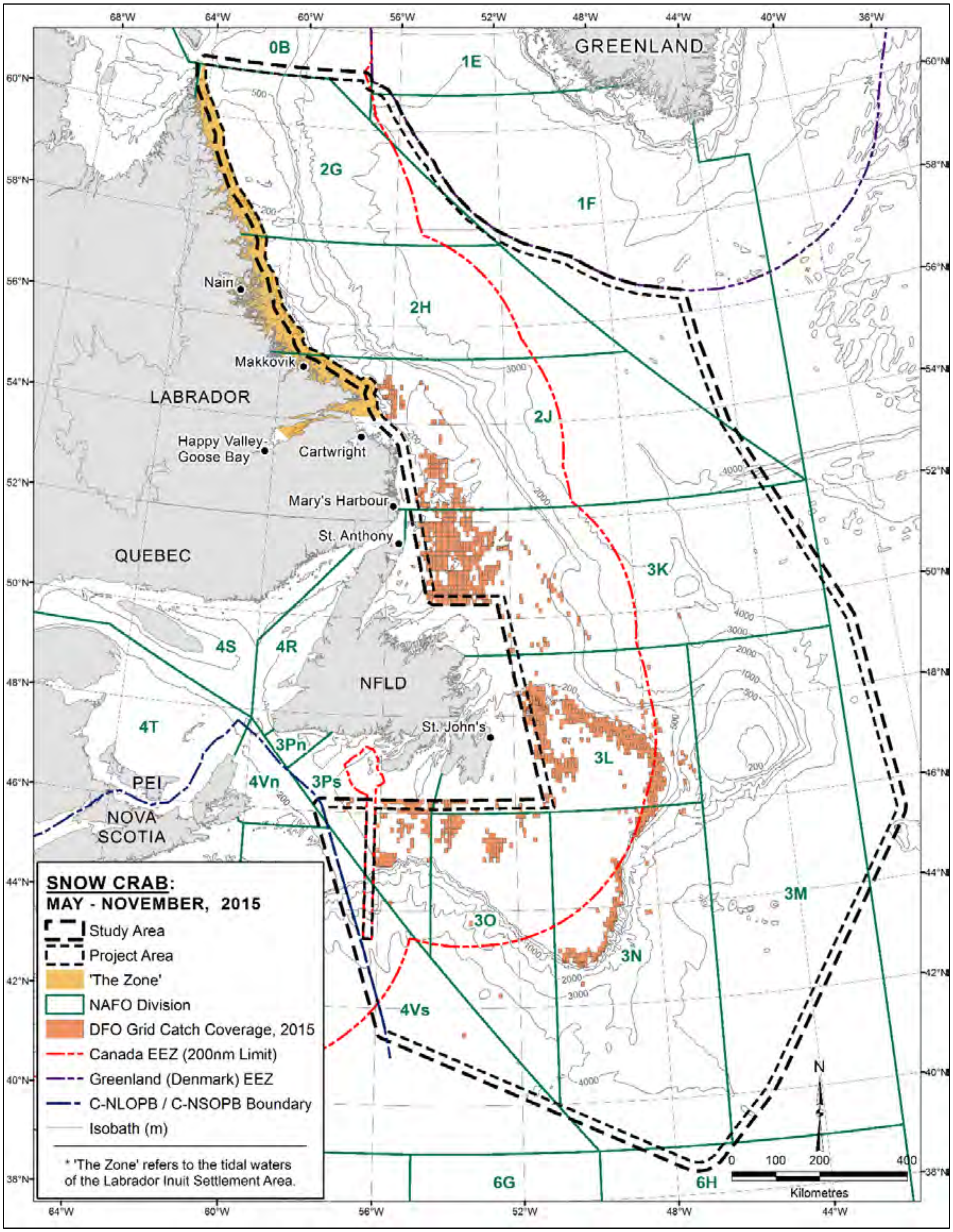
In terms of catch weight, snow crab was the second most important commercial species in the Study Area during 2010–2013, and the most important during 2014–2015. Total annual catch weight (2010) and the total sum of catch weight quartile codes (2011–2015) for snow crab in the Study Area between May and November are indicated in Figure 4.11. Snow crab harvest locations in the Study Area during 2005–2014 are provided in recent EAs (LGL 2014, 2015a,b, 2016). Figure 4.12 indicates snow crab harvesting locations in the Study Area during May–November 2015. The majority of snow crab were caught in the western portion of the Study and Project Areas, in water depths <200 m. The total monthly snow crab harvests in the Study Area during May–November 2010–2015 are shown in Figure 4.13. Snow crab were captured between May and August in the Study Area, with the majority of catch taken during May and June.



Source: DFO commercial landings database, 2010–2015.

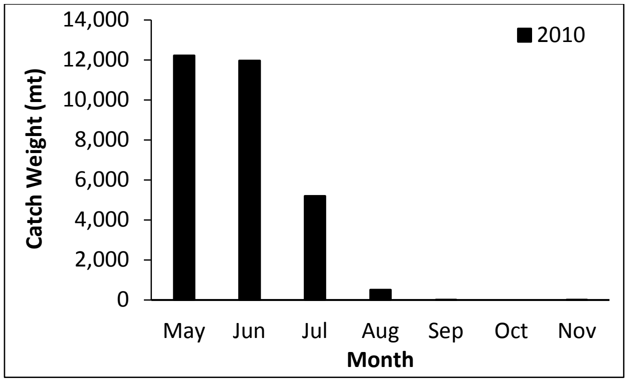
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

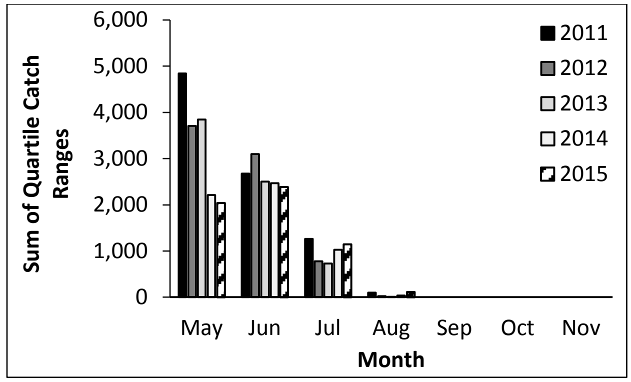
Figure 4.11 Total Annual Catch Weight, May–November 2010 (left) and Total Annual Catch Weight Quartile Codes, May–November 2011–2015 (right) for Snow Crab in the Study Area.



Source: DFO commercial landings database, 2015.

Figure 4.12 Distribution of Commercial Harvest Locations for Snow Crab, May–November 2015.





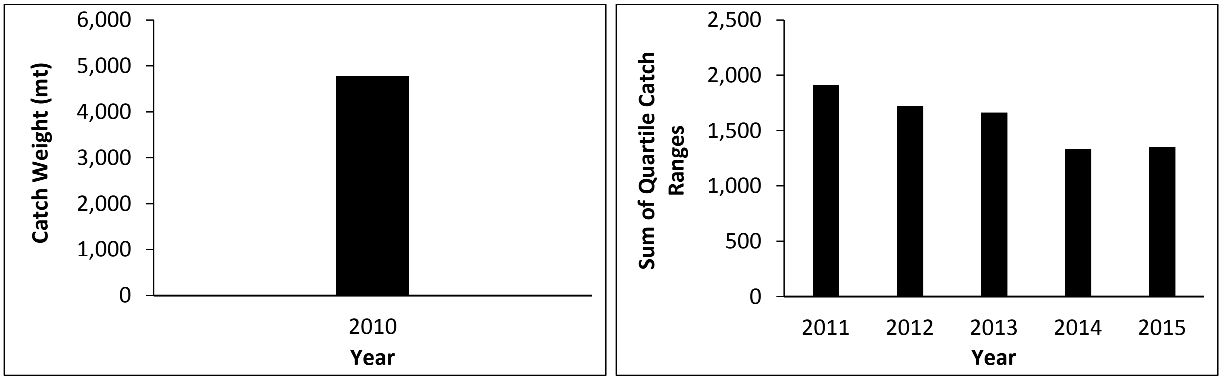
Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.13 Total Monthly Catch Weights, May–November 2010 (left) and Total Monthly Catch Weight Quartile Codes, May–November 2011–2015 (right) for Snow Crab in the Study Area.

Greenland Halibut

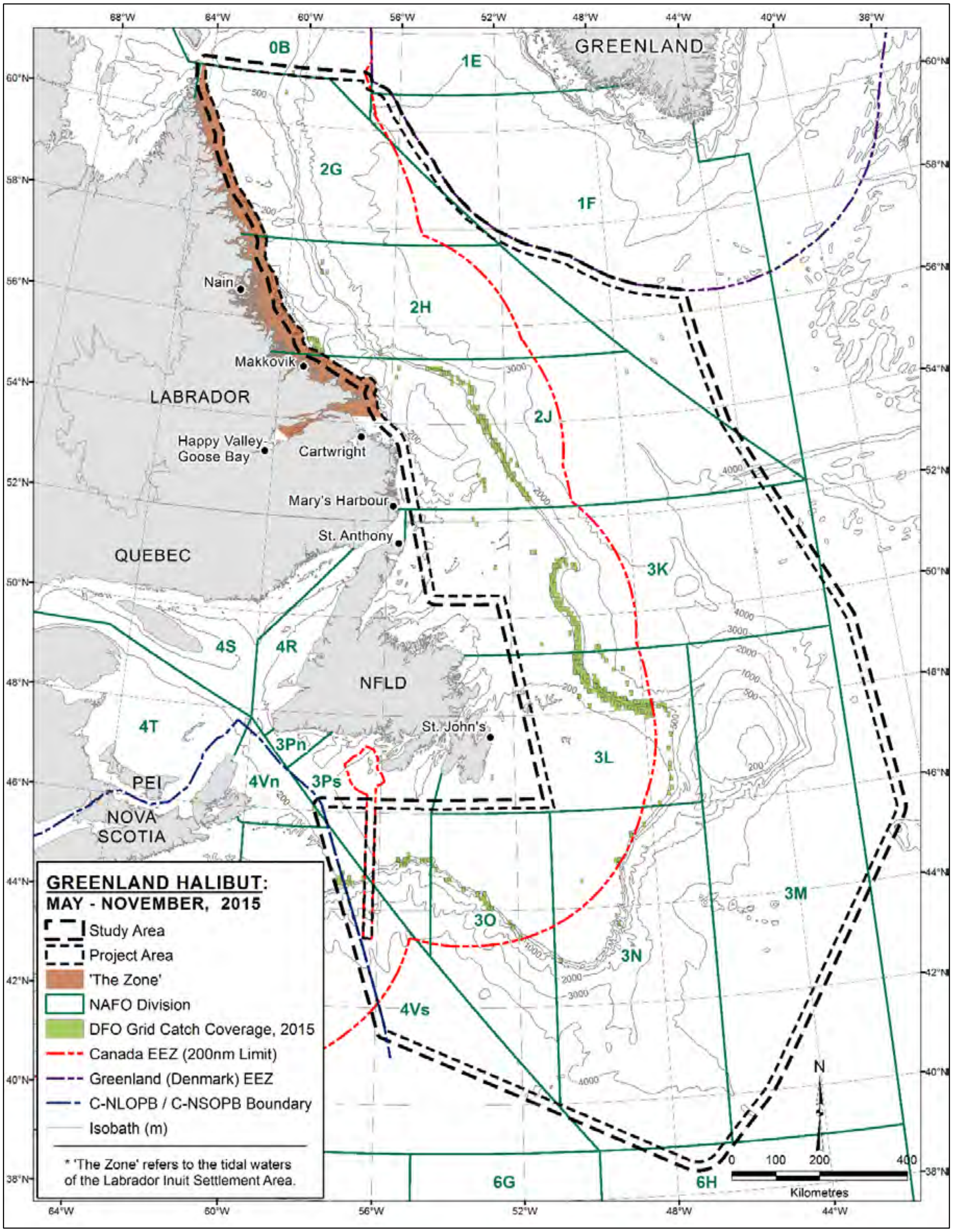
Greenland halibut comprised the largest portion of groundfish catches and was the third most important commercial species in the Study Area during 2011–2015 (fourth most important during 2010). Total catch weight (2010) and the total sum of catch weight quartile codes (2011–2015) for Greenland halibut in the Study Area during May–November are shown in Figure 4.14. Greenland halibut harvest locations in the Study Area during 2005–2014 are provided in recent EAs (LGL 2014, 2015a,b, 2016). Figure 4.15 shows Greenland halibut catch locations in the Study Area during May–November 2015. Greenland halibut were predominantly captured in the central and north-central portions of the Study and Project Areas, almost exclusively between the 500 and 1,000-m isobaths. The total monthly Greenland halibut harvests in the Study Area during May–November, 2010–2015 are indicated in Figure 4.16. This species was primarily taken during the June–August period in the Study Area.



Source: DFO commercial landings database, 2010–2015.

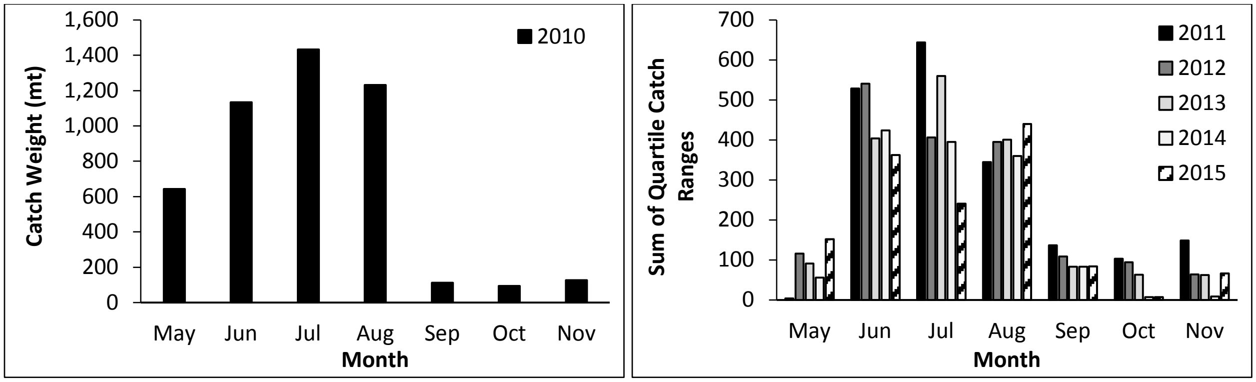
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.14 Total Annual Catch Weight, May–November 2010 (left) and Total Annual Catch Weight Quartile Codes, May–November 2011–2015 (right) for Greenland Halibut in the Study Area.



Source: DFO commercial landings database, 2015.

Figure 4.15 Distribution of Commercial Harvest Locations for Greenland Halibut, May–November 2015.



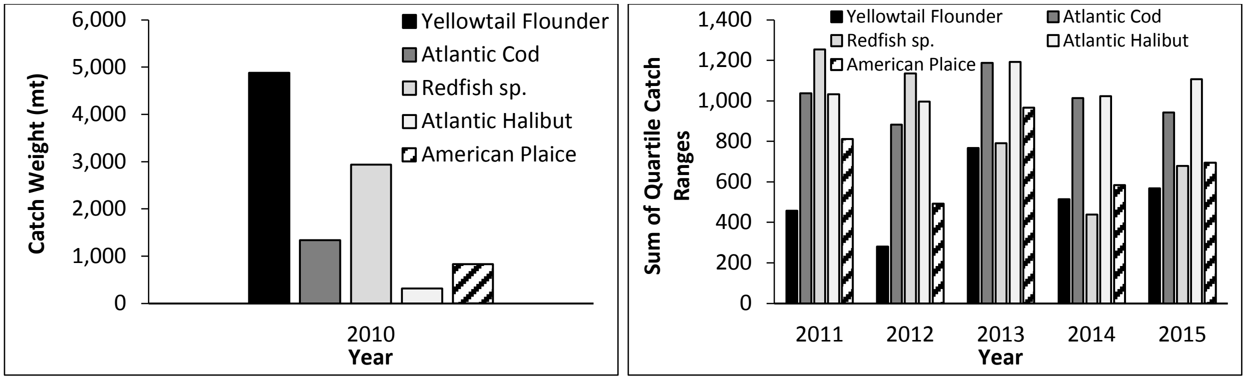
Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.16 Total Monthly Catch Weights, May–November 2010 (left) and Total Monthly Catch Weight Quartile Codes, May–November 2011–2015 (right) for Greenland Halibut in the Study Area.

Other Notable Species: Yellowtail Flounder, Atlantic Cod, Redfish, Atlantic Halibut and American Plaice

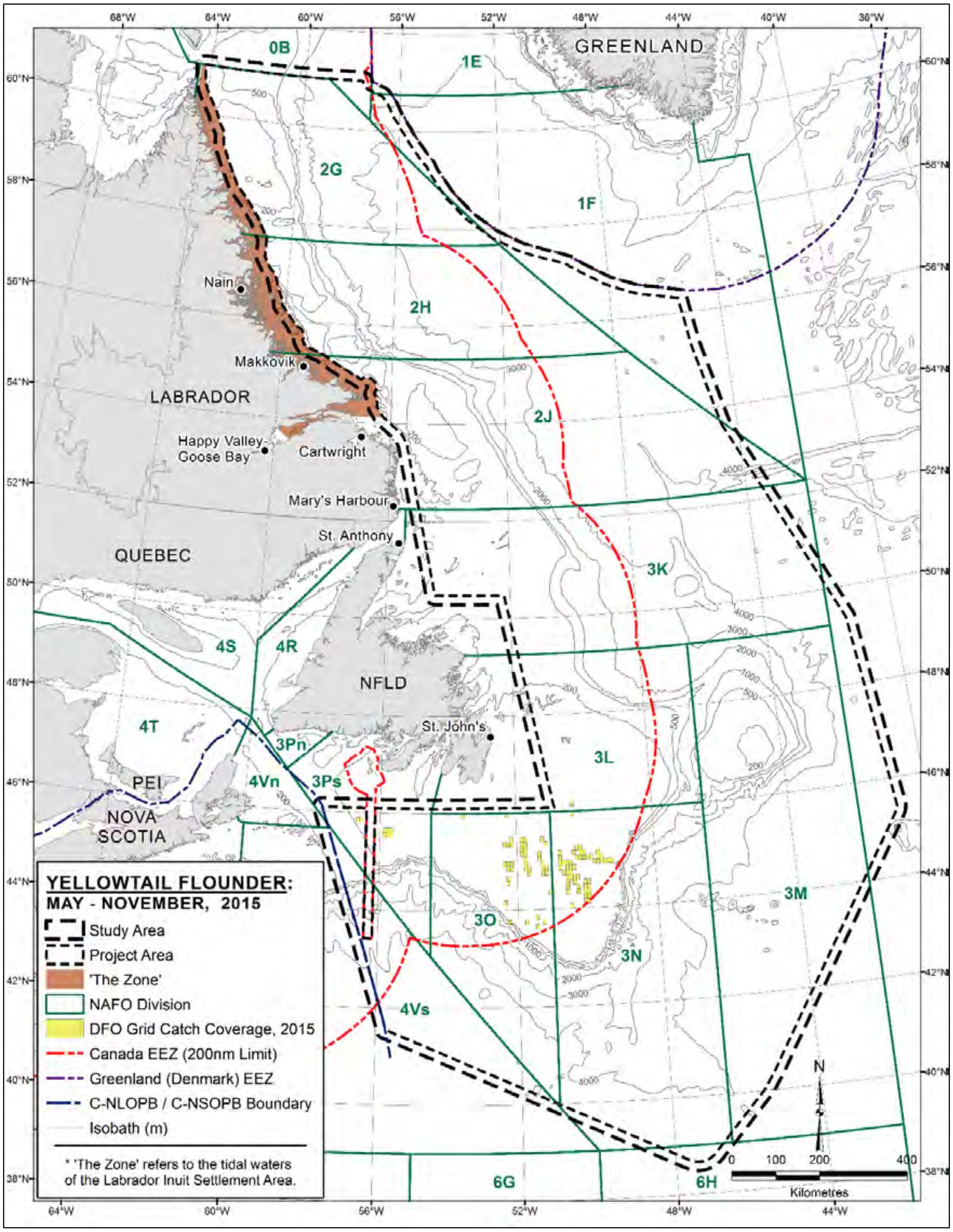
In addition to the three species already discussed, yellowtail flounder, Atlantic cod, redfish, Atlantic halibut and American plaice have also been identified as important commercial species in the Study Area (see § 4.3.3.2 and Tables 4.2–4.7). Total catch weight (2010) and the total sum of catch weight quartile codes (2011–2015) for these species between May and November are shown in Figure 4.17. Harvest locations for yellowtail flounder, Atlantic cod, redfish, and Atlantic halibut in the Study Area during May–November 2013 and 2014, are shown in Figures 4.19–4.21 of LGL (2016). Figures 4.18–4.22 indicate harvest locations in the Study Area during May–November 2015. Most of these species were harvested in the central and south-western portions of the Study Area, in areas with water depths <1,000 m. The total monthly harvests for these species in the Study Area during the May–November 2010–2015 period are shown in Figure 4.23. Most harvesting of yellowtail flounder, Atlantic cod and American plaice occurred during late-spring and fall. Redfish and Atlantic halibut were caught primarily during late-spring and summer.



Source: DFO commercial landings database, 2010–2015.

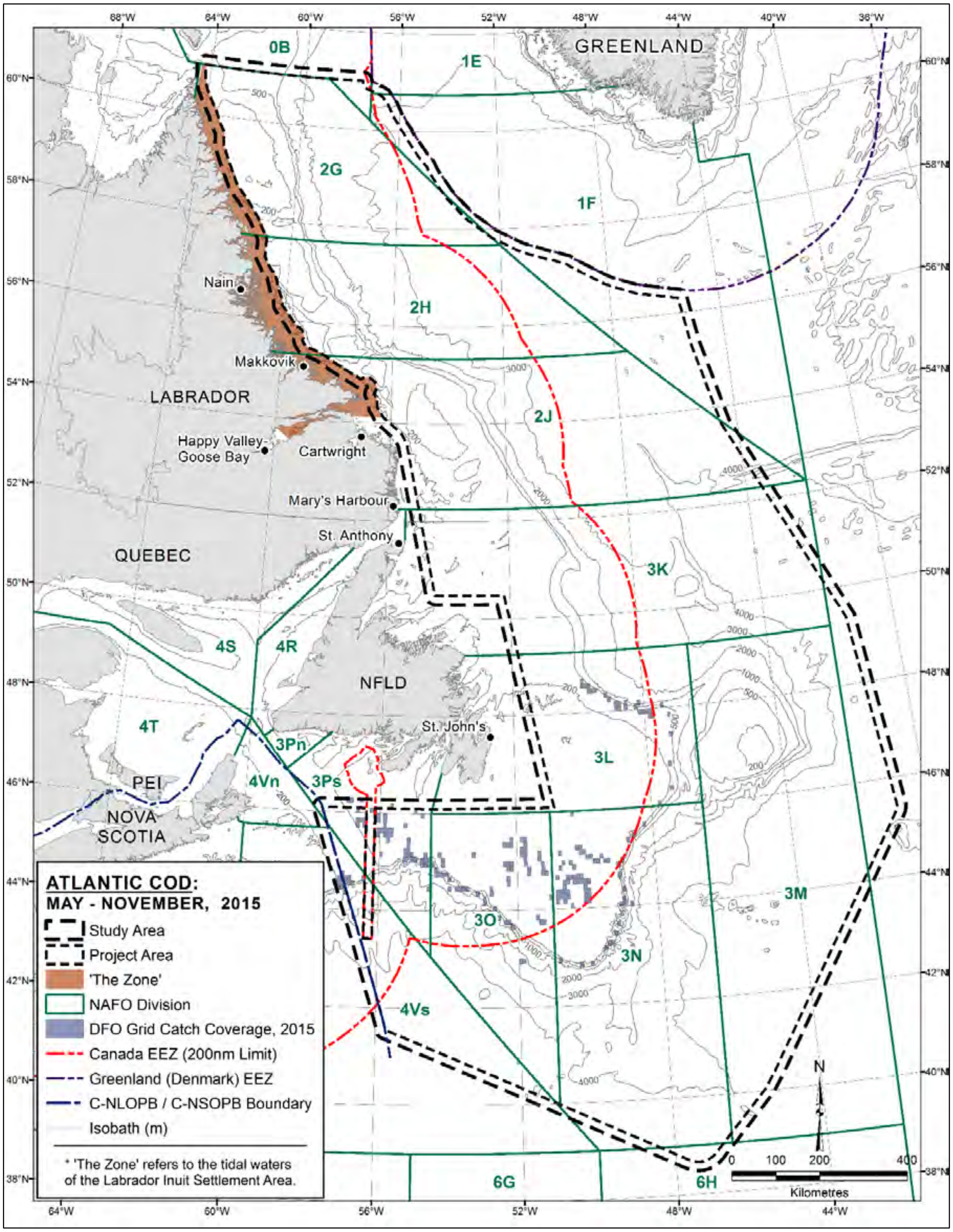
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.17 Total Annual Catch Weight, May–November 2010 (left) and Total Annual Catch Weight Quartile Codes, May–November 2011–2015 (right) for Yellowtail Flounder, Atlantic Cod, Redfish, Atlantic Halibut and American Plaice in the Study Area.



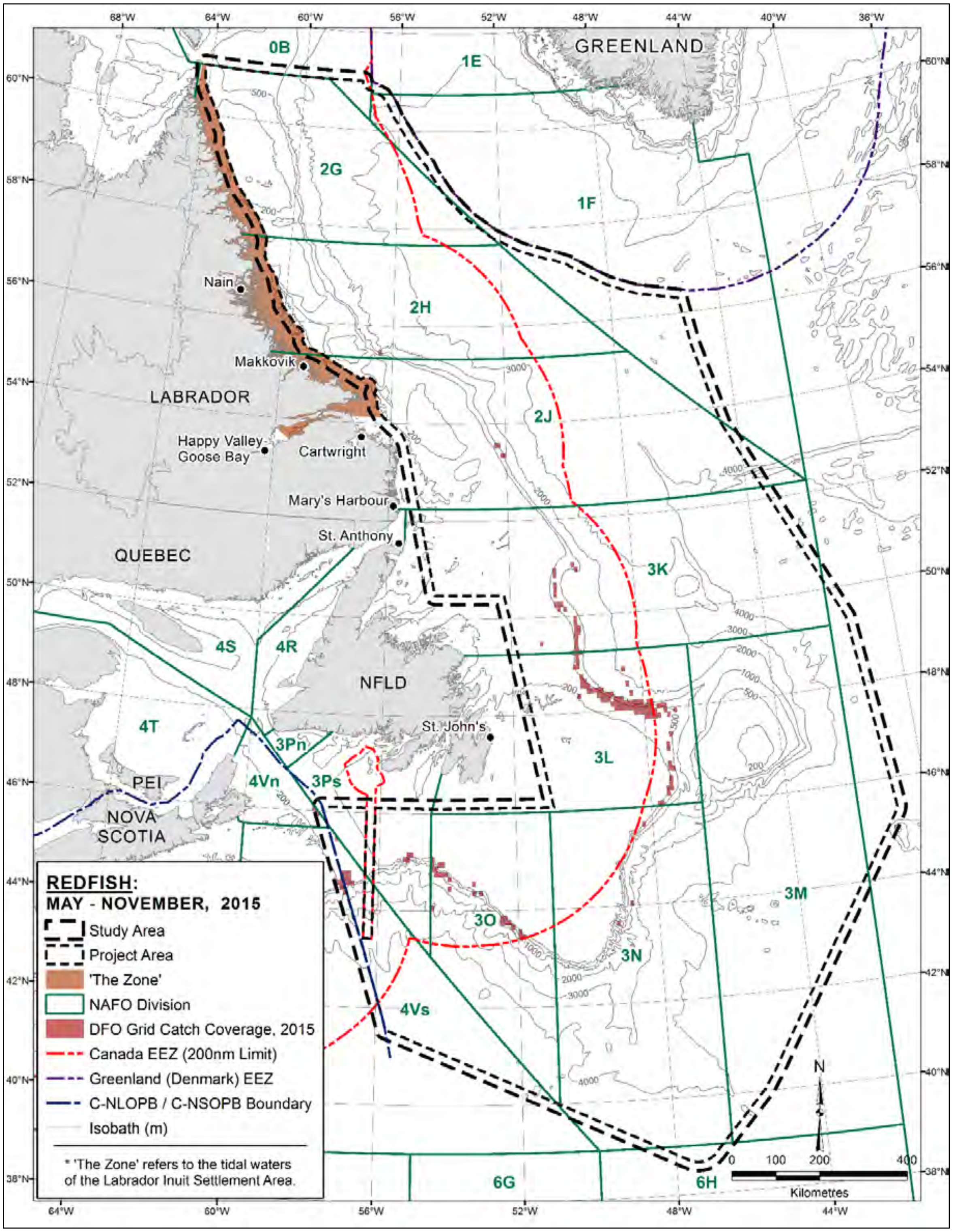
Source: DFO commercial landings database, 2015.

Figure 4.18 Distribution of Commercial Harvest Locations for Yellowtail Flounder, May–November 2015.



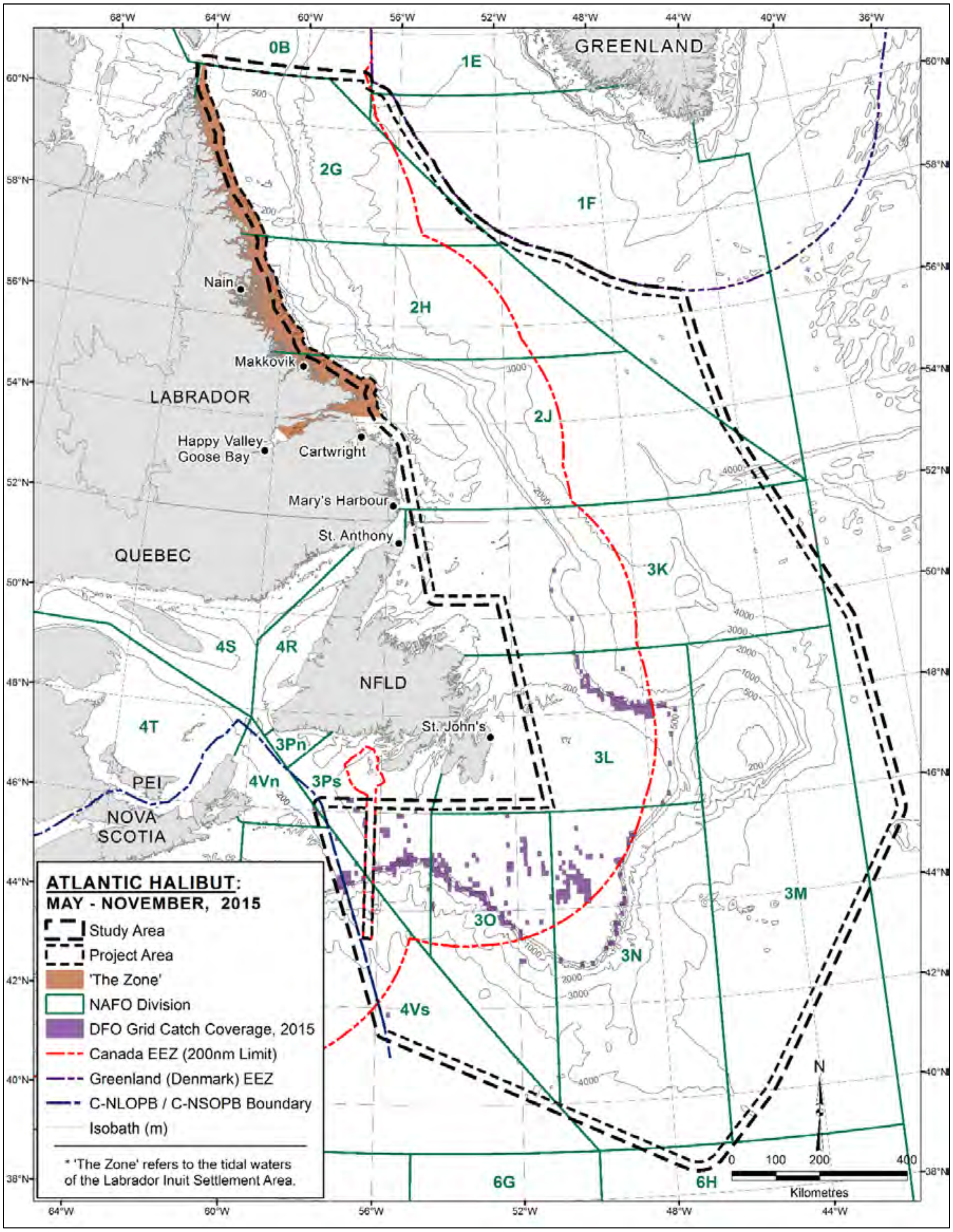
Source: DFO commercial landings database, 2015.

Figure 4.19 Distribution of Commercial Harvest Locations for Atlantic Cod, May–November 2015.



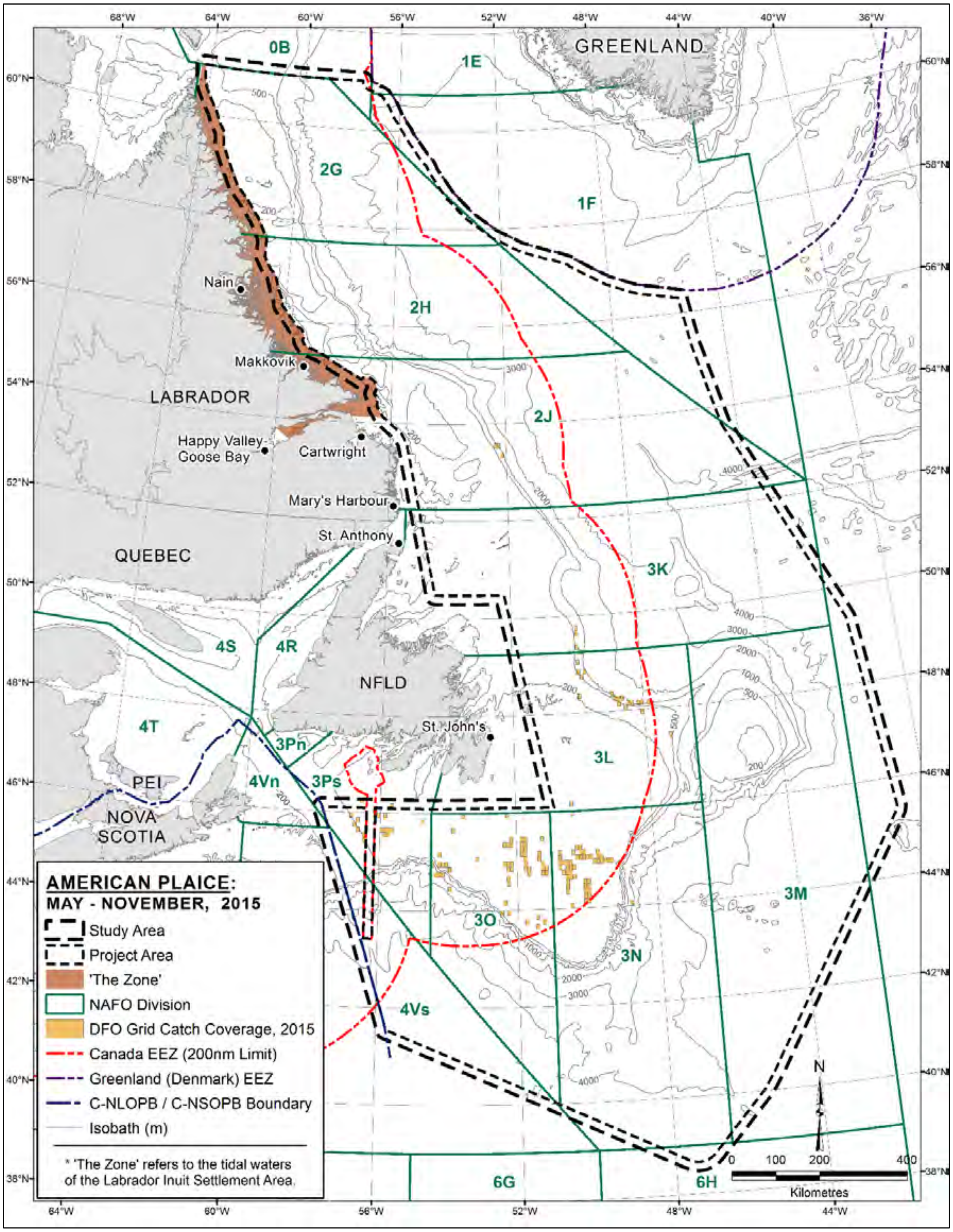
Source: DFO commercial landings database, 2015.

Figure 4.20 Distribution of Commercial Harvest Locations for Redfish, May–November 2015.



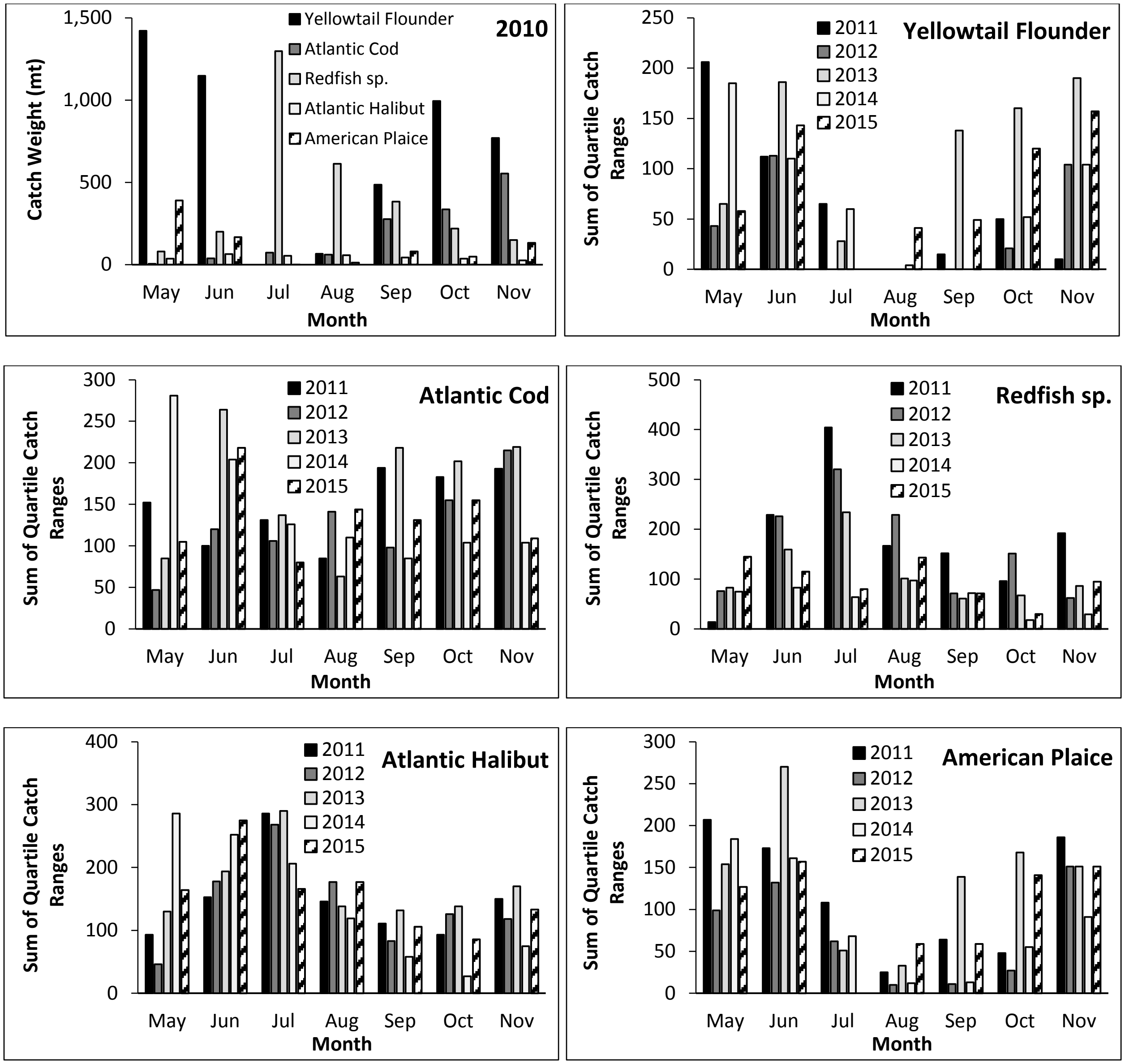
Source: DFO commercial landings database, 2015.

Figure 4.21 Distribution of Commercial Harvest Locations for Atlantic Halibut, May–November 2015.



Source: DFO commercial landings database, 2015.

Figure 4.22 Distribution of Commercial Harvest Locations for American Plaice, May–November 2015.



Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.23 Total Monthly Catch Weights, May–November 2010 (top left) and Total Monthly Catch Weight Quartile Codes, May–November 2011–2015 for Yellowtail Flounder, Atlantic Cod, Redfish, Atlantic Halibut and American Plaice in the Study Area.

4.3.4 Traditional and Aboriginal Fisheries

Traditional and Aboriginal fisheries within the Study Area, including Communal Commercial Fisheries Licences (CCFL), a Communal Snow Crab licence and communal fixed gear groundfish licence, are described in § 4.3.4 of LGL (2016) (Note: pers. comm.'s within the aforementioned section are attributed to D. Ball and D. Tobin of "DFO, Resource Management and Aboriginal Affairs"; this should instead be listed as "DFO, Resource Management and Aboriginal Fisheries"). Traditional fishing activities are also reviewed in § 1.8 and § 4.10.3 of the Labrador Shelf SEA (C-NLOPB 2008), and § 3.3.4 of the Southern Newfoundland SEA (C-NLOPB 2010). According to the Eastern Newfoundland SEA (C-NLOPB 2014), there are no known Aboriginal fisheries that occur within the easternmost portion of the Study Area.

In an effort to increase Indigenous access to the northern shrimp fishery in Shrimp Fishing Area (SFA) 5, three Indigenous groups (Innu, the NunatuKavut Community Council and Nunatsiavut Government) will receive "increased stable and predictable shares", beginning in the 2016/2017 fishing season (DFO 2016f), accounting for ~21% of the TAC among all fleets/interests this season.

4.3.5 Recreational Fisheries

Recreational fisheries in Newfoundland and Labrador are described in § 5.8.4 of the Labrador Shelf SEA (C-NLOPB 2008), § 4.3.4.4 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 3.3.1.2, *Fishing Enterprises and Licenses*, § 3.3.3 of the Southern Newfoundland SEA (C-NLOPB 2010), and § 4.3.5 of LGL (2015a).

In 2016, the Newfoundland and Labrador recreational groundfish fishery was set to be open for a total of 46 days, an increase of 14 days from previous years, beginning with the first weekend in July and ending in the beginning of October (DFO 2016f). This extension is considered a transitional measure that was implemented ahead of the upcoming licence and tag regime for all recreational fishery participants, which is anticipated prior to the 2017 season (DFO 2016f). The recreational groundfish fishery occurs in all NAFO Divisions around the province, including 2GHJ, 3KLPsPn and 4R, with the exception of the Eastport and Gilbert Bay Marine Protected Areas (MPA) (DFO 2016f). Of these NAFO Divisions, 2GHJ and 3KLPs overlap with the Study Area.

It is possible that recreational fisheries will be conducted within the shallower portions of the Study Area.

4.3.6 Aquaculture

Aquaculture operations (or the absence thereof) in Newfoundland and Labrador are described in § 4.10.4 of the Labrador Shelf SEA (C-NLOPB 2008), § 4.3.4.3 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 3.3.2 of the Southern Newfoundland SEA (C-NLOPB 2010). Currently, all aquaculture sites in the province are located in coastal waters. There are no approved aquaculture sites within the Study Area (DFFA 2016).

4.3.7 Macroinvertebrates and Fishes Collected during DFO Research Vessel (RV) Surveys

DFO RV survey data collected during annual multi-species trawl surveys provide additional distributional information for some of the commercial species described in § 4.3.3, as well as for species not discussed in that subsection.

The total catch weight during the 2009–2014 spring (May–August) and fall (September–November) DFO RV surveys in the Study Area was 1,148 mt. It should be noted that there were no RV tows conducted north of the Nain Bank (57.7ºN) between 2010 and 2013. Data collected during these surveys were analyzed, and catch weights, catch numbers and mean catch depths of species/groups contributing ≥0.1% of the total catch weight as well as species at risk (§ 4.6) are presented in Table 4.10.

Table 4.10 Catch Weights and Numbers, and Mean Catch Depths of Macroinvertebrates and Fishes Collected during DFO RV Surveys within the Study Area, May–November 2009–2014.

Species	Catch Weight (mt)	Catch Number	Mean Catch Depth (m)	
			Spring	Fall
Deepwater Redfish	501	3,466,926	376	316
Yellowtail Flounder	88	300,849	75	76
Northern Shrimp	85	19,389,327	324	256
American Plaice	67	419,529	212	188
Atlantic Cod	66	94,882	201	169
Greenland Halibut	48	195,963	357	403
Thorny Skate	43	30,341	306	226
Capelin	31	2,124,967	145	157
Sponges	21	170[b]	294	329
Sand Lance (offshore)	17	1,371,200	91	88
Shrimp (Natantia)	16	106[b]	463	313
Silver Hake	12	86,095	265	283
Roughhead Grenadier	10	24,735	470	579
Sea Cucumber (*Cucumaria frondosa*)	10	36,588	115	127
Striped Shrimp	8	2,154,603	207	135
Witch Flounder	8	25,868	406	289
Snow Crab	7	55,756	178	202
Jellyfishes (Schyphozoa)	6	417	438	482
Atlantic (striped) Wolffish	5	9,595	219	192
Sea Anemone (Actinaria)	5	65,711	358	323
Basket Star (*Gorgonocephalus arcticus*)	5	426	218	197
White Hake	4	4,918	275	246
Longfin Hake	4	45,990	467	412
Northern Wolffish	4	1,045	456	438
Atlantic Haddock	4	3,768	132	125
Blue Hake	3	27,415	575	788
Comb Jelly (Ctenophora)	3	654	72	74
Shrimp (*Argis dentata*)	3	476,762	220	129
Spotted Wolffish	3	1,176	342	280
Green Sea Urchin	2	157,253	108	122
Sea Cucumber (Holothuroidea)	2	12,226	127	170
Roundnose Grenadier	2	18,293	614	798

Species	Catch Weight (mt)	Catch Number	Mean Catch Depth (m)	
			Spring	Fall
Basket Star (Gorgonocephalidae)	2	428	173	228
Marlin Spike	2	39,719	463	538
Arctic Cod	2	113,826	203	178
Atlantic Halibut	2	176	238	349
Longnose Eel	2	36,040	504	661
Black Dogfish Shark	2	3,017	588	811
Sand Dollar (*Echinarachnius parma*)	2	76,137	135	169
Greenland Shark	2	2	593	798
Sea Urchin (Echinoidea)	2	68,317	192	209
Monkfish	1	368	246	318
Spinytail Skate	1	191	513	688
Longhorn Sculpin	1	4,820	105	104
Shorthorn Sculpin	1	2,102	135	98
Sea Urchin (*Strongylocentrotus* sp.)	1	60,403	117	150
Arctic Eelpout	1	5,222	222	141
Corals	1[b]	13,781[b]	307	466
Eelpout (*Lycodes* sp.)	1	16,945	325	248
Brittle Star (Ophiuroidea)	1	27,099	180	300
Toad Crab	1	98,487	148	121
Sea Raven	1	588	74	71
Lanternfishes (Myctophidea)	1	122,954	453	561
Moustache Sculpin	1	72,615	101	138
Sand Sifting Sea Star (*Astropecten americanus*)	1	11,511	424	541
Brittle Star (*Ophiura* sp.)	1	8,551	90	96
Atlantic Argentine	1	3,534	313	320
Pollock	1	193	168	234
Atlantic Herring	1	3,485	188	155
Mud Star (*Ctenodiscus crispatus*)	1	113,168	233	291
Invertebrate sp.	1	106	283	294
Smooth Skate	0.3	1,932	240	293
Spiny Dogfish	0.0	25	120	417
Cusk	0.0	10	615	443
Winter Skate	0.02	15	318	527
Wolffishes	0.001	2	635	-
Total	**1,131**	**31,509,323**	**259**	**269**

Source: DFO RV Survey Data, 2009–2014.

[a] There were no RV tows conducted north of the northern shelf of the Nain Bank (57.7ºN) between 2010–2013.
[b] Denotes data incomplete.

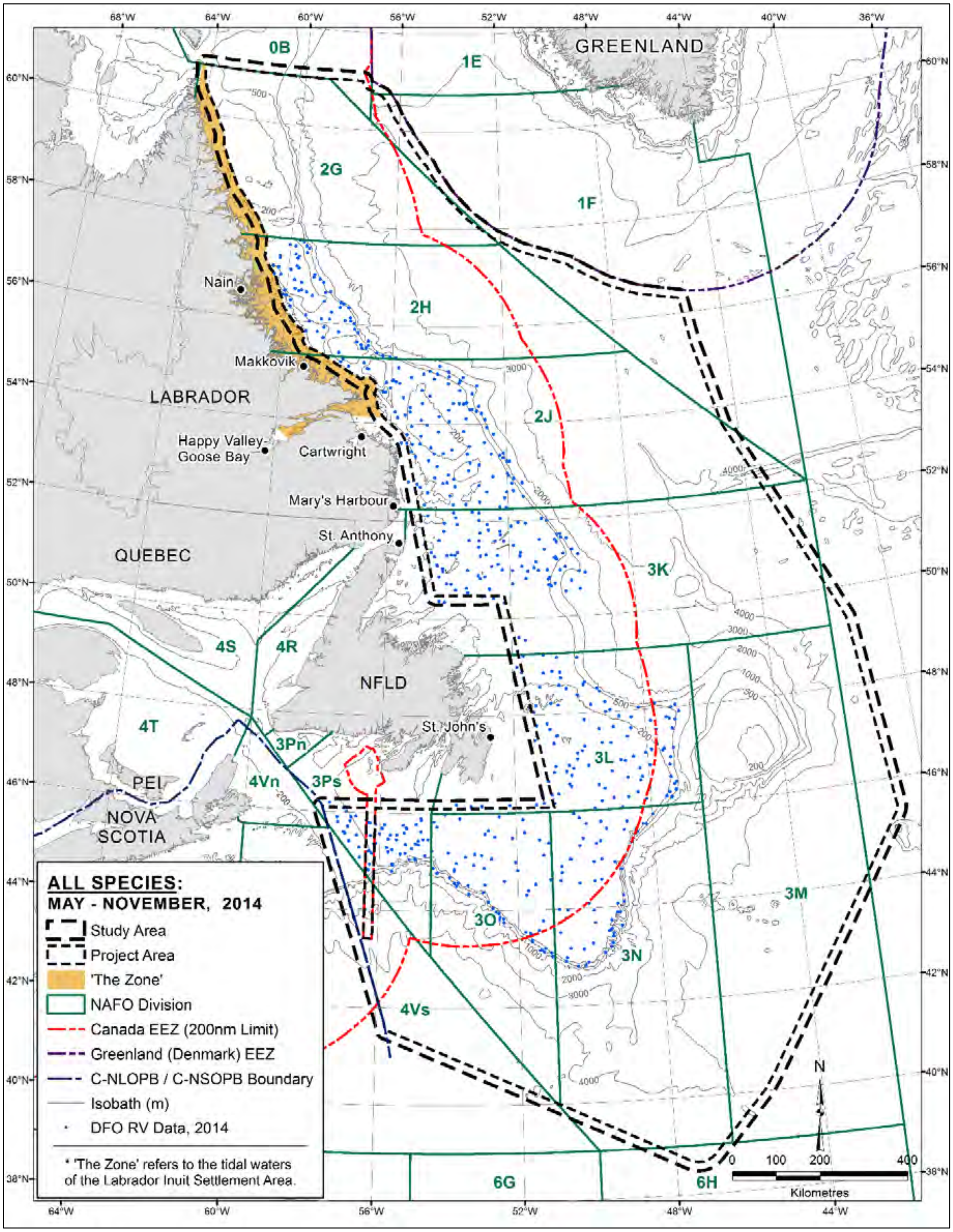
Deepwater redfish accounted for 44% of the total May–November 2009–2014 catch weight, followed by yellowtail flounder (8%), northern shrimp (7%), American plaice and Atlantic cod (6% each), Greenland halibut and thorny skate (4% each), capelin (3%), sponges (2%), and sand lance, shrimp (Natantia), silver hake, roughhead grenadier, sea cucumber (*C. frondosa*), striped shrimp, witch flounder, snow crab and jellyfishes (Schyphozoa) (1% each). All other species/groups accounted for <1% of the total May–November 2009–2014 catch weight in the Study Area. Principal species capture during the May–November 2009–2014 DFO RV surveys were generally representative of predominant species targeted using similar mobile gear (bottom trawls) in the commercial fishery in recent years (§ 4.3.3).

DFO RV survey catch locations for corals (2000–2012) and for sand lance, capelin, redfish, yellowtail flounder, American plaice, sculpins, lanternfish, Atlantic cod, Greenland halibut, blue hake and roughhead grenadier (2005–2009) are shown in Figure 4.72 and Figures 4.74–4.84, respectively, of the Eastern Newfoundland SEA (C-NLOPB 2014). Catch locations for all deepwater redfish, thorny skate, yellowtail flounder, American plaice, Atlantic cod, sand lance, winter flounder, white hake, sea cucumber, black dogfish shark, longfin hake, Greenland halibut and haddock (2006–2007 combined) are presented in Figures 3.2–3.8 of the Southern Newfoundland SEA (C-NLOPB 2010). DFO RV survey catch locations for all species in the Study Area during May–November 2013 are shown in Figure 4.23 of LGL (2016). The distribution of georeferenced catch locations reported during the May–November 2014 DFO RV surveys within the Study Area is shown in Figure 4.24. Species were captured in the western portions of the Study Area during the May–November 2009–2014 DFO RV surveys, in water depths <2,000 m (predominantly <1,000 m). Across all species caught during the May–November 2009–2014 DFO RV surveys in the Study Area, total catch weight ranged from 136–229 mt per year.

Spring and fall surveys accounted for 43% and 57% of the total catch weight, respectively. The average mean depths of catch during spring and fall surveys during 2009–2014 were 259 m (min: 37 m; max: 1,084 m) and 269 m (min: 38 m; max 1,526 m), respectively.

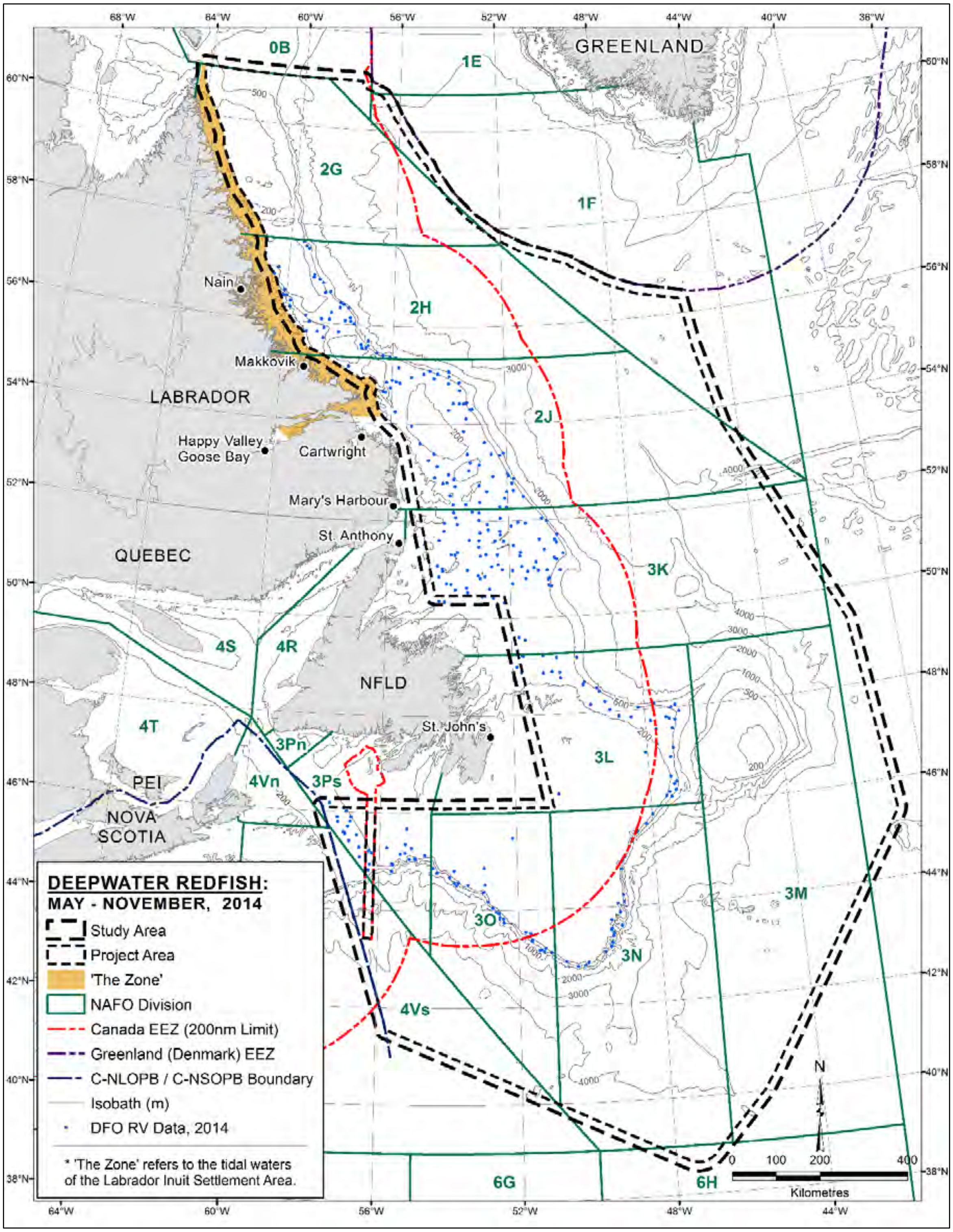
In descending order, the top five species/groups in terms of catch weight during the 2009–2014 spring surveys were deepwater redfish, yellowtail flounder, Atlantic cod, American plaice and capelin; and during the fall surveys were deepwater redfish, northern shrimp, Greenland halibut, American plaice and yellowtail flounder. Species/groups captured predominantly during the spring surveys included striped shrimp, green sea urchin, snow crab, brittle star (*Ophiura* sp.), sand sifting sea star (*A. americanus*), shorthorn sculpin and mud star (*C. crispatus*); and during the fall surveys included Greenland shark, Atlantic (striped) wolffish, shrimp (*A. dentata*), sponges and Atlantic argentine. Species/groups captured in essentially equal portions during both spring and fall surveys included invertebrate sp., spotted wolffish, monkfish, deepwater redfish, Atlantic haddock, shrimp (Natantia), Atlantic herring, eelpout (*Lycodes* sp.), spinytail skate and sand dollar (*E. parma*). The survey depth differences between spring and fall surveys likely account for some of the seasonal differences observed.

Figures 4.24–4.26 indicate 2013 DFO RV survey catch locations for offshore Labrador and offshore eastern and southern Newfoundland for deepwater redfish, yellowtail flounder, northern shrimp, American plaice, Atlantic cod, Greenland halibut, thorny skate, sponges, wolffishes and corals (see also additional Figures referenced for these species during previous years in § 4.3.7 of LGL (2016). Figures 4.25–4.34 show catch locations during 2014 DFO RV surveys for these species, in order of descending total catch weight (see Table 4.10).



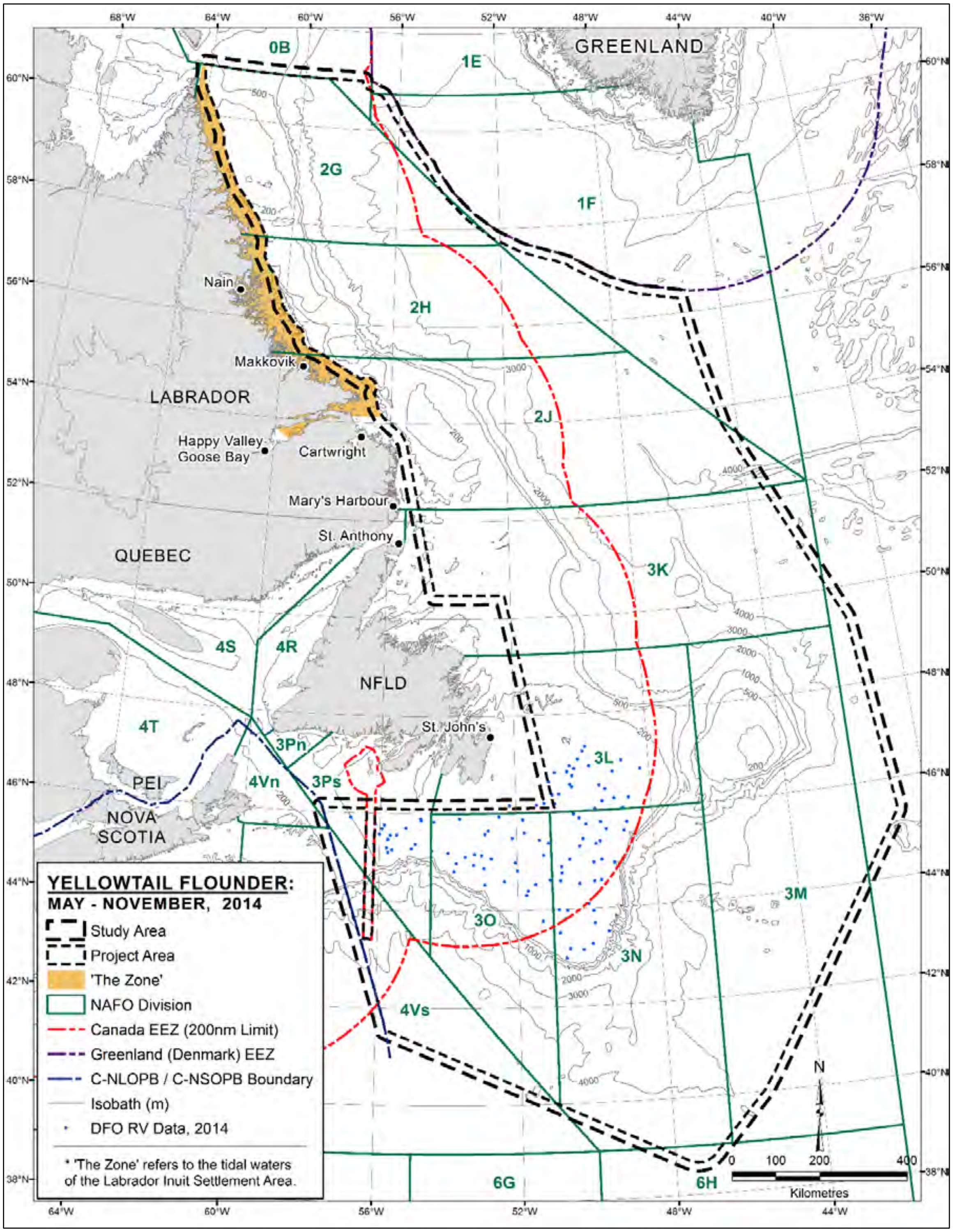
Source: DFO RV Survey database, 2014.

Figure 4.24 Distribution of DFO RV Survey Catch Locations in the Study Area, All Species, May–November 2014.



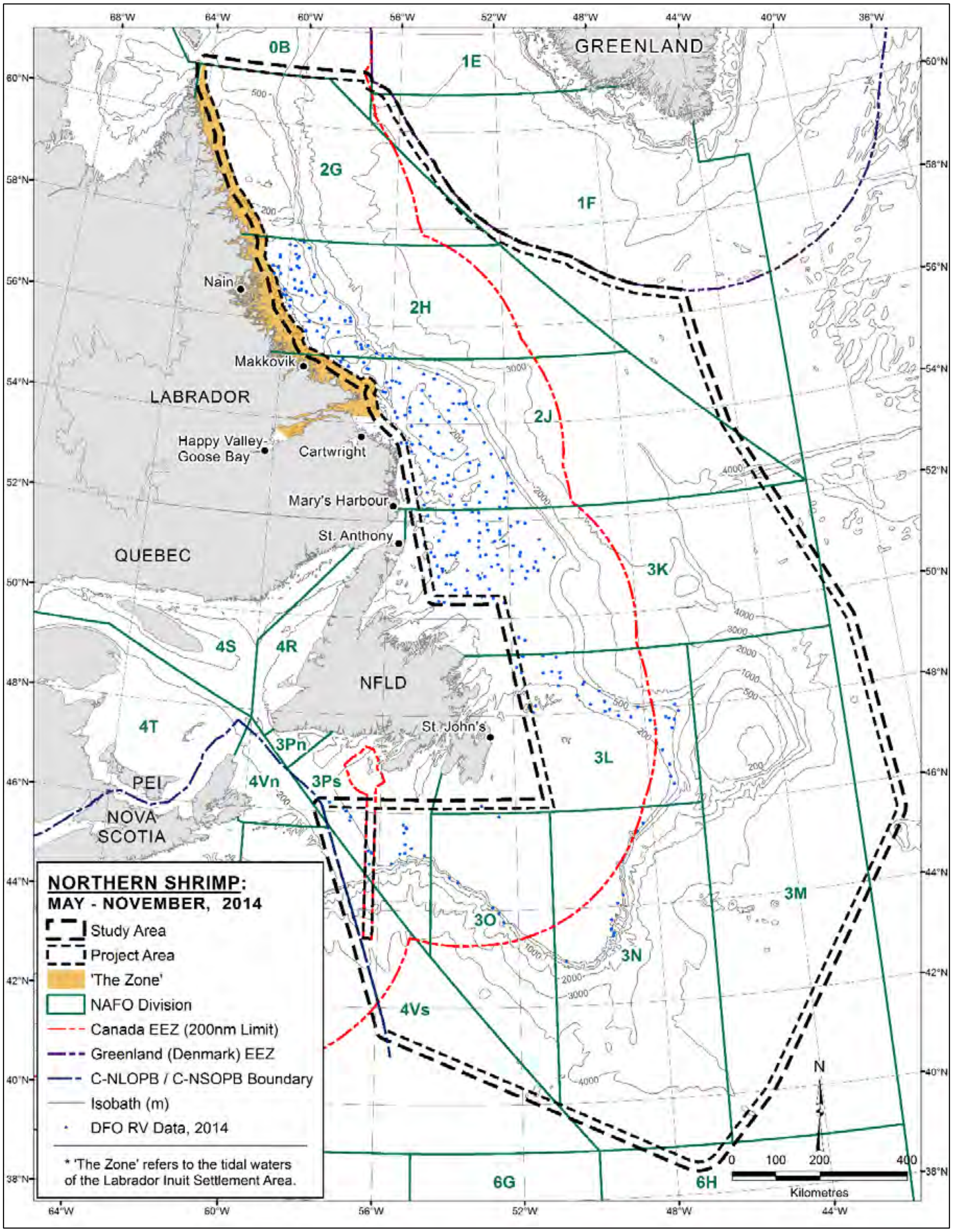
Source: DFO RV Survey database, 2014.

Figure 4.25 Distribution of DFO RV Survey Catch Locations of Deepwater Redfish in the Study Area, May–November 2014.



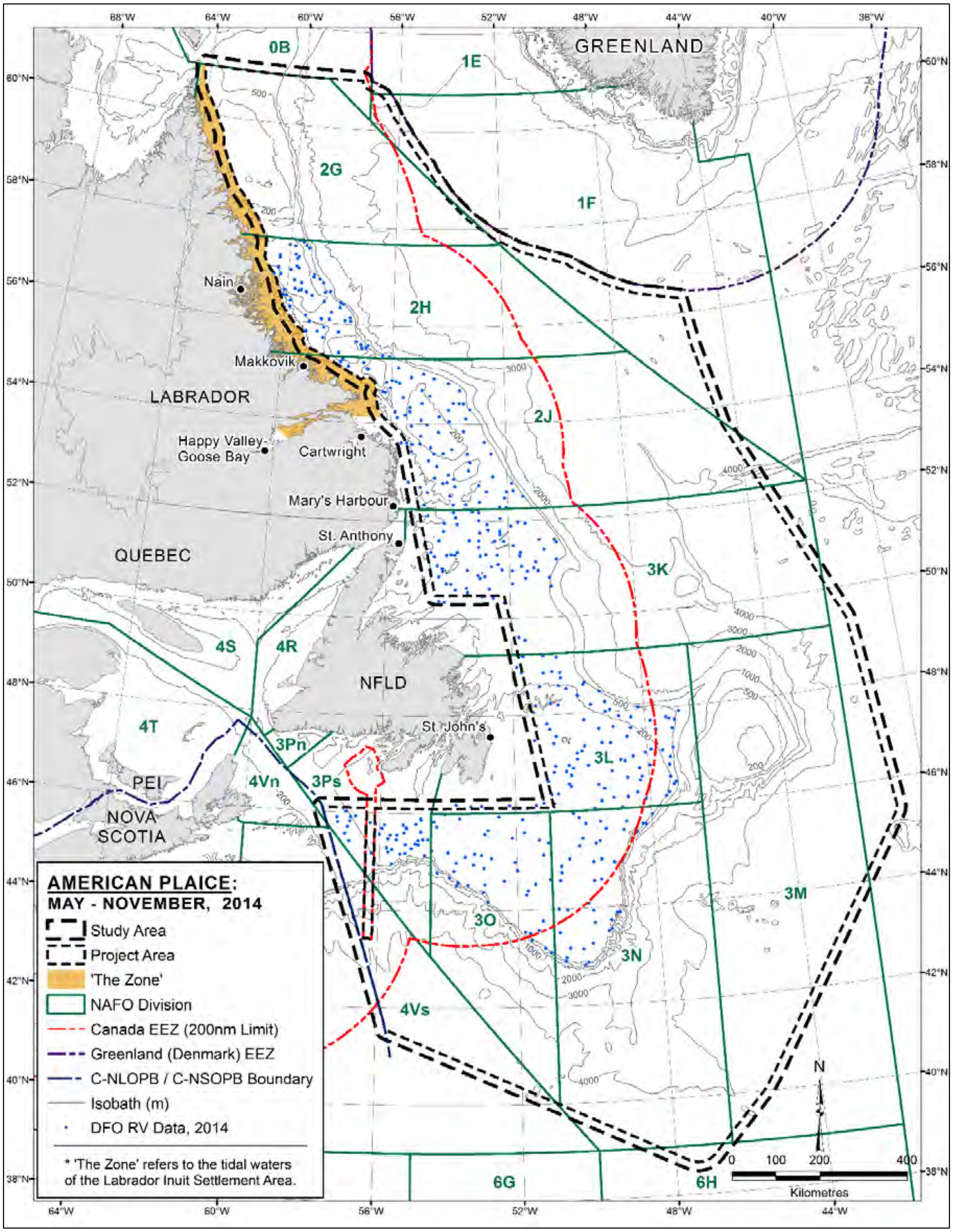
Source: DFO RV Survey database, 2014.

Figure 4.26 Distribution of DFO RV Survey Catch Locations of Yellowtail Flounder in the Study Area, May–November 2014.



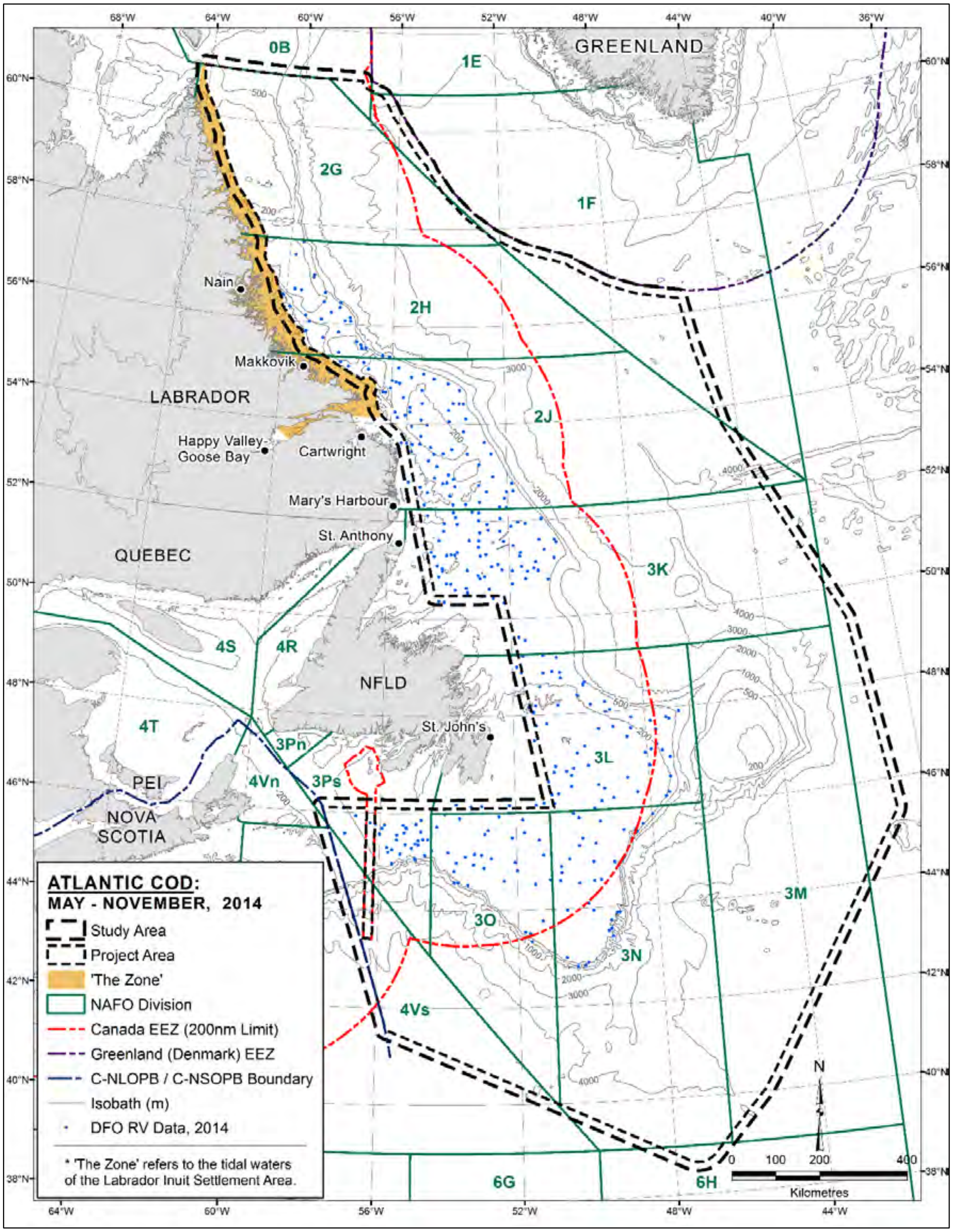
Source: DFO RV Survey database, 2014.

Figure 4.27 Distribution of DFO RV Survey Catch Locations of Northern Shrimp in the Study Area, May–November 2014.



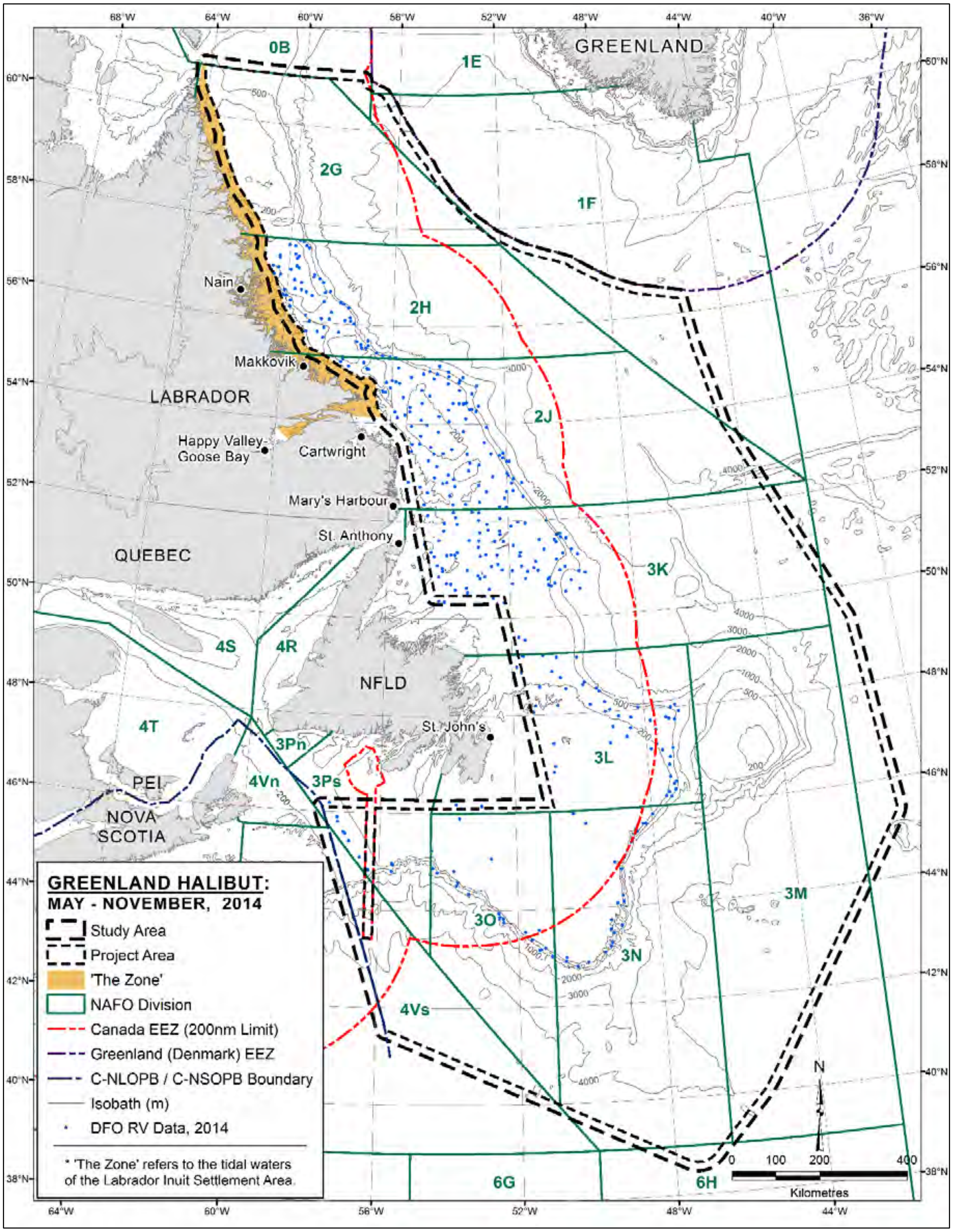
Source: DFO RV Survey database, 2014.

Figure 4.28 Distribution of DFO RV Survey Catch Locations of American Plaice in the Study Area, May–November 2014.



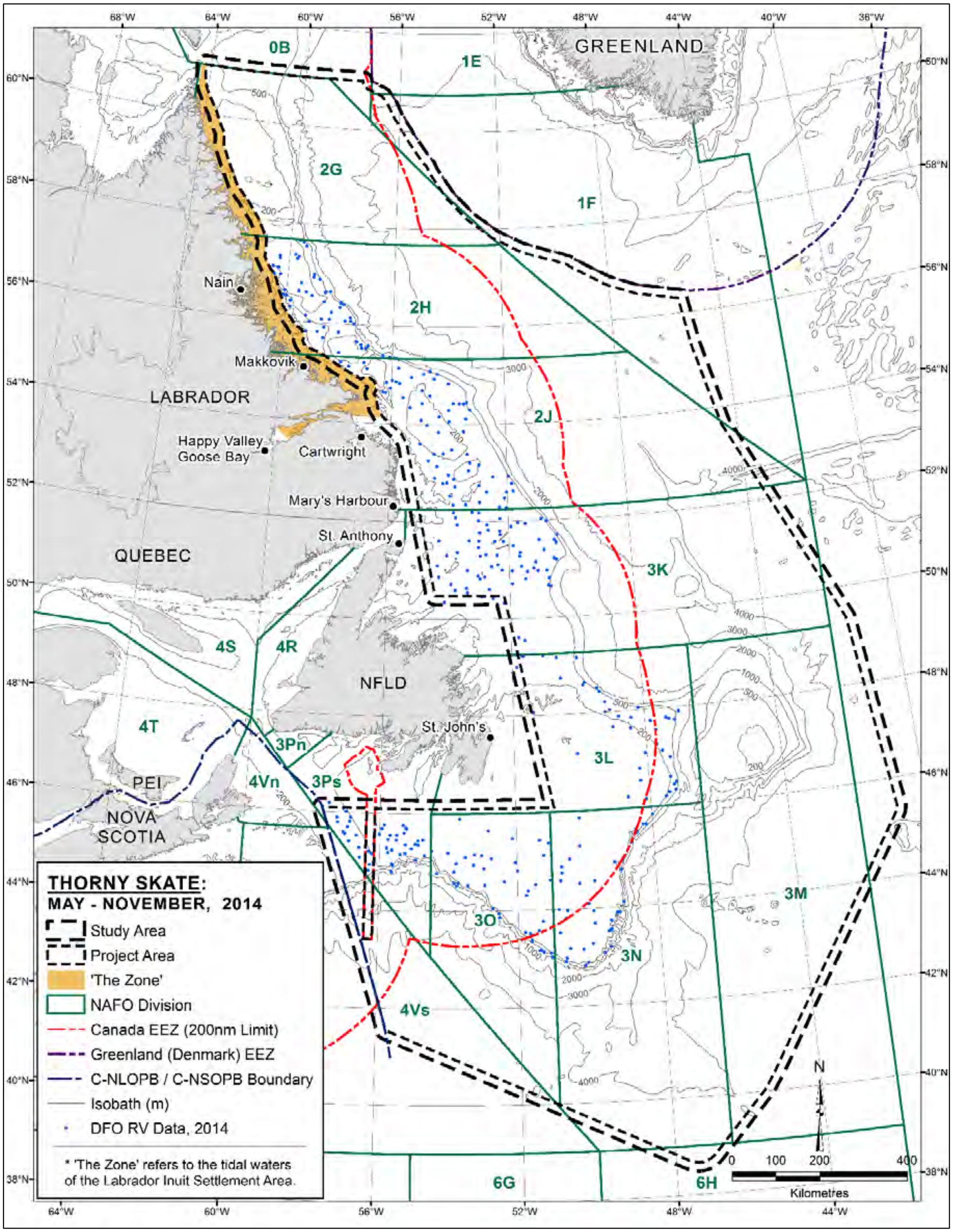
Source: DFO RV Survey database, 2014.

Figure 4.29 Distribution of DFO RV Survey Catch Locations of Atlantic Cod in the Study Area, May–November 2014.



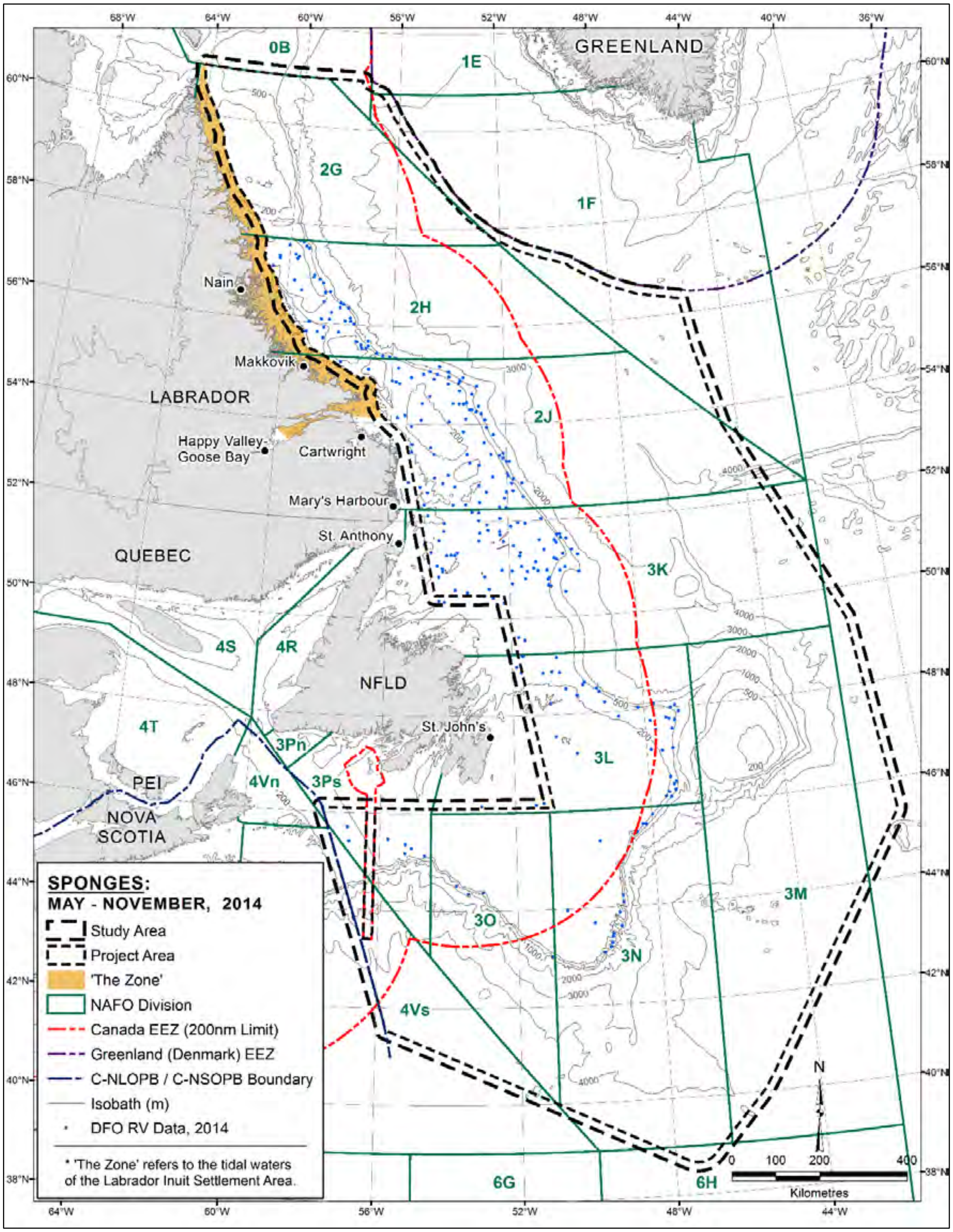
Source: DFO RV Survey database, 2014.

Figure 4.30 Distribution of DFO RV Survey Catch Locations of Greenland Halibut in the Study Area, May–November 2014.



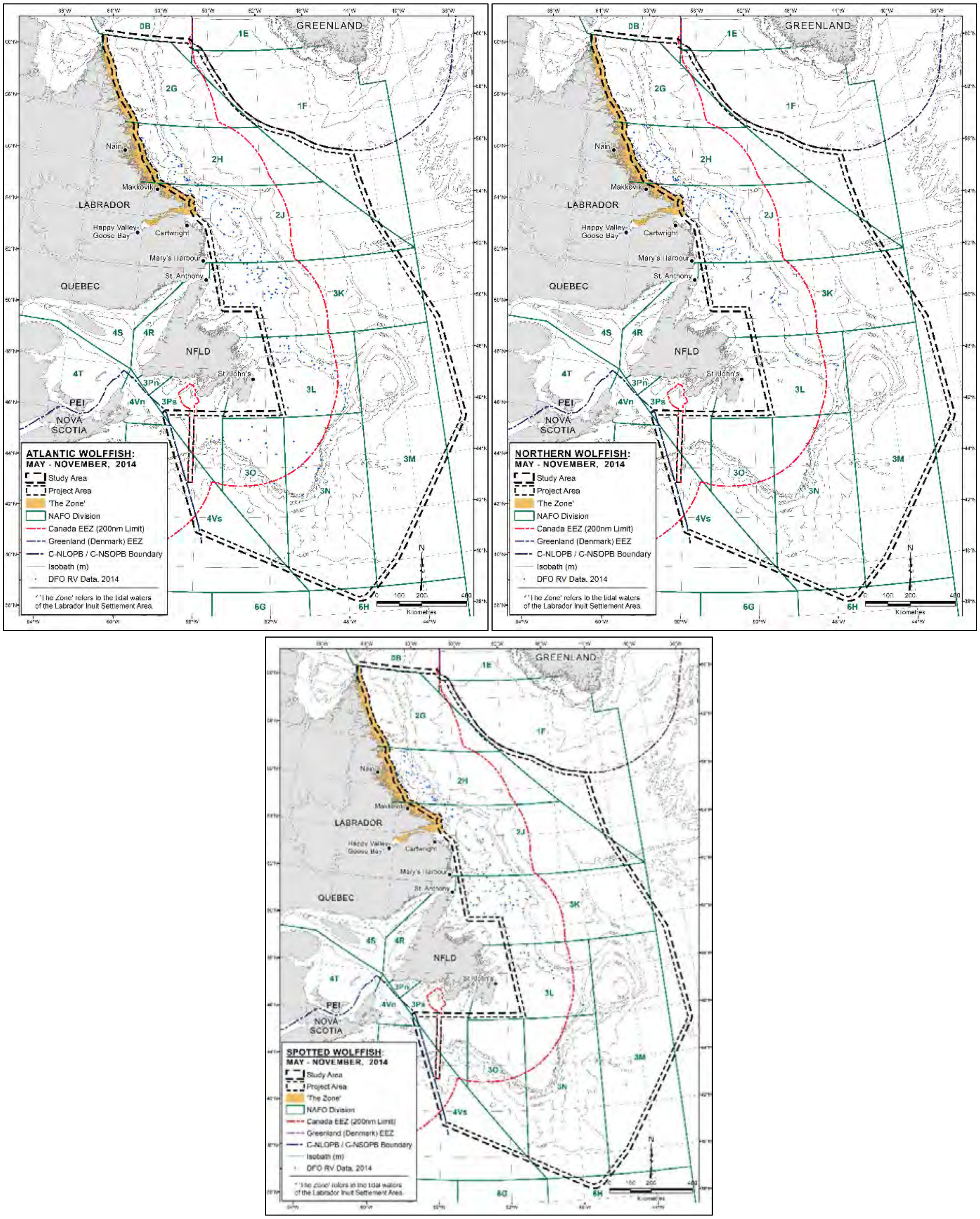
Source: DFO RV Survey database, 2014.

Figure 4.31 Distribution of DFO RV Survey Catch Locations of Thorny Skate in the Study Area, May–November 2014.



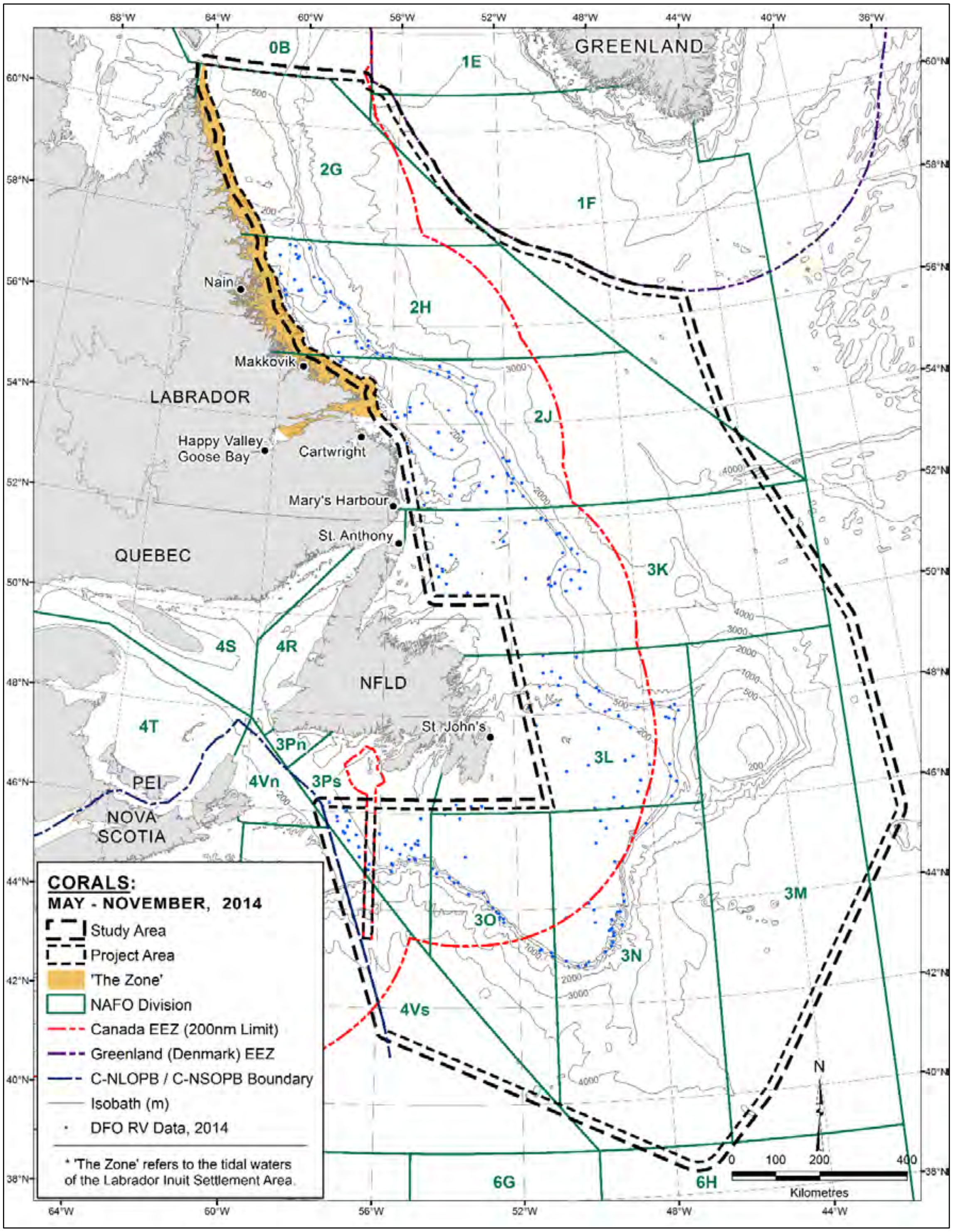
Source: DFO RV Survey database, 2014.

Figure 4.32 Distribution of DFO RV Survey Catch Locations of Sponges in the Study Area, May–November 2014.



Source: DFO RV Survey database, 2014.

Figure 4.33 Distribution of DFO RV Survey Catch Locations of Atlantic (striped), Northern and Spotted Wolffish in the Study Area, May–November 2014.



Source: DFO RV Survey database, 2014.

Figure 4.34 Distribution of DFO RV Survey Catch Locations of Corals in the Study Area, May–November 2014.

Catches are various mean depth ranges are also examined in this subsection. Table 4.11 presents total catch weights and predominant species/groups caught within each mean depth range in the Study Area during the 2009–2014 period. Northern shrimp and Greenland halibut (predominant commercial species; mainly targeted using mobile gear) were caught primarily at depths ranging from 200–300 m and 300–500 m, respectively.

Table 4.11 Total Catch Weights and Predominant Species Caught at Various Mean Catch Depth Ranges, DFO RV Surveys, May–November 2009–2014.

Mean Catch Depth Range (m)	Total Catch Weight (mt)	Predominant Species (% of Total Catch Weight)
<100	111	Yellowtail Flounder (79%) Sand Lance (offshore) (15%)
≥100 – <200	138	Atlantic Cod (48%) Capelin (22%)
≥200 – <300	241	Northern Shrimp (35%) American Plaice (28%) Thorny Skate (18%)
≥300 – <400	557	Deepwater Redfish (90%) Sponges (4%)
≥ 400 – <500	56	Greenland Halibut (87%) Longfin Hake (8%)
≥500 – <600	25	Roughhead Grenadier (40%) Jellyfishes (Scyphozoa) (24%) Northern Wolffish (17%)
≥600 – <700	6	Longnose Eel (34%) Greenland Shark (26%) Spinytail Skate (23%)
≥700 – <800	6	Blue Hake (57%) Black Dogfish Shark (32%)
≥800 – <900	3	Roundnose Grenadier (88%) Shrimp (*Acanthephyra pelagica*) (9%)
≥900 – <1,000	1	Smoothheads (Alepocephalidae) (28%) Shortnose Snipe Eel (12%) Soft Deep Sea Urchin (12%) Goitre Blacksmelt (10%)
≥1,000	2	Black Herring (33%) Jensen's Skate (23%) Deepsea Cat Shark (16%)

Source: DFO Research Vessel Survey Database, 2009–2014.

4.3.8 Industry and DFO Science Surveys

Fisheries research surveys conducted by DFO and the fishing industry are important to the commercial fisheries in determining stock status. In a given year, there will be spatial overlap between the Study Area and research surveys in NAFO Divisions 2HJ and 3KLOPs.

The tentative schedule of DFO RV surveys in the Study Area in 2017 is indicated in Table 4.12. Spring surveys within the Study Area are currently scheduled to commence 31 March and continue until 10 June. Fall RV surveys are set to occur in the Study Area from 31 August until 5 December.

Table 4.12 Tentative 2017 Schedule of DFO RV Surveys in the Study Area Vicinity.

NAFO Division	Start Date	End Date	Vessel
3P	31 March	11 April	*Needler*
3L	4 April	25 April	*Teleost*
3P + 3KLMNO	26 April	1 May	*Teleost*
3P	12 April	25 April	*Needler*
3P + 3O	26 April	9 May	*Needler*
3KL	2 May	23 May	*Teleost*
3O + 3N	9 May	23 May	*Needler*
3L + 3N	24 May	10 June	*Needler*
2J + 4R	31 August	12 September	*Needler*
3O	13 September	26 September	*Needler*
3O + 3N	26 September	10 October	*Needler*
2H	5 October	10 October	*Teleost*
3N + 3L	11 October	24 October	*Needler*
2H + 2J	11 October	24 October	*Teleost*
3L	24 October	7 November	*Needler*
2J + 3K	24 October	7 November	*Teleost*
3K + 3L	8 November	21 November	*Needler*
3K	8 November	21 November	*Teleost*
3K + 3L Deep	21 November	5 December	*Teleost*

Note: Start/end dates subject to change as trip plans are finalized (G. Sheppard, DFO, Technician, pers. comm., 16 February 2017).

Members of the FFAW have been involved in a DFO-industry collaborative post-season snow crab trap survey annually since 2003. This survey is intended to “allow the fishing industry to more accurately assess and ultimately better manage the valuable snow crab resource” (FFAW|Unifor 2017). Data from these surveys are incorporated into the scientific assessment of snow crab and as a result, harvesters and managers have improved partnership and higher confidence in the accuracy of recent stock status assessments (FFAW|Unifor 2017).

The post-season snow crab survey typically occurs between early-September and November. During the 2015 and 2016 seasons, the annual snow crab TAC for this survey was 350 mt

(DFO 2016f). The station locations remained consistent from year to year up to and including the 2016 survey year. The total number of stations has been increased to 1,316 in 2017, occurring in NAFO Divisions 2J3KLOPs. Of these, 556 stations occur in the Project Area and within 30 km of the Project Area (i.e., spatial buffer for the stations) (452 in Project Area; 104 within 30 km of Project Area). The survey station locations in relation to the Study and Project Areas are shown in Figure 4.35.

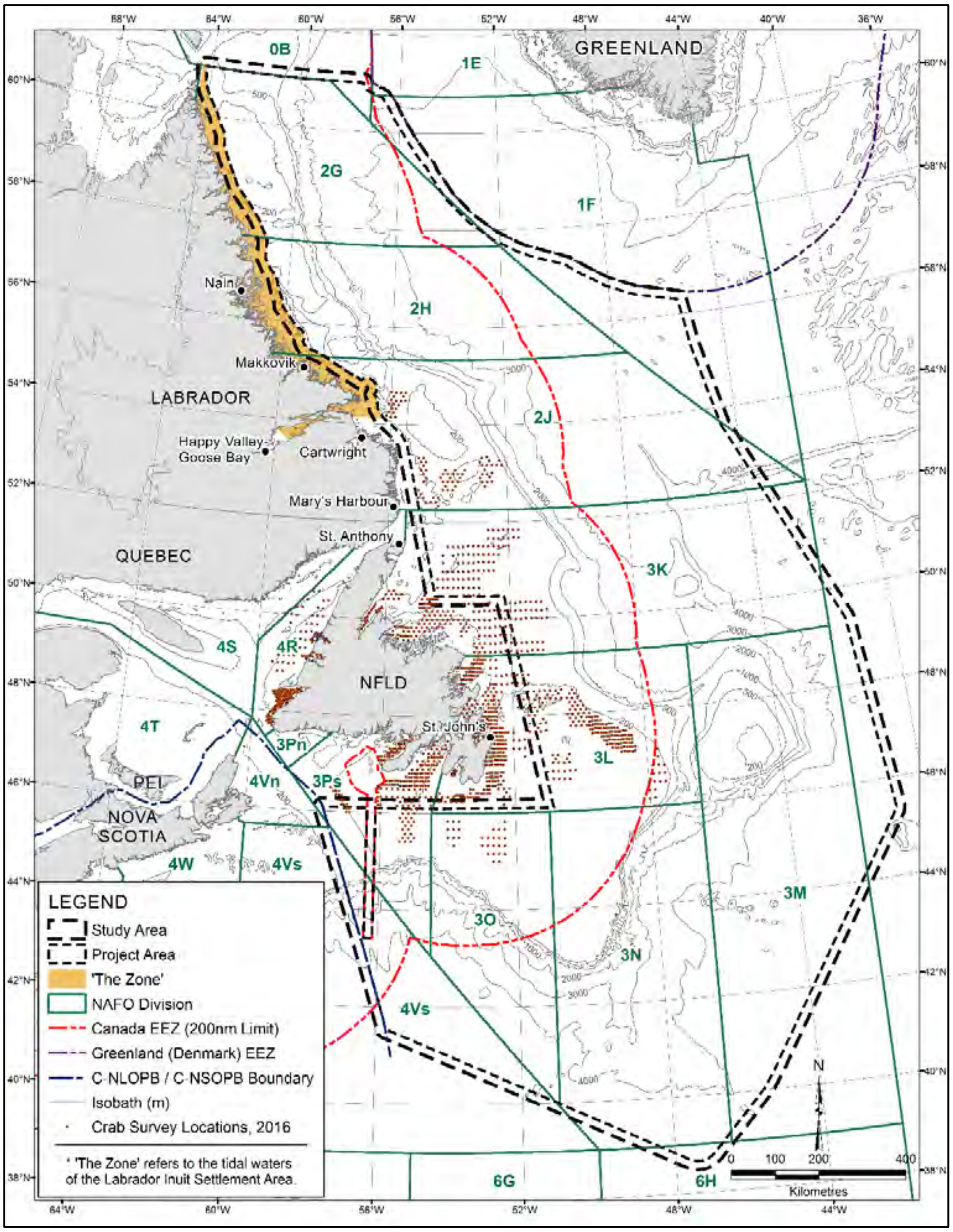


Figure 4.35 Locations of DFO-Industry Collaborative Post-Season Snow Crab Trap Survey Stations in relation to the Study Area and Project Area.

4.3.9 Data Gaps associated with the Fisheries VEC

The following data gaps associated with the Fisheries VEC were identified in the Labrador Shelf SEA (§ 4.10.7 of C-NLOPB 2008).

- Inconsistent multispecies surveys off Labrador since 1995 has resulted in major sources of uncertainty; and
- The effects of climate change on the fisheries are unknown.

The following data gaps associated with the Fisheries VEC were identified in the Eastern Newfoundland SEA (§ 6.1.6 of C-NLOPB 2014).

- DFO datasets are known not to be entirely comprehensive, particularly with regard to important inshore fisheries.

The following data gaps associated with the Fisheries VEC were identified in the Southern Newfoundland SEA (§3.3.6 of C-NLOPB 2010).

- DFO data related to certain inshore fisheries (e.g., lobster) are lacking; and
- Data related to foreign fisheries outside the 200 nm limit have poor spatial resolution. These data are currently only available on a NAFO Division basis.

In addition to the data gaps identified in the three SEAs, as of 2011 DFO commercial fishery landings data are no longer provided as empirical data, but rather as quartile ranges of landed catch weight and value for 6' x 6' grid cells.

All of the above data gaps still exist, although efforts are being put forth for the 2017 season to improve the gathering of data regarding recreational fisheries in Newfoundland and Labrador by implementing a licence and tag regime for all recreational fishery participants (see § 4.3.5), and post-season snow crab survey data will be altered through randomization of survey stations to be sampled in 2017 (see § 4.3.8).

Although filling these data gaps could result in changes to the data presented in § 4.3, it is unlikely that increased data accuracy would alter the overall results, such as predominant species caught within the Study Area. As such, these data gaps are unlikely to limit the assessment of potential interactions between the Project and the Fisheries VEC. MKI will revise the Fisheries VEC and associated assessments as needed as new fisheries data become available, and will reflect these changes in future EA Updates.

4.4 Marine-associated Bird VEC

The Marine-associated Bird VEC of the Study Area has been described in the Labrador Shelf SEA (§ 4.9.8 to 4.9.13 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.2 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.4 of C-NLOPB 2010), and four project-specific EAs (§ 4.4 of LGL 2014, 2015a,b, 2016). An overview of the marine-associated birds of the Study Area, based on the aforementioned documents, is provided below. Newly available information since publication of the SEAs and EAs is also summarized. Data gaps regarding marine-associated birds identified in the three SEAs are reviewed in terms of current status.

Pelagic seabird abundance data in the shelf areas off Newfoundland and Labrador are available from the Canadian Wildlife Service (CWS) programme intégré de recherches sur les oiseaux pélagiques (PIROP) shipboard surveys conducted during 1967 to 1994 (Lock et al. 1994). The more recent (2006 to 2009) CWS Eastern Canadian Seabirds at Sea (ECSAS) survey program sampled areas off eastern and southern Newfoundland (Fifield et al. 2009). The anticipated update of this document is expected in 2017 (D. Fifield, EC-CWS, pers. comm., December 2016). These results, if available in time, will be provided in subsequent updates to this EA.

Since the late 1990s, seabird observations have been collected on the northeast Grand Banks by the offshore oil and gas industry from drill platforms and supply vessels (Baillie et al. 2005; Burke et al. 2005; Fifield et al. 2009). Reports on seabird surveys conducted from vessels associated with geophysical surveys in the Study Area during 2004 to 2008 were available (Moulton et al. 2005, 2006a; Lang et al. 2006; Lang 2007; Lang and Moulton 2008; Abgrall et al. 2008a,b and 2009). The most current census data related to important seabird nesting colonies in Newfoundland and Labrador have been acquired from the CWS and are incorporated into this EA.

The Study Area encompasses a wide range of marine habitats extending from the Labrador Sea to the deep water south of the Grand Banks of Newfoundland. Seabirds tend to concentrate over oceanographic features such as continental shelf edges and convergences of warm and cold currents, both of which occur in the Study Area. The Labrador Current running southward along the edge of continental shelf edge from the northern tip of Labrador to the northern Grand Banks creates areas of upwelling and water mixing that brings mineral nutrients to the surface, thereby resulting in high phytoplankton productivity which forms the basis for increased productivity at higher trophic levels (e.g., seabirds). South of Flemish Cap and the Grand Banks, the Gulf Stream meets the Labrador Current, causing more mixing of different water types and potentially rich zones for marine productivity. A summary of the marine bird life in the Study Area can be found in § 4.4 of LGL (2016).

Offshore Labrador is a known wintering area for the Ivory Gull (*Pagophila eburnea*), a species with *endangered* status under Schedule 1 of *SARA*, COSEWIC, and the Newfoundland and Labrador *Endangered Species Act*. Ivory Gull occurs in the Study Area mainly outside the time frame of the proposed seismic survey period (i.e., May–November) (Spencer et al. 2016). This species is typically associated with pack ice, which will be avoided during seismic exploration. Harlequin Duck (*Histrionicus histrionicus*) and Barrow's Goldeneye (*Bucephala islandica*) moult and stage at some sites along the Labrador coast and around islands off the Labrador coast. Both species have *special concern* status under Schedule 1 of *SARA* and COSEWIC. Typically they would occur outside the Study Area close to shorelines of the coast or coastal islands. Details on Barrow's Goldeneye and Harlequin Duck are in § 4.4.2.1 of LGL (2016) while Ivory Gull is discussed in § 4.6 of LGL (2016). Shorebirds and other species found on the coast but not in the Study Area are not discussed in detail in this EA. Details on coastal species can be found in the Labrador Shelf SEA (§ 4.9.10 and § 4.9.11 of C-NLOPB 2008).

4.4.1 Seasonal Occurrence and Abundance

The global range, seasonal occurrence and seasonal abundance of seabirds occurring regularly in the Study Area are described below. Tables 4.13 and 4.14 summarize the predicted monthly abundance status for each species in the Study Area. The following four categories that qualitatively define the relative abundance of seabirds are used.

1) Common: likely present daily in moderate to high numbers;
2) Uncommon: likely present daily in small numbers;
3) Scarce: likely present regularly in very small numbers; and
4) Rare: usually absent, individuals occasionally present.

Seasonal occurrence and abundance information was derived from Brown (1986), Lock et al. (1994), Baillie et al. (2005), Moulton et al. (2005, 2006a,b), Lang et al. (2006), Lang (2007), Abgrall et al. (2008a,b), and Fifield et al. (2009).

There are over 30 species of marine-associated birds occurring regularly on the Labrador coast and the east and south coast of Newfoundland (Tables 4.13 and 4.14). Note that Table 4.13 refers to pelagic seabirds that occur in the portion of the Study Area north of 52°N, and Table 4.14 refers to pelagic seabirds that occur in the portion of the Study Area south of 52°N. Large numbers of seabirds occur in parts of the Study Area at all times of the year.

Table 4.13 Monthly Occurrences and Abundances of Pelagic Seabirds in Offshore Labrador (52°N to 60°N).

Species	Scientific Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Northern Fulmar*	*Fulmarus glacialis*	C[1]	C	C	C	C	C	C	C	C	C	C	C
Great Shearwater	*Puffinus gravis*					S	C	C	C	C	C	S	
Sooty Shearwater	*Puffinus griseus*					S	U	U	U	U	S		
Manx Shearwater*	*Puffinus puffinus*						S	S	S	S			
Wilson's Storm-Petrel	*Oceanites oceanicus*						S	S	S	S			
Leach's Storm-Petrel*	*Oceanodroma leucorhoa*					U	U	U	U	U	U		
Northern Gannet*	*Morus bassanus*					S	U	U	U	U	S		
Red-necked Phalarope*	*Phalaropus lobatus*					U	U	U	U	U	S		
Red Phalarope	*Phalaropus fulicarius*					U	U	C	C	C	U		
Great Skua	*Stercorarius skua*					R	S	U	U	U	U		
South Polar Skua	*Stercorarius maccormicki*						R	R	R	R			
Pomarine Jaeger	*Stercorarius pomarinus*					U	U	U	U	U	U		
Parasitic Jaeger	*Stercorarius parasiticus*					U	U	U	U	U	U		
Long-tailed Jaeger	*Stercorarius longicaudus*					U	U	U	U	U			
Dovekie	*Alle alle*	C	C	C	C	C	U	S	S	U	C	C	C
Common Murre*	*Uria aalge*	R	R	R	R	C	C	C	C	C	C	U	S
Thick-billed Murre*	*Uria lomvia*	C	C	C	C	C	C	U	U	U	C	C	C
Razorbill*	*Alca torda*				R	C	C	C	C	C	C	U	R
Black Guillemot*	*Cepphus grylle*	U	U	U	C	C	C	C	C	C	C	C	C
Atlantic Puffin*	*Fratercula arctica*				U	C	C	C	C	C	C	U	S
Black-legged Kittiwake*	*Rissa tridactyla*	C	C	C	C	C	C	C	C	C	C	C	C
Ivory Gull	*Pagophila eburnea*	U	U	U	U	U						S	U
Herring Gull*	*Larus argentatus*				C	C	C	C	C	C	C	U	U
Iceland Gull	*Larus glaucoides*	C	C	C	C	C	U	S	S	S	C	C	C
Lesser Black-backed Gull	*Larus fuscus*				S	S	S	S	S	S			
Glaucous Gull*	*Larus hyperboreus*	C	C	C	C	C	C	C	C	C	C	C	C
Great Black-backed Gull*	*Larus marinus*	S	S	S	C	C	C	C	C	C	C	C	C
Common Tern*	*Sterna hirundo*					C	C	C	C	S			
Arctic Tern*	*Sterna paradisaea*					C	C	C	C	U			

Notes: * Breeds in Newfoundland and Labrador.

[1] Abundance definitions valid for at least part of Study Area but not necessarily the whole Study Area. Common = likely present daily in moderate to high numbers; Uncommon = likely present daily in small numbers; Scarce = likely present regularly in very small numbers; Rare = usually absent, individuals occasionally present. Blank spaces indicate not expected to occur in that month. Predicted monthly occurrences derived from extrapolation of marine bird distribution at sea in eastern Canada in Brown (1986); Lock et al. (1994) and Fifield et al. (2009).

Table 4.14 Monthly Occurrences and Abundances of Pelagic Seabirds in Offshore Newfoundland and South of Grand Banks (38°N to 52°N).

Species	Scientific Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Northern Fulmar*	*Fulmarus glacialis*	C[1]	C	C	C	C	C	C	C	C	C	C	C
Cory's Shearwater	*Calonectris diomedea*						S	S	S	S			
Great Shearwater	*Puffinus gravis*					U	C	C	C	C	C	S	
Sooty Shearwater	*Puffinus griseus*					S	U	U	U	U	U	S	
Manx Shearwater*	*Puffinus puffinus*					R	R	R	R	R	R		
Wilson's Storm-Petrel	*Oceanites oceanicus*						R	S	S	R	R		
Leach's Storm-Petrel*	*Oceanodroma leucorhoa*				U-C	C	C	C	C	C	C	S	
Northern Gannet*	*Morus bassanus*			U	U	U	U	U	U	U	U		
Red-necked Phalarope*	*Phalaropus lobatus*					R	R	R	R	R	R		
Red Phalarope	*Phalaropus fulicarius*					R	R	R	S	S	R		
Great Skua	*Stercorarius skua*					R	R	R	R	R	R	R	
South Polar Skua	*Stercorarius maccormicki*					R	R	R	R	R	R		
Pomarine Jaeger	*Stercorarius pomarinus*				S	S	S	S	S	S	S	S	
Parasitic Jaeger	*Stercorarius parasiticus*					R	R	R	R	R	R		
Long-tailed Jaeger	*Stercorarius longicaudus*					S	S	S	S	S			
Dovekie	*Alle alle*	C	C	C	C	U	R	R	R	S	C	C	C
Common Murre*	*Uria aalge*	C	C	C	C	C	C	C	C	C	C	C	C
Thick-billed Murre*	*Uria lomvia*	C	C	C	C	C	S	S	S	U	C	C	C
Razorbill*	*Alca torda*	S	S	S	U	U	U	U	U	U	U	U	S
Black Guillemot*	*Cepphus grylle*	R	R	R	R	R	R	R	R	R	R	R	R
Atlantic Puffin*	*Fratercula arctica*	C	C	C	C	C	C	C	C	C	C	C	C
Black-legged Kittiwake*	*Rissa tridactyla*	C	C	C	C	C	C	C	C	C	C	C	C
Ivory Gull	*Pagophila eburnea*	R-S	R-S	R-S	R								
Herring Gull*	*Larus argentatus*	U	U	U	U	U	S	S	S	S	U	U	U
Iceland Gull	*Larus glaucoides*	C	C	C	C	S					S	C	C
Lesser Black-backed Gull	*Larus fuscus*				R	R	R	R	R	R	R	R	R
Glaucous Gull*	*Larus hyperboreus*	C	C	C	C	U	R				S	U	C
Great Black-backed Gull*	*Larus marinus*	U	U	U	U	U	S	S	U	U	U	U	U
Common Tern*	*Sterna hirundo*					R	R	R	R	R			
Arctic Tern*	*Sterna paradisaea*					S	S	S	S	S			

Sources: Brown (1986); Lock et al. (1994); Baillie et al. (2005); Moulton et al. (2005, 2006a,b); Lang et al. (2006); Lang (2007); Lang and Moulton (2008); Abgrall et al. (2008a,b, 2009).

Notes: * Breeds in Newfoundland and Labrador.

[1] Abundance definitions valid for at least part of Study Area but not necessarily the whole Study Area. C=common - likely present daily in moderate to high numbers; U=uncommon - likely present daily in small numbers; S=scarce - likely present regularly in very small numbers; R=rare - usually absent, individuals occasionally present. Blank spaces indicate not expected to occur in that month. Predicted monthly occurrences derived from 2004, 2005, 2006, 2007 and 2008 monitoring studies in the Orphan Basin, Jeanne d'Arc Basin, Laurentian Sub-basin and extrapolation of marine bird distribution at sea in eastern Canada in Brown (1986); Lock et al. (1994) and Fifield et al. (2009).

4.4.2 Breeding Seabirds in Newfoundland and Labrador

There are seabird breeding colonies of worldwide significance in southeast Labrador and eastern Newfoundland (Tables 4.15 and 4.16). Over 4 million pairs of seabirds nest on the southeast coast of Newfoundland alone. These include 2.8 million pairs of Leach's Storm-Petrels and 796,000 pairs of Common Murres (Tables 4.15 and 4.16). Funk Island, Baccalieu Island, and the Witless Bay are the largest seabird breeding colonies in Atlantic Canada. More than 3.4 million pairs of seabirds nest at these three locations alone (Tables 4.15 and 4.16). These include the largest Atlantic Canadian colonies of Leach's Storm-petrel (2.02 million pairs on Baccalieu Island), Common Murre (470,000 pairs on Funk Island), Black-legged Kittiwake (13,950 pairs on Witless Bay Islands), and Atlantic Puffin (324,650 pairs on Witless Bay Islands). These birds use the Study Area during their breeding season. After the nesting season, seabirds disperse over a wider area of the Newfoundland and Labrador offshore area, including most of the Study Area. Large numbers of seabirds that did not nest in Newfoundland and Labrador also spend part of their non-breeding season within the Study Area. Several million Great Shearwater and Sooty Shearwater migrate from breeding islands in the South Atlantic and occur in the waters offshore Newfoundland and Labrador in summer. Many of the 3.8 million Thick-billed Murres breeding in the eastern Canadian Arctic as well as up to 10 million Dovekies from Greenland either winter in the Labrador Sea and Grand Banks or migrate through these areas on the way to the continental shelf waters of Nova Scotia and areas farther south. Large numbers of sub-adults of Northern Fulmar and Black-legged Kittiwake from breeding colonies in the eastern Arctic and Europe spend the early parts of their lives in the Labrador Sea.

Important Bird Areas (IBAs) form a network of sites that are important to the natural diversity of Canadian bird species and are critical for the long-term viability of naturally occurring bird populations. The Canadian IBA program (www.ibacanada.ca) was launched in 1996 by BirdLife International partners Bird Studies Canada and the Canadian Nature Federation (now Nature Canada). The goal of the IBA program is to ensure the conservation of sites through the development and implementation of conservation plans in partnership with local stakeholders for priority IBAs. There are 31 IBAs along coastal Labrador and the east and southeast coast of Newfoundland. Figures 4.96 in C-NLOPB (2008), 4.110 in C-NLOPB (2014) and 3.69 in C-NLOPB (2010) show the IBA locations in and proximate to the Study Area.

The following subsections address the distribution and abundance of the various regularly occurring species of marine-associated birds in the Study Area.

Table 4.15 Number of Pairs of Seabirds Nesting at Colonies in Labrador and Northeastern Newfoundland (60°N to 49°30'N).

Species	Southeast of Nain	Quaker Hat	Northeast Groswater Bay	Gannet Islands	Bird Island	Northern Groais Island	Wadham Islands	Funk Island	Cape Freels/Cabot Island
Northern Fulmar	-	-	-	24[d]	-	-	-	6[a]	-
Leach's Storm-Petrel	-	-	10[a]	20[a]	present	-	200[a]	-	250[a]
Northern Gannet	-	-	-	-	-	-	-	10,159[a]	-
Herring Gull	30[a]	-	220[a]	-	-	-	-	150[a]	-
Glaucous Gull	385[a]	-	-	-	-	-	-	-	-
Great Black-backed Gull	90[a]	-	125[a]	30[d]	20	-	-	75[a]	-
Black-legged Kittiwake	-	4[a]	-	72[a]	-	1,050[f]	-	95[a]	-
Arctic and Common Terns	-	-	-	-	-	-	22[f]	-	250[a]
Common Murre	87[a]	648[a]	2,360[a,c]	31,170[a]	3,100	-	-	472,259[g]	9,897[a]
Thick-billed Murre	5,200[a]	126[a]	365[a]	1,846[a]	present	-	-	250[a]	-
Razorbill	815	450[a]	1,520[a,c]	14,801[a]	1,530	-	273[e]	200[a]	25[a]
Black Guillemot	1,850[a]	-	present	110[a]	-	-	50[a]	1[b]	-
Atlantic Puffin	2,470[a,c]	2,100[a]	18,210[a,c]	38,666[d]	8,070	-	6,190[e]	2,000[a]	20[a]
Totals	**24,382**	**130**	**23,653**	**86,821**	**12,720**	**1,050**	**6,735**	**485,195**	**10,442**

Source: [a] EC-CWS unpublished data, [b] Cairns et.al. 1989, [c] Robertson et al. 2002., [d] Robertson and Elliot 2002a., [e] Robertson and Elliot 2002b, [f] Thomas et al. 2014, [g] Wilhelm et al. 2015.

Table 4.16 Number of Pairs of Seabirds Nesting at Colonies in Eastern Newfoundland (49°30'N to 46°N).

Species	Baccalieu Island	Witless Bay Islands	Mistaken Point	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island	Grand Colombier Island	Miquelon Cape
Northern Fulmar	-	60[a]	-	Present[a]	-	-	-		
Manx Shearwater	-	-	-	-	7[c]	-	-		
Leach's Storm-Petrel	2,022,000[a,b]	314,020[a]	-	-	8,773[a]	100,000[b]	48,000[a]	363,787[e]	
Northern Gannet	3,092[a]	-	-	13,515[a]	-	-	-		
Herring Gull	46[a]	2,266[a]	-	39[b]	20[b]	50[b]	Present[b]	60[f]	265[d]
Great Black-backed Gull	2[a]	15[a]	-	Present[b]	6[b]	25[b]	-	10[f]	
Black-legged Kittiwake	5,096[a]	11,787[a]	4,170[f]	10,000[b]	-	50[b]	-	196[f]	2,415[d]
Arctic and Common Terns	-	-	-	-	-	-	Present[b]		
Common Murre	1,440[a]	252,667[a]	84[b]	15,484[a]	-	-	-	7,176[h]	
Thick-billed Murre	73[a]	240[a]	-	1,000[f]	-	-	-		
Razorbill	406[a]	846[a]	22[f]	100[b]	-	-	-	1,443[h]	
Black Guillemot	113[a]	20[a]	Present[b]	Present[b]	-	-	-	95[i]	Present[d]
Atlantic Puffin	75,000[f]	304,042[a,j]	79[f]	-	-	-	-	9,543[i]	
TOTALS	**2,107,268**	**885,963**	**4,355**	**40,138**	**8,806**	**100,125**	**48,000**	**382,310**	**2,680**

Sources: [a] EC-CWS unpublished data, [b] Wilhelm et al., submitted; [c] Fraser et al. (2013); [d] Cairns et al. (1989); [e] Lormée et al. (2012); [f] Parks and Natural Areas Division, unpublished data; [g] Thomas et al. (2014); [h] Lormée et al. (2015); [i] Lormée (2008); [j] Wilhelm et al. (2015).

4.4.2.1 Anatidae (Ducks and Geese)

Large numbers of Common Eider nest on the Labrador coast and occur during migration and winter in open winter from Labrador to Newfoundland. Moult aggregations of Surf, Black and White-winged Scoters occur on the Labrador coast by mid-summer. Barrow's Goldeneye and Harlequin Duck both have *special concern* status under Schedule 1 of *SARA*. A detailed profile of Barrow's Goldeneye is provided in § 4.6.1.11 of the MKI Labrador Sea EA (LGL 2014), and a detailed profile of Harlequin Duck is provided in § 4.6.1.10 of the MKI Labrador Sea EA (LGL 2014).

Subsection 4.4.2.1 of LGL (2016) provides more information on waterfowl occurrence and abundance in the Study Area.

4.4.2.2 Procellariidae (Fulmars and Shearwaters)

Five species of this family occur regularly in the Study Area: (1) Northern Fulmar; (2) Great Shearwater; (3) Cory's Shearwater; (4) Sooty Shearwater; and (5) Manx Shearwater.

Northern Fulmar

Northern Fulmar is expected to be common throughout the Study Area year-round (see Tables 4.13 and 4.14). The number of breeding pairs and their breeding locations are indicated in Tables 4.15 and 4.16.

Subsections 4.4.2.2 of LGL (2014), 4.4.4.1 of LGL (2015a) and 4.4.3.2 of LGL (2015b) provide more information on Northern Fulmar occurrence and abundance in the Study Area.

Great Shearwater

Great Shearwater is expected to be common throughout the Study Area during June–October but either uncommon or scarce during May and November (see Tables 4.13 and 4.14).

Subsections 4.4.2.2 of LGL (2014), 4.4.4.1 of LGL (2015a) and 4.4.3.3 of LGL (2015b) provide more information on Great Shearwater occurrence and abundance in the Study Area.

Other Shearwaters

Cory's Shearwater is expected to be scarce in the southern part of the Study Area during June–September, and absent in the northern part of the Study Area (see Tables 4.13 and 4.14).

Sooty Shearwater is expected to be uncommon in the northern part of the Study Area during June–September and scarce during May and October (see Table 4.13). In the southern part of the

Study Area, Sooty Shearwater are expected to be uncommon during June–October, and scarce during May and November (see Table 4.14).

Manx Shearwater is expected to be rare in the northern part of the Study Area during June–September (see Table 4.13), and rare in the southern part of the Study Area during May–October (see Table 4.14). Manx Shearwater breeds at a colony at Middle Lawn Island (see Table 4.16).

Subsections 4.4.2.2 of LGL (2014), 4.4.4.1 of LGL (2015a) and 4.4.3.3 of LGL (2015b) provide more information on occurrences and abundances of Cory's Shearwater, Sooty Shearwater and Manx Shearwater in the Study Area.

4.4.2.3 Hydrobatidae (Storm-Petrels)

Leach's Storm-Petrel

Leach's Storm-Petrel is expected to be uncommon in the northern part of the Study Area during May–October (see Table 4.13), and common in the southern part of the Study Area during May–October (see Table 4.14). Number of breeding pairs and their breeding locations are indicated in Tables 4.15 and 4.16.

More than two million pairs of Leach's Storm-Petrel nest on the Avalon Peninsula. Accumulating evidence suggests the population of Newfoundland Leach's Storm-Petrels is experiencing a significant decline. Preliminary results from a 2013 survey of nesting Leach's Storm-Petrel on Baccalieu Island, the largest breeding colony of Leach's Storm-Petrels in the world, give an estimate of just over 2 million pairs, a decline of 40% from the previous survey in 1984 (EC-CWS unpublished data). The results of surveys of nesting Leach's Storm-Petrels on Gull Island in the Witless Bay Ecological Reserve indicated a decline from 352,000 breeding pairs in 2001 to 180,000 pairs in 2012, a drop of 51%. (EC-CWS unpublished data). A 2015 population estimate update for Green Island, Fortune Bay (next to St. Pierre et Miquelon) was 48,000 pairs (EC-CWS unpublished data), down from a previous estimate of 103,833 pairs (Russell 2008). The cause of the Leach's Storm-Petrel population decline has not yet been determined.

Recent studies using geolocators attached to the birds examined the movements of Leach's Storm-Petrel. A bird outfitted with a geolocator in the Gull Island, Newfoundland colony migrated to Cape Verde Islands off the west coast of Africa in early December, averaging 420 km/day over 12 days of migration. It remained in this area for at least five weeks at which time the transmitter stopped working. A Nova Scotia bird followed a similar track southward but departed in mid-October. It staged for several weeks near the Cape Verde Islands before continuing to the eastern tip of Brazil where it spent the rest of the winter. It migrated north in early April (Pollet et al. 2014a).

Leach's Storm-Petrels with geolocators have been shown to travel up to 1,015±238 km during foraging trips from nesting colonies in Nova Scotia (Pollet et al. 2014b). Newfoundland breeders can be expected to travel a similar distance from the breeding colonies, if required, putting the northwestern third of the Study Area within reach of these birds.

Subsections 4.4.2.3 of LGL (2014), 4.4.4.2 of LGL (2015a) and 4.4.3.4 of LGL (2015b) provide more information on Leach's Storm-Petrel occurrence and abundance in the Study Area.

Wilson's Storm-Petrel

Wilson's Storm-Petrel is expected to be rare in the northern part of the Study Area during June–September (see Table 4.13), and either uncommon or scarce during June–September in the southern part (see Table 4.14).

Subsections 4.4.4.2 of LGL (2015a) and 4.4.3.4 of LGL (2015b) provide more information on Wilson's Storm-Petrel occurrence and abundance in the Study Area.

4.4.2.4 Sulidae (Gannets)

Northern Gannet

Northern Gannet is expected to be uncommon in the northern part of the Study Area during June–September, and scarce during May and November (see Table 4.13). In the southern part of the Study Area, Northern Gannet are expected to be uncommon during May–November (see Table 4.14). The number of breeding pairs and their breeding locations are indicated in Tables 4.15 and 4.16.

Subsections 4.4.2.4 of LGL (2014), 4.4.4.3 of LGL (2015a) and 4.4.3.5 of LGL (2015b) provide more information on Northern Gannet occurrence and abundance in the Study Area.

4.4.2.5 Phalaropodinae (Phalaropes)

Red and Red-necked Phalarope

Red Phalarope is expected to be uncommon in the northern part of the Study Area during July–September, and scarce during May–June and October (see Table 4.13). In the southern part of the Study Area, Red Phalarope is expected to be scarce during August and September and rare during May–July and October (see Table 4.14).

Red-necked Phalarope is expected to be scarce in the northern part of the Study Area during May– September, and rare in October (see Table 4.13). In the southern part of the Study Area, Red-necked Phalarope is expected to be rare during May–October (see Table 4.14).

Subsections 4.4.2.5 of LGL (2014) and 4.4.4.4 of LGL (2015a) provide more information on Red and Red-necked Phalarope occurrences and abundances in the Study Area.

4.4.2.6 Laridae (Gulls and Terns)

Great Black-backed, Herring, Iceland, Glaucous and Lesser Black-backed Gull

Great Black-backed Gull, Herring Gull, Glaucous Gull are expected to be common in the northern part of the Study Area during May–November (see Table 4.13). In the southern part of the Study Area, Great Black-backed Gull and Herring Gull are expected to be either uncommon or scarce during May–November, while Glaucous Gulls is expected to be either uncommon, scarce, or rare during May–November (see Table 4.14).

Iceland Gull is expected to be either uncommon or scarce in the northern part of the Study Area during June–September, and common in May, October and November (see Table 4.13). In the southern part of the Study Area, Iceland Gull is expected to be scarce in May and October, common in November and absent during June–September (see Table 4.14).

Lesser Black-backed Gull is expected to be scarce in the northern part of the Study Area during May–September (see Table 4.13), and rare in the southern part during May–November (see Table 4.14).

The numbers of breeding pairs of Herring and Great Black-backed Gulls and their breeding locations are indicated in Tables 4.15 and 4.16, while the same information for Glaucous Gull is indicated in Table 4.15.

Subsections 4.4.2.6 of LGL (2014), 4.4.4.5 of LGL (2015a) and 4.4.3.6 of LGL (2015b) provide more information on the occurrences and abundances of these gull species in the Study Area.

Black-legged Kittiwake

Black-legged Kittiwake is expected to be common during May–November in the entire Study Area (see Tables 4.13 and 4.14). The number of breeding pairs of Black-legged Kittiwake and their breeding locations are indicated in Tables 4.15 and 4.16.

Subsections 4.4.2.6 of LGL (2014), 4.4.4.5 of LGL (2015a) and 4.4.3.6 of LGL (2015b) provide more information on the occurrence and abundance of Black-legged Kittiwake in the Study Area.

Ivory Gull

The Ivory Gull likely occurs in small numbers in the portion of the Study Area north of 50°N during periods when sea ice is present (i.e., late-winter and early-spring). It probably occurs irregularly south of 50°N in the ice pack during heavier ice years. As indicated in Tables 4.13 and 4.14, Ivory Gull is expected to be either uncommon or scarce during May and November in the northern part of the Study Area, and to not occur in the southern part during May–November.

The Ivory Gull has *endangered* status under both Schedule 1 of *SARA* and COSEWIC (COSEWIC website 2016). More information on the Ivory Gull is presented in § 4.6 of LGL (2016).

Arctic and Common Tern

Arctic Tern and Common Tern are expected to be common in the northern part of the Study Area during May–August, and either uncommon or scarce in September (see Table 4.13). In the southern part of the Study Area, both tern species are expected to be either rare or scarce during May–September (Table 4.14). Common Tern is less likely to occur in the offshore areas than Arctic Tern. The numbers of breeding pairs of Arctic Tern and Common Tern and their breeding locations are indicated in Tables 4.15 and 4.16.

Subsections 4.4.2.6 of LGL (2014), 4.4.4.5 of LGL (2015a) and 4.4.3.6 of LGL (2015b) provide more information on tern occurrence and abundance in the Study Area.

4.4.2.7 Stercorariidae (Skuas and Jaegers)

Great and South Polar Skua

In the northern part of the Study Area, Great Skua is expected to be rare in May and June and scarce during July–October (see Table 4.13). In the southern part of the Study Area, this skua species is expected to be scarce during May–November (see Table 4.14).

South Polar Skua is expected to be rare during June–September in the northern part of the Study Area (see Table 4.13), and rare during May–October in the southern part (see Table 4.14).

Subsections 4.4.2.7 of LGL (2014) and 4.4.4.6 of LGL (2015a) provide more information on skua occurrence and abundance in the Study Area.

Pomarine, Parasitic and Long-tailed Jaeger

These three jaeger species are expected to be scarce in the northern part of the Study Area during May–November (see Table 4.13), and rare in the southern part during the same period (see Table 4.14).

Subsections 4.4.2.7 of LGL (2014), and 4.4.4.6 of LGL (2015a) provide more information on jaeger occurrence and abundance in the Study Area.

4.4.2.8 Alcidae (Dovekie, Murres, Atlantic Puffin, Razorbill, Black Guillemot)

There are six species of alcids that breed in the North Atlantic. All of these, except for Dovekie, nest in large numbers in eastern Newfoundland (see Tables 4.15 and 4.16). Dovekie nests primarily in Greenland. Dovekie, Common Murre, Thick-billed Murre, and Atlantic Puffin occur in the Study Area during a large portion of the year. Black Guillemot and Razorbills are more coastal and are expected to be scarce or uncommon within most of the Study Area.

Dovekie

In the northern part of the Study Area, Dovekie is expected to be common in May, October and November, uncommon in June and September, and scarce in July and August (see Table 4.13). In the southern part of the Study Area, Dovekie is expected to be uncommon in May, rare during June–August, scarce in September, and common in October and November (see Table 4.14).

Subsections 4.4.2.8 of LGL (2014), 4.4.4.7 of LGL (2015a) and 4.4.3.7 of LGL (2015b) provide more information on Dovekie occurrence and abundance in the Study Area.

Murres

Since Common Murre and Thick-billed Murre are often difficult to differentiate with certainty at sea, they are often aggregated as “murres” during offshore seabird surveys.

Common Murre is expected to be common in the northern part of the Study Area during May–October, and uncommon in November (see Table 4.13). This murre species is expected to be common in the southern part of the Study Area during May–November (see Table 4.14).

Thick-billed Murre is expected to be common in the northern part of the Study Area during May, June, October and November and uncommon during July–September (see Table 4.13). In the southern part, this murre is expected to be common in May, October and November, scarce during June–August, and uncommon during September (see Table 4.14).

Studies using geolocators attached to 19 Thick-billed Murres and 20 Common Murres from five nesting colonies in the Northwest Atlantic revealed that murres exhibit a combination of site fidelity and flexibility during both migration and the winter (McFarlane et al. 2014). During the non-breeding season, Thick-billed Murres occurred in the offshore from Davis Strait south to the Flemish Cap and Southeast Grand Banks. Common Murres occurred off eastern Newfoundland to Flemish Cap and the Southeast Grand Banks during migration and winter (McFarlane et al. 2014).

The numbers of breeding pairs for each species and their breeding locations are indicated in Tables 4.15 and 4.16.

Subsections 4.4.2.8 of LGL (2014), 4.4.4.7 of LGL (2015a) and 4.4.3.7 of LGL (2015b) provide more information on murre occurrence and abundance in the Study Area.

Atlantic Puffin

Atlantic Puffin is expected to be common in the entire Study Area during May–November (see Tables 4.13 and 4.14). The number of breeding pairs and their breeding locations are indicated in Tables 4.15 and 4.16.

Subsections 4.4.2.8 of LGL (2014) and 4.4.4.7 of LGL (2015a) provide more information on Atlantic Puffin occurrence and abundance in the Study Area.

Razorbill and Black Guillemot

Razorbill and Black Guillemot are expected to be common in the northern part of the Study Area during May–November (see Table 4.13). In the southern part of the Study Area, Black Guillemot and Razorbill are expected to be rare and uncommon, respectively, during May–November (see Table 4.14).

Black Guillemot is expected to be common nearshore in Newfoundland and Labrador. Unlike the other members of the Alcidae, it feeds near shore and is rarely found more than a few kilometres from shore or pack ice. The number of breeding pairs for each species and their breeding locations are indicated in Tables 4.15 and 4.16.

Subsections 4.4.2.8 of LGL (2014) and 4.4.4.7 of LGL (2015a) provides more information on Razorbill and Black Guillemot occurrences and abundances in the Study Area.

4.4.3 Prey and Foraging Habits

Seabirds in the Study Area employ a variety of foraging strategies and feed on a variety of prey species. The estimated head submergence time and diving depth of various seabirds are provided in Table 4.16 in § 4.4.3 of LGL (2016).

More details regarding prey and foraging habits of seabirds likely to occur in the Study Area are provided in § 4.4.3 of LGL (2014), § 4.4.5 of LGL (2015a), and § 4.4.4 of LGL (2015b).

4.4.4 Marine-associated Bird Data Gaps Identified in Relevant SEAs

The following data gap associated with the Marine-associated Bird VEC was identified in the Labrador Shelf SEA (§ 4.9.12 of C-NLOPB 2008).

- Many of the data related to marine-associated birds in Labrador are either dated or deficient.

The following data gap associated with the Marine-associated Bird VEC was identified in the Eastern Newfoundland SEA (§ 6.1.6 of C-NLOPB 2014).

- Detailed information on the occurrence, abundance and distribution of marine-associated birds is not available for all locations and times in the Study Area.

The following data gaps associated with the Marine-associated Bird VEC were identified in the Southern Newfoundland SEA (§ 3.4.9 of C-NLOPB 2010).

- Knowledge of the offshore distribution and abundance of seabirds is incomplete;
- Seabird data for areas that have been surveyed typically do not cover all seasons;
- Pelagic seabird distribution data are lacking during winter on much of the continental shelf and the deep waters beyond the shelf; and
- Much of the existing data on seabirds are dated.

All of the data gaps indicated above still exist and thus limit the certainty of impact predictions made in § 5.7.6. Opportunistic efforts are being made during geophysical surveys to collect more distribution and abundance data for seabirds.

The CWS ECSAS survey program sampled areas off eastern and southern Newfoundland (Fifield et al. 2009). Data from offshore Labrador surveys will be summarized in a document expected in 2017 (D. Fifield, EC-CWS, pers. comm.). As noted above, these results, if available in time, will be provided in subsequent updates of this EA.

4.5 Marine Mammals and Sea Turtles VEC

The Marine Mammal and Sea Turtle VEC of the Study Area has been recently described in the Labrador Shelf SEA (§ 4.9.1 to 4.9.7 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.3 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.5 and 3.6 of C-NLOPB 2010), and four project-specific EAs (§ 4.5 of LGL 2014, 2015a,b, 2016). An overview of marine mammals and sea turtles that occur in the Study Area, based primarily on the aforementioned documents, is provided below. New information not included in the SEAs and EAs is also summarized. DFO research and scientific documents and COSEWIC species assessment and status reports also served as primary sources of information on the occurrence, distribution, and abundance of marine mammals and sea turtles in the Study Area. Historical and more recent sightings of cetaceans and sea turtles within Newfoundland and Labrador waters have been compiled and made available by DFO in St. John's (§ 4.5.1.1). Marine mammal and sea turtle data gaps identified in the three SEAs are also discussed in terms of current status.

4.5.1 Marine Mammals

Twenty-seven marine mammal species are known to occur near or within the Study Area, including 20 species of cetaceans (whales, dolphins, and porpoises), six species of phocids (true seals), and the polar bear. Most marine mammals use the area seasonally. The region likely represents important foraging habitat for many marine mammals.

Information on the occurrence, habitat, and conservation status for each of the marine mammal species that could occur near or within the Study Area is presented in Table 4.17. Four cetacean species that have been reported within or near the Study Area (bowhead whale, *Balaena mysticetus*; pygmy sperm whale, *Kogia breviceps*; false killer whale, *Pseudorca crassidens*; and Cuvier's beaked whale, *Ziphius cavirostris*) are considered unlikely to occur there during the seismic program and are not discussed further.

4.5.1.1 DFO Sightings Database

A large database of cetacean and sea turtle sightings in Newfoundland and Labrador waters has been compiled from various sources by DFO in St. John's (J. Lawson, DFO Research Scientist, pers. comm., January 2017), and has been made available for the purposes of describing species sightings within the Study Area. These data have been opportunistically gathered and have no indication of survey effort. Therefore, while these data can be used to indicate what species may occur in the Study Area, they cannot be used to predict species abundance, distribution, or fine-scale habitat use in the area.

The caveats that should be considered when using data from the DFO sightings database were described in § 4.5.1.1 of LGL (2014, 2015a,b).

Cetacean sightings in the Study Area within the temporal boundary of the project (May–November) compiled from the DFO sightings database (1947–2015) are summarized in Table 4.18. Sightings include baleen whales, large toothed whales, dolphins and porpoises.

4.5.1.2 Baleen Whales (Mysticetes)

Six species of baleen whales are known to occur in the Study Area, three of which occur commonly (Table 4.17). Given that the Atlantic populations of blue whale and North Atlantic right whale each have *endangered* status under Schedule 1 of *SARA*, they are described in § 4.6, Species at Risk. Although some individual baleen whales may be present in offshore waters of

Newfoundland and Labrador year-round, most baleen whale species presumably migrate to lower latitudes during the winter months (C-NLOPB 2014).

Table 4.17 Marine Mammals with Reasonable Likelihood of Occurrence in the Study Area.

Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Baleen Whales (Mysticetes)					
North Atlantic Right Whale (*Eubalaena glacialis*)	Rare	Summer	Coastal, shelf & pelagic	Schedule 1: Endangered	E
Humpback Whale (*Megaptera novaengliae*)	Common	Year-round, but mostly May–Sept	Coastal & banks	Schedule 3: Special Concern	NAR
Minke Whale (*Balaenoptera acutorostrata*)	Common	Year-round, but mostly May–Oct	Coastal, shelf, & banks	NS	NAR
Sei Whale (*B. borealis*)	Uncommon	May–Nov	Pelagic	NS	DD; HPC
Fin Whale (*B.physalus*)	Common	Year-round, but mostly summer	Shelf breaks, banks & pelagic	Schedule 1: Special Concern	SC
Blue Whale (*B. musculus*)	Uncommon	Year-round	Coastal & pelagic	Schedule 1: Endangered	E
Toothed Whales (Odontocetes)					
Sperm Whale (*Physeter macrocephalus*)	Common	Year-round, but mostly summer	Slope, canyons & pelagic	NS	NAR; MPC
Northern Bottlenose Whale (*Hyperoodon ampullatus*)	Rare	Year-round	Slope, canyons & pelagic	Schedule 1: Endangered [c] / NS [d]	E [c] / SC [d]
Sowerby's Beaked Whale (*Mesoplodon bidens*)	Rare	Year-round	Slope, canyons & pelagic	Schedule 1: Special Concern	SC
Beluga Whale (*Delphinapterus leucas*)	Rare	Winter or summer	Coastal & ice edge	NS	E [e]
Striped Dolphin (*Stenella coeruleoalba*)	Rare	Summer	Shelf & pelagic	NS	NAR
Atlantic Spotted Dolphin (*Stenella frontalis*)	Rare	Summer	Shelf, slope & pelagic	NS	NAR
Short-beaked Common Dolphin (*Delphinus delphis*)	Common	Summer	Shelf & pelagic	NS	NAR
White-beaked Dolphin (*Lagenorhynchus albirostris*)	Common	Year-round, but mostly June–Sept	Shelf & pelagic	NS	NAR
Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)	Common	Year-round, but mostly summer–fall	Coastal & shelf	NS	NAR
Common Bottlenose Dolphin (*Tursiops truncatus*)	Rare	Summer	Coastal & pelagic	NS	NAR
Risso's Dolphin (*Grampus griseus*)	Rare	Year-round	Continental slope	NS	NAR
Killer Whale (*Orcinus orca*)	Uncommon	Year-round	Coastal & pelagic	NS	SC

Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Long-finned Pilot Whale (*Globicephala melas*)	Common	Year-round, but mostly spring–fall	Shelf break, pelagic & slope	NS	NAR
Harbour Porpoise (*Phocoena phocoena*)	Uncommon	Year-round, but mostly spring–fall	Coastal, shelf & pelagic	Schedule 2: Threatened	SC
True Seals (Phocids)					
Harp Seal (*Pagophilus groenlandicus*)	Common	Year-round, but mostly winter–spring	Pack ice & pelagic	NS	NC; LPC
Hooded Seal (*Cystophora cristata*)	Common	Year-round, but mostly winter–spring	Pack ice & pelagic	NS	NAR; MPC
Grey Seal (*Halichoerus grypus*)	Uncommon	Year-round, but mostly summer	Coastal & shelf	NS	NAR
Harbour Seal (*Phoca vitulina*)	Uncommon	Year-round	Coastal	NS	NAR
Ringed Seal (*Phoca hispida*)	Common	Winter–spring	Landfast ice with snow cover	NS	NAR; HPC
Bearded Seal (*Erignathus barbatus*)	Uncommon	Year-round	Coastal, shallow & ice edge	NS	DD;MPC
Bears (Urcids)					
Polar Bear (*Ursus maritimus*)	Uncommon	Winter–summer	Coastal & pack ice	Schedule 1: Special Concern	SC

[a] Species designation under the Species at Risk Act (*SARA* website 2016); NS = No Status.
[b] Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC website 2016); E = Endangered, SC = Special Concern, DD = Data Deficient, NAR = Not at Risk, NC = Not Considered, LPC = Low-priority Candidate, MPC = Mid-priority Candidate, HPC = High-priority Candidate.
[c] Scotian Shelf population.
[d] Davis Strait-Baffin Bay-Labrador Sea population.
[e] Ungava Bay and Eastern Hudson Bay populations.

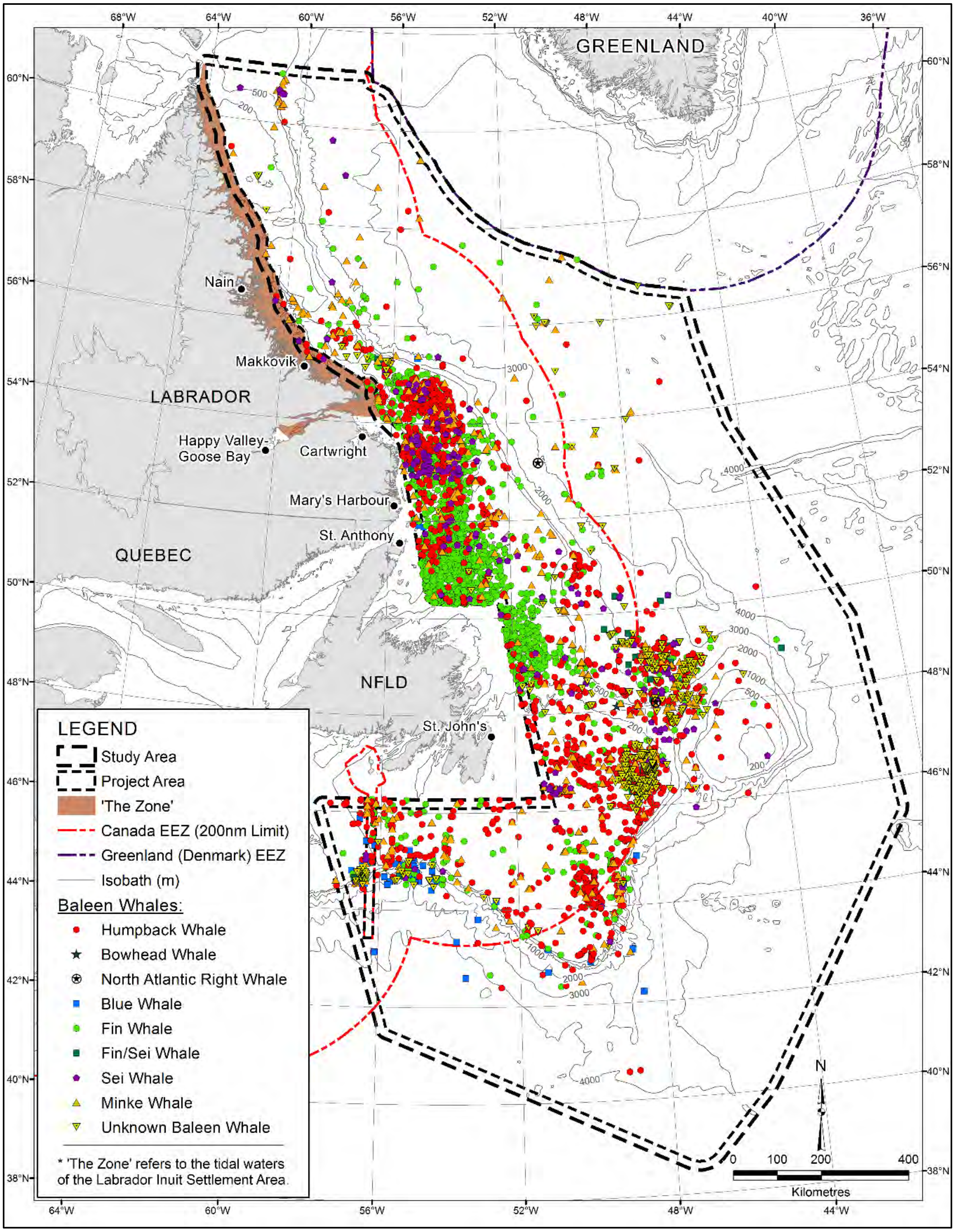
Humpback Whale

Humpbacks are the most commonly recorded mysticete in the Study Area in the DFO sightings database (2,078 sightings; 8,943 individuals). While humpback sightings occur year-round, they are predominant during June–November (Table 4.18; Figure 4.36). Similarly, based on habitat-density modeling for the southwestern region of the Study Area, the U.S. National Oceanic and Atmospheric Administration (NOAA 2016) predicted the highest densities (up to 0.68 whales/100 km^2) from May–November. Modeling by Mannocci et al. (2016) for the summer months showed the highest densities in the southern portion of the Study Area. Humpback whales are expected to be common throughout the Study Area.

Table 4.18 Cetacean Sightings in the Study Area during the Temporal Boundary of the Project (compiled from the DFO sightings database, 1947–2015).

Species	Number of Sightings	Number of Individuals	Months Sighted
Mysticetes			
North Atlantic Right Whale	2	4	June, Aug
Humpback Whale	2,078	8,943	May–Nov
Minke Whale	549	990	May–Nov
Sei Whale	207	397	May–Nov
Fin Whale	2,694	3,472	May–Nov
Sei/Fin Whale	46	71	May–Oct
Blue Whale	87	113	May–Nov
Bowhead Whale	1	1	May
Unidentified Baleen Whale	337	444	May–Nov
Odontocetes			
Sperm Whale	477	1,254	May–Nov
Pygmy Sperm Whale	1	2	June
Northern Bottlenose Whale	219	925	May–Nov
Sowerby's Beaked Whale	2	11	Sept, Nov
Cuvier's Beaked Whale	1	1	July
Beluga	5	35	July
Striped Dolphin	10	487	Aug, Sept
Atlantic Spotted Dolphin	1	1	June
Common Dolphin	296	5,260	Jun–Nov
White-beaked Dolphin	319	2,247	May–Nov
Atlantic White-sided Dolphin	457	6,634	May–Nov
Bottlenose Dolphin	18	151	May–June, Aug–Oct
Risso's Dolphin	26	78	June–Aug, Oct–Nov
False Killer Whale	1	2	June
Killer Whale	180	1,206	May–Nov
Long-finned Pilot Whale	1031	17,098	May–Nov
Harbour Porpoise	182	904	May–Nov
Unidentified Dolphin	896	14,698	May–Nov
Unidentified *Stenella*	3	3	June, Aug, Oct
Unidentified Beaked Whale	2	2	June, Sept
Unidentified *Mesoplodon*	1	2	Aug
Unidentified Toothed Whale	20	53	June–Sept
Other			
Unidentified Cetacean	25	73	May–Oct
Unidentified Whale	569	1,686	May–Nov
Unidentified Large Whale	448	966	May–Nov
Unidentified Medium Whale	5	6	June, Aug, Oct
Unidentified Small Whale	32	221	May–Nov

Note: see § 4.3.1.1 for description of DFO sightings database and caveats associated with these data.



Data source: DFO cetacean sightings database, see text for description of data and caveats associated with these data.

Figure 4.36 Baleen Whale Sightings in the Study Area during May–November (compiled from the DFO sightings database, 1947–2015).

Two humpbacks outfitted with satellite transmitters near the Dominican Republic travelled within the Study Area. One whale was recorded on the eastern edge of Cabot Strait in May 2011, and a second whale was recorded on the Grand Banks in June 2012 (Kennedy et al. 2014). Humpbacks were also sighted within the Study Area off eastern Newfoundland and in the southern Laurentian Channel during July 2012 (Ryan et al. 2013). In addition, sightings were made off the northeast coast of Newfoundland, just to the west of the Study Area, during 2000–2011 (Davoren 2013). Humpback whales have also been sighted off the northeastern edge of the Scotian Shelf within and near the Study Area (Gomez-Salazar and Moors-Murphy 2014).

Minke Whale

The minke whale is the third most commonly recorded mysticete in the Study Area in the DFO sightings database (549 sightings; 990 individuals), with most sightings recorded during June–November (see Table 4.18; Figure 4.36). Similarly, based on habitat-density modeling for the southwestern region of the Study Area, NOAA (2016) predicted the highest densities (up to 3.2 whales/100 km^2) from June–November. Modeling by Mannocci et al. (2016) showed the highest year-round densities in the southern portion of the Study Area. Minke whales are considered common throughout the Study Area.

Minke whales were commonly recorded in Jeanne d'Arc Basin during seismic monitoring programs in 2008, 2013, and 2015 (Abgrall et al. 2009; Holst and Lang 2014; Keats 2015). Minke whales were also sighted within the Study Area off southern Newfoundland, eastern Newfoundland, and south of the Grand Banks during July 2012 (Ryan et al. 2013). In addition, sightings were made during surveys off the northeastern coast of Newfoundland, just to the west of the Study Area, during 2000 and 2007–2011 (Davoren 2013). Minke whales have also been sighted along the northeastern edge of the Scotian Shelf within and near the Study Area (Gomez-Salazar and Moors-Murphy 2014). Whitehead (2013) reported one sighting in Haldimand Canyon at the edge of the Scotian Shelf near the Study Area between 1988 and 2012.

Sei Whale

Based on the DFO sightings database, there have been at least 207 sightings (397 individuals) of sei whales in the Study Area; sightings occurred mainly during June–October (see Table 4.18; Figure 4.36). Based on habitat-density modeling for the southwestern region of the Study Area, NOAA (2016) predicted the highest densities (~1 whale/100 km^2) from July–September. Habitat-density modeling for the summer by Mannocci et al. (2016) showed that sei whales are likely to occur throughout the Study Area. Nonetheless, sei whales are considered uncommon in the Study Area.

Sei whales were occasionally sighted in the Orphan Basin during the seismic monitoring programs in 2004 and 2005 (6 and 15 sightings, respectively; Moulton et al. 2005, 2006a). One sei whale sighting was recorded in Jeanne d'Arc Basin during seismic monitoring programs in 2008 and 2013 (Abgrall et al. 2009; Holst and Lang 2014). In addition, one sei whale was observed off Southern Newfoundland during a summer 2007 aerial survey (Lawson and Gosselin 2009). A sei whale that was tagged in the Azores during 2005 (Olsen et al. 2009) and seven individuals that were tagged in the Azores during 2008–2009 travelled to the Labrador Sea, where they spent extended periods of time on the northern shelf, presumably to feed (Prieto et al. 2010, 2014). Sei whales were sighted off the northeastern coast of Newfoundland, just to the west of the Study Area, during surveys in 2000–2002 (Davoren 2013). Sei whales have also been seen off the northeastern edge of the Scotian Shelf near or within the Study Area (Gomez-Salazar and Moors-Murphy 2014). Whitehead (2013) reported two sightings in Haldimand Canyon at the edge of the Scotian Shelf near the Study Area between 1988 and 2012.

Fin Whale

The Atlantic population of fin whale currently has a *special concern* status under Schedule 1 of *SARA* (*SARA* website 2016) and COSEWIC (COSEWIC 2005), and a management plan has recently been proposed (DFO 2016g). Delarue et al. (2014) suggested that there are four distinct stocks in the NW Atlantic based on geographic differences in fin whale calls.

Fin whales are the second most commonly recorded mysticete in the Study Area in the DFO sightings database (3,472 individuals), with most sightings occurring during June–November (see Table 4.18; Figure 4.36). Similarly, according to Edwards et al. (2015), highest densities of fin whales occur in offshore waters off Newfoundland during June–August. Based on habitat-density modeling in the southwestern region of the Study Area, NOAA (2016) predicted the highest densities (up to 3.2 whales/100 km^2) from May–December. Modeling by Mannocci et al. (2016) showed the highest year-round densities in the southern portion of the Study Area. Fin whales are expected to be common throughout the Study Area during late spring to fall.

Fin whales were commonly observed in Orphan Basin during the 2004 and 2005 seismic monitoring programs (Moulton et al. 2005, 2006a) and during seismic monitoring programs in Jeanne d'Arc Basin in 2008 and 2013 (Abgrall et al. 2009; Holst and Lang 2014). Fin whales were also seen within the Study Area south of the Grand Banks during July 2012 (Ryan et al. 2013). In addition, sightings were made during surveys off the northeastern coast of Newfoundland, just to the west of the Study Area, during 2000 and 2009–2011 (Davoren 2013). Fin whales have also been sighted off the northeastern edge of the Scotian Shelf within and near the Study Area (Gomez-Salazar and Moors-Murphy 2014). Whitehead (2013) reported three sightings in Haldimand Canyon and four in Shortland Canyon, at the edge of the Scotian Shelf near the Study Area, during 1988–2012.

4.5.1.3 Toothed Whales (Odontocetes)

Fourteen species of toothed whales are likely to occur in the Study Area (see Table 4.17), ranging from the largest, the sperm whale, to one of the smallest, the harbour porpoise. Several of these species only occur in the Study Area seasonally, but in general, there is little information about the distribution and abundance of these species. The Scotian Shelf population of northern bottlenose whale has *endangered* status under Schedule 1 of *SARA*, and its profile is included in § 4.6, Species at Risk.

Sperm Whale

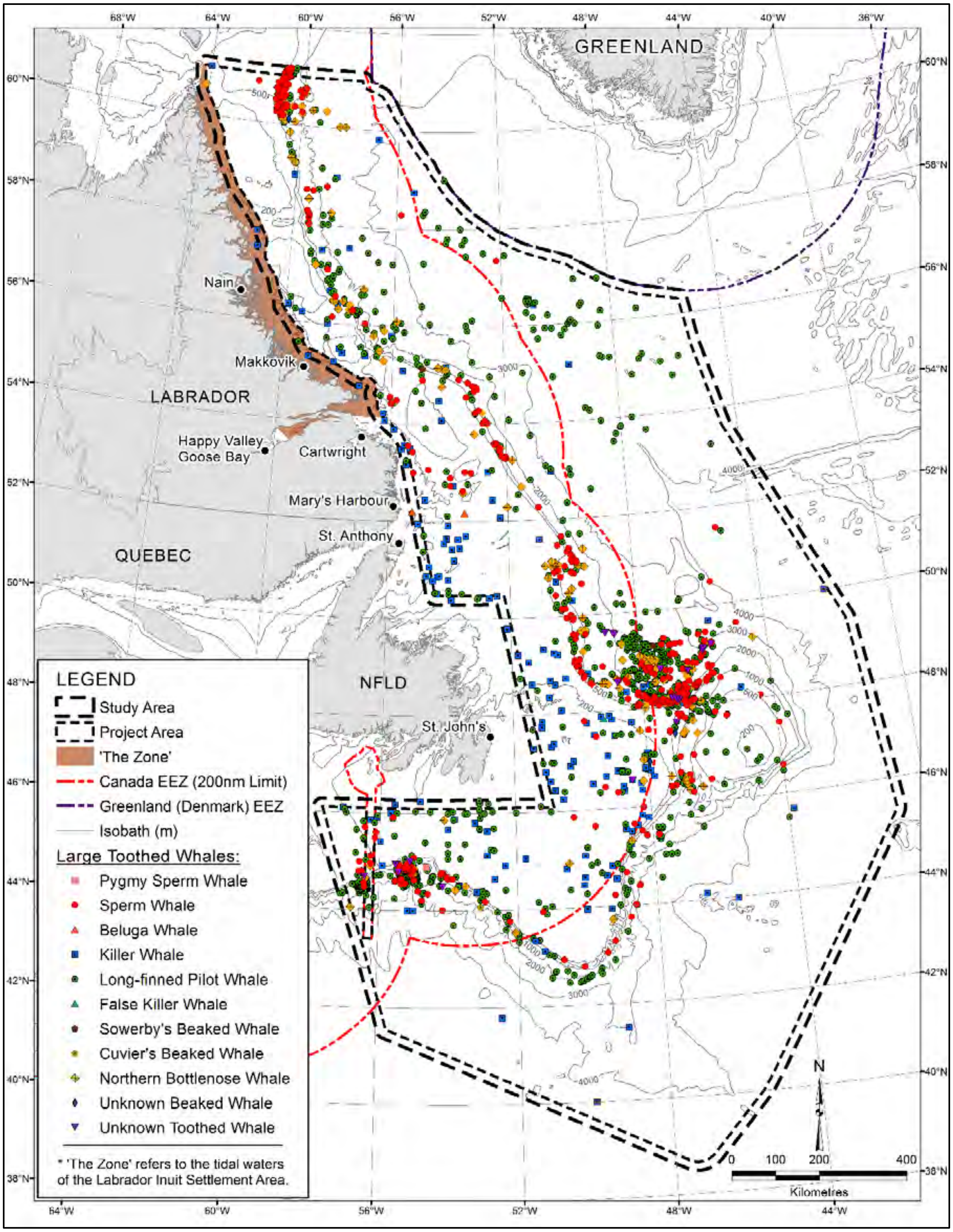
There are 477 sightings (1,254 individuals) of sperm whales in the Study Area in the DFO sightings database for May–November, but sightings occur year-round (see Table 4.18; Figure 4.37). Based on habitat-density modeling for the southwestern region of the Study Area, NOAA (2016) predicted the highest densities (~3.2 whales/100 km^2) from June–October. Mannocci et al. (2016) presented modeled year-round densities of sperm whales, with higher densities occurring in deep, offshore waters of the Study Area. Sperm whales are expected to be common in deep water of the Study Area.

Sperm whales were regularly sighted in the deep waters of Orphan Basin during the summers of 2004–2007 (Moulton et al. 2005, 2006a; Abgrall et al. 2008c), but were not observed in the shallower waters of Jeanne d'Arc Basin in 2005–2008, 2013, and 2015 (Lang et al. 2006; Lang and Moulton 2008; Abgrall et al. 2008a, 2009; Holst and Lang 2014; Keats 2015). There were two sightings in the Flemish Pass Basin during a monitoring program in 2014 (Thomas et al. 2014). Sperm whales were observed in small numbers (11 sightings of single individuals) off eastern and southern Newfoundland during aerial surveys conducted in the summer of 2007 (Lawson and Gosselin 2009). Sperm whales have also been sighted in Shortland Canyon at the edge of the Scotian Shelf near the Study Area (Gomez-Salazar and Moors-Murphy 2014).

Sowerby's Beaked Whale

Sowerby's beaked whale has a *special concern* status under Schedule 1 of *SARA* (*SARA* website 2016) and COSEWIC (COSEWIC 2006), and a management plan has recently been proposed (DFO 2016h). It is considered rare in the Study Area.

There are two sightings of 11 Sowerby's beaked whales in the Study Area in the DFO sightings database for May–November (see Table 4.18; Figure 4.37). One sighting of four was made during a seismic survey in Orphan Basin in September 2005 (Moulton et al. 2006a), and the other sighting was made off the coast of Labrador during November 2013. There are also several stranding records for Newfoundland and Labrador (DFO 2016h).



Data source: DFO cetacean sightings database, see text for description and caveats associated with these data.

Figure 4.37 Toothed Whale Sightings in the Study Area during May–November (compiled from the DFO sightings database, 1947–2015).

Whitehead (2013) reported a significant increase in Sowerby's beaked whale sightings in the Gully, on the edge of the Scotian Shelf, from 1988 to 2011; 30 sightings were made in Haldimand Canyon and 12 in Shortland Canyon, near the Study Area.

Beluga Whale

Based on distinct summer distributions and genetic isolation, seven populations of beluga are recognized in Canadian waters. Although they have no status under *SARA*, the Ungava Bay and eastern Hudson Bay populations of beluga currently have *endangered* status under COSEWIC. Beluga whales are considered rare in the Study Area.

Beluga occurring offshore of Labrador likely represent either the Ungava Bay or the eastern Hudson Bay populations (COSEWIC 2004). The Ungava Bay population is too small to estimate and might have been extirpated. The eastern Hudson Bay population includes ~2,000 individuals (COSEWIC 2004). Based on the DFO cetacean sightings database, there were five beluga sightings of 35 individuals during July in the Study Area; one animal was seen in the Orphan Basin, and the others were sighted off the southeast coast of Labrador (see Table 4.18; Figure 4.37).

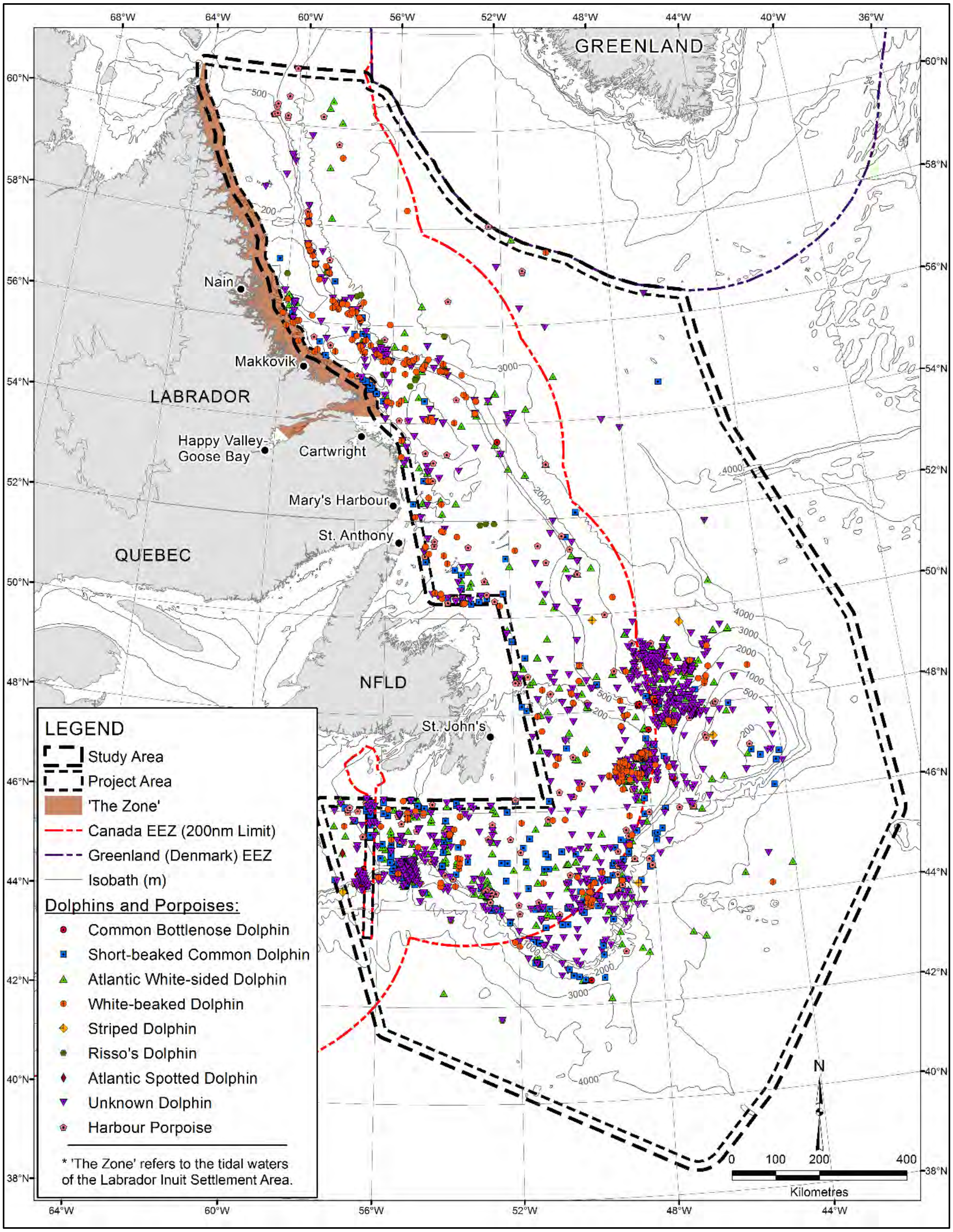
Striped Dolphin

Based on the DFO sightings database, there are 10 sightings (487 individuals) of striped dolphins in the Study Area. All sightings occurred in August and September (see Table 4.18; Figure 4.38). Mannocci et al. (2016) also reported on the occurrence of striped dolphins in deep, offshore waters of the Study Area, with highest densities generally occurring in the southern portion. Based on habitat-density modeling NOAA (2016) predicted a density of up to 68 striped dolphins/100 km^2 in the southwestern region of the Study Area.

Whitehead (2013) reported six sightings in Haldimand Canyon and six in Shortland Canyon, at the edge of the Scotian Shelf near the Study Area, during 1988–2012. Nonetheless, striped dolphins are considered rare in the rest of the Study Area.

Atlantic Spotted Dolphin

Based on the DFO sightings database, a single sighting of an Atlantic spotted dolphin was made in the Laurentian Channel within the Study Area during June 2007. Neither Whitehead (2013) nor Gomez-Salazar and Moors-Murphy (2014) reported any sightings along the edge of the Scotian Shelf near the Study Area. However, Mannocci et al. (2016) reported relatively high densities (up to 40 individuals/100 km^2) in the southern portion of the Study Area. Atlantic spotted dolphins are considered rare in the rest of the Study Area.



Data source: DFO cetacean sightings database, see text for description and caveats associated with these data.

Figure 4.38 Dolphin and Porpoise Sightings in the Study Area during May–November (compiled from the DFO sightings database, 1947–2015).

Short-beaked Common Dolphin

Based on the DFO sightings database, there are 296 sightings (5,260 individuals) of short-beaked common dolphins in the Study Area; sightings were reported in shelf, upper slope and deep-water regions (see Table 4.18; Figure 4.38). Most sightings occurred during July–September (see Table 4.18). Similarly, based on habitat-density modeling for the southwestern region of the Study Area, NOAA (2016) predicted the highest densities (~100 common dolphins/100 km^2) from June–November. Mannocci et al. (2016) presented modeled year-round densities of short-beaked common dolphins for Study Area, with higher densities in deep, offshore waters. The short-beaked common dolphin is considered common in the Study Area.

Common dolphins have been sighted along the northeastern edge of the Scotian Shelf within and near the Study Area (Gomez-Salazar and Moors-Murphy 2014). Whitehead (2013) reported nine sightings in Haldimand Canyon and 10 in Shortland Canyon, at the edge of the Scotian Shelf near the Study Area, during 1988–2012.

White-beaked Dolphin

Based on the DFO sightings database, there are 319 sightings (2,247 individuals) of white-beaked dolphins in the Study Area. Most sightings occurred during June–August (see Table 4.18; Figure 4.38). The white-beaked dolphin is considered common in the Study Area. White-beaked dolphins were sighted during surveys off the northeast coast of Newfoundland, just to the west of the Study Area, during 2000–2011 (Davoren 2013). Two rare sightings in high latitudes of the Canadian Arctic off south-eastern Baffin Island, Nunavut, have also been reported (Reinhart et al. 2014).

Atlantic White-sided Dolphin

Based on the DFO sightings database, there are 457 sightings (6,634 individuals) of white-sided dolphins in the Study Area. Sightings occurred primarily during July–September (see Table 4.18; Figure 4.38). Based on habitat-density modeling for the southwestern region of the Study Area, NOAA (2016) predicted the highest densities (up to ~10 dolphins/100 km^2) from May–December. Based on modeling by Mannocci et al. (2016), higher year-round densities likely occur in the southern portion of the Study Area. The Atlantic white-sided dolphin is considered common in the Study Area.

Atlantic white-sided dolphins were sighted during surveys off the northeast coast of Newfoundland, just to the west of the Study Area, during 2000–2011 (Davoren 2013). Atlantic White-sided dolphins have also been sighted along and off the northeastern edge of the Scotian Shelf within and near the Study Area (Gomez-Salazar and Moors-Murphy 2014). In addition, Whitehead (2013) reported four sightings in Haldimand Canyon, at the edge of the Scotian Shelf near the Study Area, during 1988–2012.

Common Bottlenose Dolphin

Two morphologically and genetically distinct stocks occur in the NW Atlantic, referred to as the coastal and offshore forms (Hoelzel et al. 1998). There are 18 bottlenose dolphin sightings (151 individuals) in the Study Area in the DFO cetacean sighting database. They occurred during May–June and August–October (see Table 4.18; Figure 4.38). Mannocci et al. (2016) also reported low densities (<6 dolphins/100 km^2) in deep, offshore waters of the southern Study Area. Based on habitat-density modeling for the southwestern region of the Study Area, NOAA (2016) predicted the highest densities (up to ~15 dolphins/100 km^2) from May–December. The common bottlenose dolphin is considered rare in the rest of the Study Area. South of Newfoundland, they have been sighted in the Laurentian Channel within the Study Area (Gomez-Salazar and Moors-Murphy 2014). In addition, Whitehead (2013) reported one sighting in Shortland Canyon, at the edge of the Scotian Shelf near the Study Area, between 1988 and 2012.

Risso's Dolphin

There are 26 sightings (78 individuals) of Risso's dolphins in the Study Area in the DFO sightings database; sightings occurred during July–August and October–November (see Table 4.18; Figure 4.38). Jefferson et al. (2014) also reported on the occurrence of Risso's dolphins off Newfoundland and Labrador and Nova Scotia. Based on habitat-density modeling for the southwestern region of the Study Area, NOAA (2016) predicted the highest densities (up to ~6.8 dolphins/100 km^2) during June–December. Mannocci et al. (2016) predicted the highest densities in the deeper, offshore waters of the Study Area. Risso's dolphins are considered rare in the Study Area. Nonetheless, Risso's dolphins have been sighted off the northeastern edge of the Scotian Shelf near the Study Area (Gomez-Salazar and Moors-Murphy 2014). Whitehead (2013) also reported one sighting in Shortland Canyon, at the edge of the Scotian Shelf near the Study Area, between 1988 and 2012.

Killer Whale

Based on the DFO sightings database, there are 180 sightings (1,206 individuals) of killer whales in the Study Area (see Table 4.18; Figure 4.37). Most sightings off Newfoundland and Labrador occurred during June–September (see Table 4.18; Lawson and Stevens 2013). High scarring rates on humpback whales indicate that killer whales may preferentially feed on marine mammals off Newfoundland (McCordic et al. 2014). Killer whales are considered uncommon in the Study Area.

Sightings of killer whales were recorded in Jeanne d'Arc Basin during seismic monitoring programs in 2008, 2013 and 2015 (Abgrall et al. 2009; Holst and Lang 2014; Keats 2015). One sighting was also recorded in the Flemish Pass during a seismic monitoring program in 2014 (Thomas et al. 2014b). In addition, killer whales were sighted off northeastern Newfoundland, just to the west of the Study Area, during 2000–2002 (Davoren 2013). At least one sighting has been made off the northeastern edge of the Scotian Shelf near the Study Area (Gomez-Salazar and Moors-Murphy 2014).

Long-finned Pilot Whale

Long-finned pilot whales are the most commonly recorded odontocete (17,098 individuals) in the Study Area in the DFO sightings database (see Table 4.18; Figure 4.37); sightings have been reported year-round but predominantly during July and August. Long-finned pilot whales are considered common in the Study Area. Mannocci et al. (2016) modeled year-round densities of pilot whales off Nova Scotia and Newfoundland and Labrador, showing the highest densities in deeper, offshore areas. Long-finned pilot whales have been sighted off the northeastern edge of the Scotian Shelf within and near the Study Area (Gomez-Salazar and Moors-Murphy 2014). In addition, Whitehead (2013) reported 15 sightings in Haldimand Canyon and 26 in Shortland Canyon, at the edge of the Scotian Shelf near the Study Area, during 1988–2012.

Harbour Porpoise

Based on the DFO sightings database, there are 182 sightings (904 individuals) of harbour porpoises in the Study Area. While sightings are reported year-round, the majority occurred from May–September (see Table 4.18; Figure 4.38). Harbour porpoises are generally considered uncommon in the offshore regions of the Study Area, although Mannocci et al. (2016) reported relatively high densities in offshore and nearshore waters of Nova Scotia and Newfoundland and Labrador. In addition, harbour porpoises were detected acoustically in the Study Area off the east coast of Newfoundland during July 2012 (Ryan et al. 2013). Sightings were also made off northeastern Newfoundland, just to the west of the Study Area, during 2000–2002 (Davoren 2013).

4.5.1.4 True Seals (Phocids)

Six seal species occur in the Study Area (see Table 4.17). Given their preference for nearshore areas, grey and harbour seals are likely to be uncommon in the Study Area. The 2014 grey seal population was estimated at 505,000 individuals (Hammill et al. 2014). The 2012 estimate for harbour seals in New England was 75,834 individuals (Waring et al. 2015). The NW Atlantic harp seal population appears to have levelled off since 2008 at ~7.4 million (Hammill et al. 2015). Declines in sea ice associated with climate change may cause harp seals to use whelping areas farther to the north (Stenson and Hammill 2014). The distributional ranges of ringed and bearded seals extend to Labrador and northern Newfoundland; however, these species are expected to be uncommon in the Study Area during the time period when seismic operations will likely occur.

Hooded seals are also likely to be uncommon in the Study Area during the summer and fall when seismic operations will likely occur. However, during spring and late fall/winter, hooded seals outfitted with satellite relay data loggers showed movements throughout the Study Area during 2004–2008 (Andersen et al. 2012, 2013, 2014). Andersen et al. (2012) suggested that hooded seals prefer areas with topographic and oceanographic conditions off the coast of Newfoundland that produce good feeding conditions. During autumn/winter, males showed greater search effort in areas with complex seabed relief, including areas in Baffin Bay, Davis Strait, and the Flemish Cap; whereas females spent more effort along the Labrador Shelf. Juveniles occurred off Labrador during autumn/winter and off the east coast of Newfoundland between the Grand Banks and the Flemish Cap during spring.

4.5.1.5 Polar Bear

Polar bears have *special concern* status under Schedule 1 of *SARA* (*SARA* website 2016) and COSEWIC (COSEWIC website 2016). However, a management plan for this species will not be available until 2018 (DFO 2016i). The size of the Davis Strait population of polar bears was estimated at 2,158 for 2007 (Peacock et al. 2013). Polar bears have been reported along the northeastern tip of Labrador between 2000 and 2010 (Rode et al. 2012). Peacock et al. (2013) also reported polar bear records for Newfoundland and Labrador, including the Study Area.

4.5.2 Sea Turtles

While four species of sea turtles have been reported in Newfoundland waters, only three are likely to occur in the Study Area. Information on the occurrence, habitat, and conservation status for the leatherback, loggerhead, and green sea turtles in the Study Area is presented in Table 4.19. The fourth species, Kemp's ridley sea turtle (*Lepidochelys kempii*), is unlikely to occur in the Study Area. The leatherback sea turtle has an *endangered* status under Schedule 1 of *SARA* and is included in § 4.6, Species at Risk. Figure 4.39 shows locations of sea turtle sightings in the Study Area, based on the DFO sightings database.

4.5.2.1 Loggerhead Sea Turtle

There are three records of loggerhead turtles in the Study Area in the DFO sightings database. Two sightings were made in the eastern part of the Study Area, near the Flemish Cap, in water depth >4,000 m during May–July, and another sighting was made during August in the Laurentian Channel (Figure 4.39). Loggerhead turtles are likely to be rare in the Study Area. Nonetheless, neonate loggerheads from Florida beaches equipped with satellite tags travelled through the southern region of the Study Area after release (Mansfield et al. 2014). Additionally, a juvenile loggerhead equipped with a satellite tag in the Canary Islands was tracked in the southern portion of the Study Area (Varo-Cruz et al. 2016).

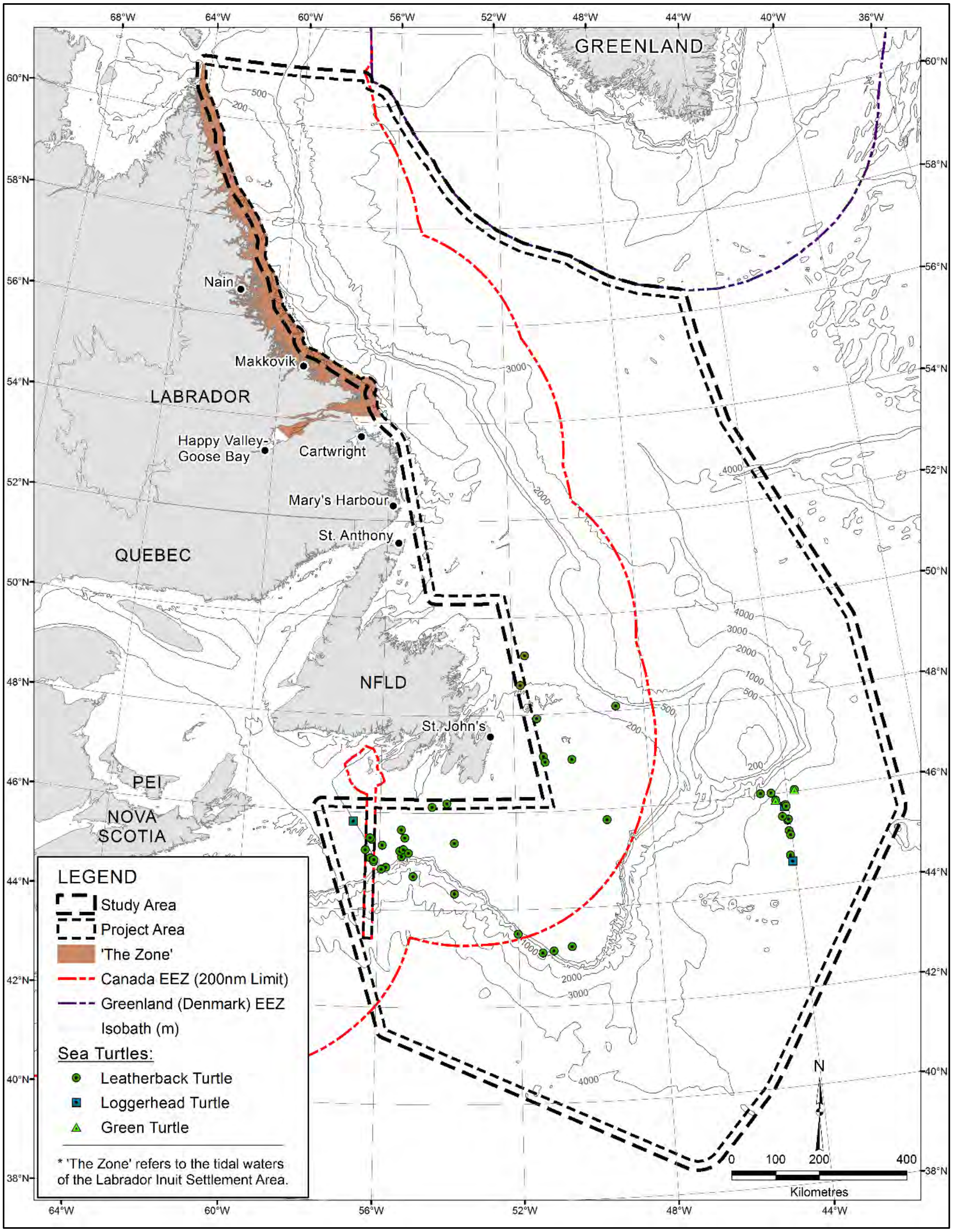
Table 4.19 Sea Turtles with Reasonable Likelihood of Occurrence in the Study Area.

Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Leatherback Sea Turtle (*Dermochelys coriacea*)	Rare	April to December	Shelf & pelagic	Schedule 1: Endangered	E
Loggerhead Sea Turtle (*Caretta caretta*)	Rare	Summer and fall	Pelagic	NS	E
Green Sea Turtle (*Chelonia mydas*)	Rare	Summer	Pelagic	NS	NC; LPC

[a] Species designation under the *Species at Risk Act* (*SARA* website 2016); NS = No Status.
[b] Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC website 2016); E = Endangered, NC = Not Considered, LPC = Low priority Candidate.

4.5.2.2 Green Sea Turtle

Green sea turtles are expected to be very rare in the Study Area. Nonetheless, there are two records of green turtles in the Study Area in July in the DFO sightings database. Both sightings were in the eastern part of the Study Area, near the Flemish Cap, in water depth >4,000 m (Figure 4.39).



Data source: DFO cetacean sightings database, see text for description of data and caveats associated with these data.

Figure 4.39 Sea Turtle Sightings in the Study Area during May–November (compiled from the DFO sightings database, 1947–2015).

4.5.3 Marine Mammal and Sea Turtle Data Gaps Identified in Relevant SEAs

The following data gap associated with the Marine Mammal and Sea Turtle VEC was identified in the Labrador Shelf SEA (§ 4.9.6 of C-NLOPB 2008).

- Distribution and abundance of marine mammals and sea turtles that occur in Labrador waters.

The following data gap associated with the Marine Mammal and Sea Turtle VEC was identified in the Eastern Newfoundland SEA (§ 6.1.6 of C-NLOPB 2014).

- Occurrence, abundance, and distribution of marine mammals and sea turtles is not available for all locations and times in the Study Area.

The following data gaps associated with the Marine Mammal and Sea Turtle VEC were identified in the Southern Newfoundland SEA (§ 3.5.7 and 3.6.4 of C-NLOPB 2010).

- Distribution and abundance of marine mammals and sea turtles;
- Potential migration routes and foraging areas of marine mammals and sea turtles are poorly understood;
- Basic life history characteristics of marine mammals and sea turtles which leads to uncertainty in the global and regional abundance estimates and population trends for many marine mammal and sea turtle species;
- Identification of marine mammal and sea turtle critical habitat; and
- Most available data on marine mammal and sea turtle species occurrence are opportunistic or incidental in nature (i.e., few directed surveys).

All of the data gaps indicated above still exist and thus limit the certainty of impact predictions made in § 5.7.7. However, opportunistic efforts are being made during seismic surveys to collect more distribution and abundance data for marine mammals and sea turtles.

4.6 Species at Risk VEC

The Species at Risk VEC has been recently described in the Labrador Shelf SEA (§ 4.2 and 4.3 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.1.7, 4.2.2.5 and 4.2.3.5 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.7 of C-NLOPB 2010), and four project-specific EAs (§ 4.6 of LGL 2014, 2015a,b, 2016). An overview of the species at risk of the Study Area, based on information from the aforementioned SEAs and EAs, along with new information, is provided below. Relevant data gaps identified in the three SEAs are also discussed in terms of current status.

4.6.1 Species at Risk within the Study Area

The *Species at Risk Act* (*SARA*) was assented to in December 2002 with certain provisions coming into force in June 2003 (e.g., independent assessments of species/populations by COSEWIC) and June 2004 (e.g., prohibitions against harming or harassing species/populations with either endangered and threatened statuses or damaging or destroying their critical habitat). Species/populations are listed under *SARA* on Schedules 1 to 3, with only those with either an *endangered* or *threatened* status under Schedule 1 having immediate legal implications. Schedule 1 is the official list of wildlife species/populations at risk in Canada. Once a species/population is designated, the measures to protect and recover that species/population are implemented. Three fish species/populations, two seabird species, four cetacean species/populations, and one sea turtle species that have potential to occur in the Study Area are legally protected under *SARA* (Table 4.20). In addition, Sowerby's beaked whale, the Atlantic population of fin whale, the polar bear, and the Atlantic wolffish have a *special concern* status under Schedule 1 of *SARA*. Schedules 2 and 3 of *SARA* identify species that have "at risk" status under COSEWIC prior to October 1999 and must be reassessed using revised criteria before they can be considered for addition to Schedule 1 of *SARA*. Species/populations that potentially occur in the Study Area and are considered at risk but have not received specific legal protection (i.e., prescribed penalties and legal requirement for recovery strategies and plans) under *SARA* are also listed in Table 4.20, as are species/populations with *endangered*, *threatened*, or *special concern* status under COSEWIC.

Under *SARA*, a 'recovery strategy' and corresponding 'action plan' must be prepared for *endangered*, *threatened* and *extirpated* species/populations. A 'management plan' must be prepared for species/populations with *special concern* status. Final recovery strategies have been prepared for eight species/populations currently with *endangered* or *threatened* statuses under Schedule 1 and the potential to occur in the Study Area: (1) the northern wolffish (Kulka et al. 2007); (2) the spotted wolffish (Kulka et al. 2007); (3) the Ivory Gull (EC 2014); (4) the blue whale (Beauchamp et al. 2009); (5) the North Atlantic right whale (Brown et al. 2009); (6) the Scotian Shelf population of the northern bottlenose whale (DFO 2010b); (7) the St. Lawrence Estuary population of beluga (DFO 2012a); and (8) the leatherback sea turtle (ALTRT 2006). The recovery strategy for the North Atlantic right whale (Brown et al. 2009) was amended in 2014 to incorporate changes made pertaining to the critical habitat of the population (DFO 2014). A management plan has been prepared for the Atlantic wolffish (Kulka et al. 2007) which currently has *special concern* status under Schedule 1 of *SARA*. A recovery strategy and management plan has been prepared for Red Knot (ECCC 2016).

Table 4.20 *SARA*- and COSEWIC-listed Marine Species with Reasonable Likelihood of Occurrence in the Study Area.

SPECIES		*SARA*[a]			COSEWIC[b]		
Common Name	**Scientific Name**	**Endangered**	**Threatened**	**Special Concern**	**Endangered**	**Threatened**	**Special Concern**
Marine Fish							
White Shark (Atlantic population)	*Carcharodon carcharias*	Schedule 1			X		
Northern Wolffish	*Anarhichas denticulatus*		Schedule 1			X	
Spotted Wolffish	*Anarhichas minor*		Schedule 1			X	
Atlantic Wolffish	*Anarhichas lupus*			Schedule 1			X
Atlantic Cod	*Gadus morhua*			Schedule 3			
Atlantic Cod (Newfoundland and Labrador population)	*Gadus morhua*				X		
Atlantic Bluefin Tuna	*Thunnus thynnus*				X		
Porbeagle Shark	*Lamna nasus*				X		
Roundnose Grenadier	*Coryphaenoides rupestris*				X		
Cusk	*Brosme brosme*				X		
Smooth Skate (Funk Island Deep population)	*Malacoraja senta*				X		
Winter Skate (Eastern Scotian Shelf-Newfoundland population)	*Leucoraja ocellata*				X		
American Eel	*Anguilla rostrata*					X	
Shortfin Mako Shark (Atlantic population)	*Isurus oxyrinchus*					X	
American Plaice (Newfoundland and Labrador population)	*Hippoglossoides platessoides*					X	
Atlantic Salmon (South Newfoundland population)	*Salmo salar*					X	
Atlantic Salmon (various populations)	*Salmo salar*				X	X	X
Acadian Redfish (Atlantic population)	*Sebastes fasciatus*					X	
Deepwater Redfish (Northern population)	*Sebastes mentella*					X	
White Hake (Atlantic and Northern Gulf of St. Lawrence population)	*Urophycis tenuis*					X	
Basking Shark (Atlantic population)	*Cetorhinus maximus*						X
Spiny Dogfish (Atlantic population)	*Squalus acanthias*						X
Roughhead Grenadier	*Macrourus berglax*						X
Thorny Skate	*Amblyraja radiata*						X
Smooth Skate (Laurentian-Scotian population)	*Malacoraja senta*						X

SPECIES		*SARA*[a]			COSEWIC[b]		
Common Name	**Scientific Name**	**Endangered**	**Threatened**	**Special Concern**	**Endangered**	**Threatened**	**Special Concern**
Marine-associated Birds							
Ivory Gull	*Pagophila eburnea*	Schedule 1			X		
Red Knot *rufa* spp.	*Calidris canutus rufa*	Schedule 1			X		
Harlequin Duck (Eastern population)	*Histrionicus*			Schedule 1			X
Barrow's Goldeneye (Eastern population)	*Bucephala islandica*			Schedule 1			X
Marine Mammals							
Blue Whale (Atlantic population)	*Balaenoptera musculus*	Schedule 1			X		
North Atlantic Right Whale	*Eubalaena glacialis*	Schedule 1			X		
Northern Bottlenose Whale (Scotian Shelf population)	*Hyperoodon ampullatus*	Schedule 1			X		
Fin Whale (Atlantic population)	*Balaenoptera physalus*			Schedule 1			X
Sowerby's Beaked Whale	*Mesoplodon bidens*			Schedule 1			X
Harbour Porpoise (Northwest Atlantic population)	*Phocoena phocoena*		Schedule 2				X
Humpback Whale (Western North Atlantic population)	*Megaptera novaeangliae*			Schedule 3			
Polar Bear	*Ursimus maritimus*			Schedule 1			X
Beluga Whale (St. Lawrence Estuary population)	*Delphinapterus leucas*		Schedule 1		X		
Beluga Whale (Eastern Hudson Bay population)	*Delphinapterus leucas*				X		
Beluga Whale (Ungava population)	*Delphinapterus leucas*				X		
Killer Whale (Northwest Atlantic/Eastern Arctic populations)	*Orcinus orca*						X
Northern Bottlenose Whale (Davis Strait-Baffin Bay-Labrador Sea population)	*Hyperoodon ampullatus*						X
Atlantic Walrus	*Odobenus rosmarus rosmarus*						X
Sea Turtles							
Leatherback Sea Turtle	*Dermochelys coriacea*	Schedule 1					
Leatherback Sea Turtle (Atlantic population)	*Dermochelys coriacea*				X		
Loggerhead Sea Turtle	*Caretta caretta*				X		

Sources: [a]*SARA* website (http://www.sararegistry.gc.ca/search/SpeciesSearch_e.cfm), accessed January 2017; [b]COSEWIC website (http://www.cosewic.gc.ca/default.asp?lang=en&n=A9DD45B7-1), accessed January 2017.

During 2016–2017, DFO plans to develop and post a recovery strategy for white shark (Atlantic population), action plans for Atlantic salmon (Inner Bay of Fundy population), beluga whale (St. Lawrence Estuary population), blue whale (Atlantic population), leatherback sea turtle (Atlantic population), north Atlantic right whale, northern bottlenose whale (Scotian Shelf population), and northern and spotted wolffish, and management plans for fin whale (Atlantic population) and Sowerby's beaked whale (DFO 2016j). A proposed management plan for the polar bear, also a species of *special concern* under Schedule 1 of *SARA*, is not expected to be available until 2018 (DFO 2016j).

MKI will monitor *SARA* issues through the Canadian Association of Petroleum Producers (CAPP), the law gazettes, the Internet and communication with DFO and Environment Canada (EC), and will adaptively manage any issues that may arise in the future. MKI will comply with relevant regulations pertaining to *SARA* Recovery Strategies and Action Plans.

MKI acknowledges the possibility of other marine species/populations receiving *endangered* or *threatened* statuses under Schedule 1 of *SARA* during the course of the Project.

4.6.2 Profiles of Marine Species/Populations with *Endangered* or *Threatened* Status under Schedule 1 of *SARA*

The statuses of all species/populations profiled below are current as of November 2016.

4.6.2.1 Fishes

Three fish species/populations have an *endangered* or *threatened* status under Schedule 1 of the *SARA*: (1) white shark (Atlantic population); (2) northern wolffish; and (3) spotted wolffish. These three species are profiled in this section. Some of the other fish species/populations that are included in Table 4.20 above (e.g., Atlantic wolffish, Atlantic cod) are profiled in § 4.2 of this EA.

White Shark

The Atlantic population of white shark currently has *endangered* status under both Schedule 1 of *SARA* and COSEWIC. This population was profiled in § 4.6.1 of LGL (2014, 2015a,b).

An adult female, 'Katharine,' originally tagged in August 2013 off Cape Cod, was present within the southern portion of the Study Area during November 2015 through February 2016 (OCEARCH website). A second adult female, 'Lydia', originally tagged in March 2013 off Jacksonville, FL, was present within the southern and eastern portions of the Study Area during December 2014 to February 2015 (OCEARCH website).

Northern and Spotted Wolffishes

Northern and spotted wolffishes currently have a *threatened* status under both Schedule 1 of *SARA* and COSEWIC. Profiles of these species are provided in § 4.6.1 of LGL (2014, 2015a,b).

During DFO RV surveys conducted in the Study Area during 2014, northern wolffish and spotted wolffish were caught primarily along the northeastern and southeastern slope areas of the Grand Banks, and on the slope and deepwater shelf areas off the southern part of Labrador. (see Figure 4.33 in § 4.3.7).

4.6.2.2 Marine-associated Birds

Two marine-associated birds have an *endangered* status under Schedule 1 of *SARA*: (1) Ivory Gull; and (2) Red Knot. These two species are profiled in this section. The remaining two bird species in Table 4.20, Harlequin Duck (eastern population) and Barrow's Goldeneye (eastern population) are profiled in § 4.6.1.10 and § 4.6.1.11 of LGL (2014), respectively.

Ivory Gull

The Ivory Gull currently has an *endangered* status under Schedule 1 of *SARA* and COSEWIC, and is profiled in § 4.6.1 of LGL (2014, 2015a,b).

Red Knot

The Red Knot currently has an *endangered* status under both Schedule 1 of *SARA* and COSEWIC. This species at risk is profiled in § 4.3.1 of C-NLOPB (2008), § 4.2.2.5 of C-NLOPB (2014), and § 3.7.2.6 of C-NLOPB (2010).

4.6.2.3 Marine Mammals and Sea Turtles

Four marine mammal and one sea turtle species/populations that have some likelihood of occurrence in the Study Area have either *endangered* or *threatened* status under Schedule 1 of *SARA*: (1) blue whale (Atlantic population); (2) North Atlantic right whale; (3) northern bottlenose whale (Scotian Shelf population); (4) beluga whale (St. Lawrence Estuary population); and (5) leatherback sea turtle. Profiles of these species are provided in this section. Some of the other marine mammal and sea turtle species/populations that are included in Table 4.20 above (e.g., Atlantic population of fin whale, Sowerby's beaked whale, polar bear) are profiled in § 4.5 of this EA

Blue Whale

The Atlantic population of blue whale currently has an *endangered* status under Schedule 1 of *SARA* and COSEWIC. This population is profiled in § 4.6.1.1 of LGL (2014) and § 4.6.1.3 of LGL (2015a,b).

There are 87 sightings (113 individuals) of blue whales in the Study Area in the DFO sightings database. Blue whales were observed during spring, summer and fall within the Study Area in the DFO sightings database, with peak numbers in July and August (see Table 4.18 in § 4.5). Sightings were made primarily in upper slope regions, particularly in the area of the St. Pierre Bank and Laurentian Channel (see Figure 4.36 in § 4.5). Blue whales are considered uncommon in the Study Area (see Table 4.17in § 4.5).

One blue whale that was tagged in the St. Lawrence Estuary in November 2014 travelled through the southwestern portion of the Study Area during March. Another individual tagged in the Gulf of St. Lawrence in September 2013 also travelled through the southwestern portion of the Study Area during October (Lesage et al. 2016). An additional blue whale that was tagged in the estuary in September 2013 was recorded along the southern Grand Banks during December where it was likely foraging (Lesage et al. 2016). Results from this study suggest that underwater seamounts and the deep ocean structures along the shelf edge may be important habitat for blue whales.

Sightings were made in and near the Study Area in the southern Laurentian Channel and south of the Grand Banks during July 2012 (Ryan et al. 2013). In addition, two sightings of blue whales were made in the Orphan Basin in August-September 2007 (Abgrall et al. 2008c), and 49 sightings (53 individuals) were made during a 3D seismic program that occurred from June–September 2005 in the Laurentian Sub-basin (Moulton et al. 2006b). Blue whales have also been sighted along the northeastern edge of the Scotian Shelf within and near the Study Area(Gomez-Salazar and Moors-Murphy 2014). Whitehead (2013) reported five sightings in Haldimand Canyon and nine in Shortland Canyon, at the edge of the Scotian Shelf near the Study Area, during 1988–2012.

North Atlantic Right Whale

The North Atlantic right whale currently has an *endangered* status under Schedule 1 of *SARA* and COSEWIC. There are at least 524 and perhaps as many as 716 catalogued individuals in the western North Atlantic (Pettis and Hamilton 2016). Profiles of this species are provided in § 4.6.1.1 of LGL (2014) and § 4.6.1.3 of LGL (2015a,b).

The North Atlantic right whale is expected to be rare in the Study Area (see Table 4.17 in § 4.5). There are two sightings of two individual right whales in the Study Area in the DFO sightings database; one was seen in June near the Flemish Cap, and the other was sighted in July off

Labrador (see Figure 4.36 in § 4.5). Right whale sightings have also been made in the Laurentian Channel, within the southwestern edge of the Study Area (Gomez-Salazar and Moors-Murphy 2014). One individual was seen off the southeastern Avalon Peninsula during July 2016, but it was outside of the Study Area (LGL, unpublished data).

Northern Bottlenose Whale

There are two genetically distinct populations of northern bottlenose whales in Canada (Dalebout et al. 2006). The Scotian Shelf population has *endangered* status under Schedule 1 of *SARA* (*SARA* website 2016) and COSEWIC (COSEWIC 2002, 2011) and is estimated to comprise 143 individuals (O'Brien and Whitehead 2013). The Davis Strait-Baffin Bay-Labrador Sea population has no status under *SARA* (*SARA* website 2016) and *special concern* status under COSEWIC (COSEWIC 2011); there is no reliable population estimate. Profiles of the northern bottlenose whale are provided in § 4.6.1.2 of LGL (2014) and 4.6.1.3 of LGL (2015a,b).

Northern bottlenose whales are expected to be rare in the Study Area (see Table 4.17in § 4.5). There are 219 sightings (925 individuals) of northern bottlenose whales in the Study Area in the DFO sightings database. These sightings occurred primarily in the deeper waters and near the shelf break (Harris et al. 2013) during March–December (see Table 4.18 and Figure 4.37 in § 4.5). Recent acoustic evidence indicates that the Scotian Shelf population remains within the Gully and adjacent submarine canyons year-round (H. Moors-Murphy, DFO Biologist, pers. comm., 18 December 2015). Northern bottlenose whales have been sighted in Haldimand and Shortland canyons, and off the northeastern edge of the Scotian Shelf within and near the Study Area (Harris et al. 2013; Gomez-Salazar and Moors-Murphy 2014).

Beluga Whale

The St. Lawrence Estuary population of beluga currently has a *threatened* status under Schedule 1 of *SARA* and an *endangered* status under COSEWIC. This population is profiled in § 3.7.3.4 of C-NLOPB (2010), and the species is profiled in § 4.3.5 of C-NLOPB (2008).

There were two beluga sightings in the Laurentian Sub-basin during June–September 2005 (Moulton et al. 2006b). There are 5 sightings (35 individuals) of beluga whales in the Study Area in the DFO sightings database. These were made during July off the eastern end of the Strait of Belle Isle and in the Sackville Spur area (see Table 4.18 and Figure 4.37 in § 4.5). Beluga whales are expected to be rare in the southern portion of the Study Area and uncommon to common in the northern portion.

Leatherback Sea Turtle

The leatherback sea turtle currently has an *endangered* status under Schedule 1 of *SARA*. Additionally, the Atlantic population of leatherbacks currently has an *endangered* status under

COSEWIC. Profiles of this species/population of leatherback sea turtle are provided in § 4.6.1.4 of LGL (2015a,b).

Leatherback sea turtles are considered rare in the Study Area (see Table 4.17 in § 4.5). Nonetheless, there are 46 sightings (up to 59 individuals) of leatherback turtles within the Study Area in the DFO sightings database (see Figure 4.39 in § 4.5). The majority of sightings were made in the southwestern Study Area and during the month of July, but records were reported from May–November. There was also a sighting of a leatherback turtle in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). Leatherback turtles outfitted with satellite telemetry tags and vessel-based sightings have been reported near and within the Study Area mainly off northern Nova Scotia and southern Newfoundland (DFO 2012b; Howard 2012; Stewart et al. 2013; Dodge et al. 2014; Archibald and James 2016).

Recent efforts in Atlantic Canadian waters have yielded new insight into the foraging and movements of leatherback sea turtles using both satellite telemetry and camera tags, providing footage of leatherbacks searching for, capturing and handling their prey (from the turtle's perspective). This footage revealed that this species finds their prey by entirely visual means, and feeds only during daylight hours, predominantly within the top 30 m of the water column (DFO 2016k).

4.6.3 Data Gaps associated with the Species at Risk VEC

The following data gaps associated with the Species at Risk VEC were identified in the Labrador Shelf SEA (§ 4.2.12, and § 4.3.10 of C-NLOPB 2008):

- Species range, seasonal distribution and stock structure/population size;
- Migration routes, breeding grounds, feeding areas and overall life history/ecology for marine mammals, leatherback turtles, wolffishes and birds;
- Identification of critical habitat, behaviour of critical life stages and effects of ongoing human activities on species and their habitat are data deficient;
- Mortality rates, including ship strikes for whales; and
- Impacts of climate.

No data gaps associated with the Sensitive Areas VEC were specified in the Eastern Newfoundland SEA (§ 5.4.8 of C-NLOPB 2014). However, the following general data gaps identified in § 6.1.6 of the SEA (C-NLOPB 2014) are applicable to the Sensitive Areas VEC:

- Fish and fish habitat in deep water beyond the continental slope, particularly for currently non-commercially important species;
- Presence, abundance and spatial and temporal distribution of marine mammals, sea turtles, fishes, invertebrates (including deep-sea corals and sponges) and seabirds throughout eastern offshore Newfoundland and Labrador; and

- Biologically-essential behaviour for marine mammals along with associated locations and time.

The following data gaps associated with the Species at Risk VEC were identified in the Southern Newfoundland SEA (§ 3.7.6 of C-NLOPB 2010):

- Migration routes, breeding grounds, feeding areas, and seasonal distribution;
- Biological and ecological information, including critical habitat, behaviour of critical life stages, inter-species relationships and the effects of ongoing human activities; and
- Marine mammal hearing capabilities, and understanding of sound exposure characteristics and intensity that result in hearing or behavioural changes.

All of the above data gaps still exist. Any new information that has been made available since the three SEAs were completed and for areas that were beyond the scope of the SEAs is noted throughout § 4.2, 4.4 and 4.5.

These data gaps limit the assessment of potential interactions between the Project and the Species at Risk VEC until updated species distributional information is available and there is an improved understanding of essential behaviour(s) and reaction to sound exposure. MKI will revise assessments as needed if new data become available, and will incorporate any necessary revisions into future EA Updates.

4.7 Sensitive Areas VEC

The Sensitive Areas VEC of the Study Area has been recently described in the Labrador Shelf SEA (§ 4.11 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.4 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.8 of C-NLOPB 2010), and four project-specific EAs (§ 4.7 of LGL 2014, 2015a,b, 2016). An overview of the sensitive areas of the Study Area, based on information from the aforementioned SEAs and EAs along with new information, is provided below. Relevant data gaps identified in the three SEAs are also discussed in terms of current status.

4.7.1 Sensitive Areas associated with the Study Area

Sensitive areas which occur either entirely or partially within the Study Area are as follows (see Figure 4.40):

- Fourteen NAFO coral/sponge fishery closure areas, and the 3O Coral Protection Zone;
- Four seamount fishery closure areas: (1) Orphan Knoll Seamount; (2) Newfoundland Seamount; (3) Fogo Seamount 1; and (4) Fogo Seamount 2;

- Eleven NL Shelves Bioregion Ecologically and Biologically Significant Areas (EBSAs): (1) Grey Islands; (2) Hamilton Inlet; (3) Hopedale Saddle; (4) Labrador Marginal Trough; (5) Labrador Slope; (6) Nain Area; (7) Northern Labrador; (8) Notre Dame Channel; (9) Orphan Spur; (10) Outer Shelf Nain Bank; and (11) Outer Shelf Saglek Bank;
- Seven Placentia Bay-Grand Banks Large Ocean Management Area (LOMA) EBSAs: (1) Laurentian Channel and Slope; (2) Lilly Canyon-Carson Canyon; (3) Northeast Shelf and Slope; (4) Southeast Shoal and Tail of the Banks; (5) Southwest Shelf Edge and Slope; (6) St. Pierre Bank; and (7) Virgin Rocks;
- Five Scotian Shelf Bioregion EBSAs: (1) Eastern Shoal; (2) Laurentian Channel Cold Seep Communities; (3) Laurentian Channel Slope; (4) Scotian Slope; and (5) Stone Fence and Laurentian Environs;
- DFO Laurentian Channel Area of Interest;
- Bonavista Cod Box;
- Coral protection zone off northern Labrador that was established voluntarily by the fishing industry;
- Two candidate National Marine Conservation Areas: (1) Nain Bight; and (2) Hamilton Inlet;
- Hawke Channel;
- Funk Island Deep;
- Gannet Islands Ecological Reserve;
- 'The Zone';
- Three Important Bird Areas (IBAs): (1) Seven Islands Bay; (2) Quaker Hat Island; and (3) Gannet Islands;
- Two Marine Protected Areas (MPAs): (1) Gilbert Bay; (2) Milne Seamount Complex (IUCN and UNEP-WCMC 2016);
- *Lophelia* Coral Conservation Area (DFO 2015c); and
- A study area associated with an ongoing seismic-snow crab ESRF study in the Carson Canyon area. The 70-km radius 'no-go' zone around the control and treatment stations are in effect during August–October 2017 (Corey Morris, DFO, pers. comm., February 2017)

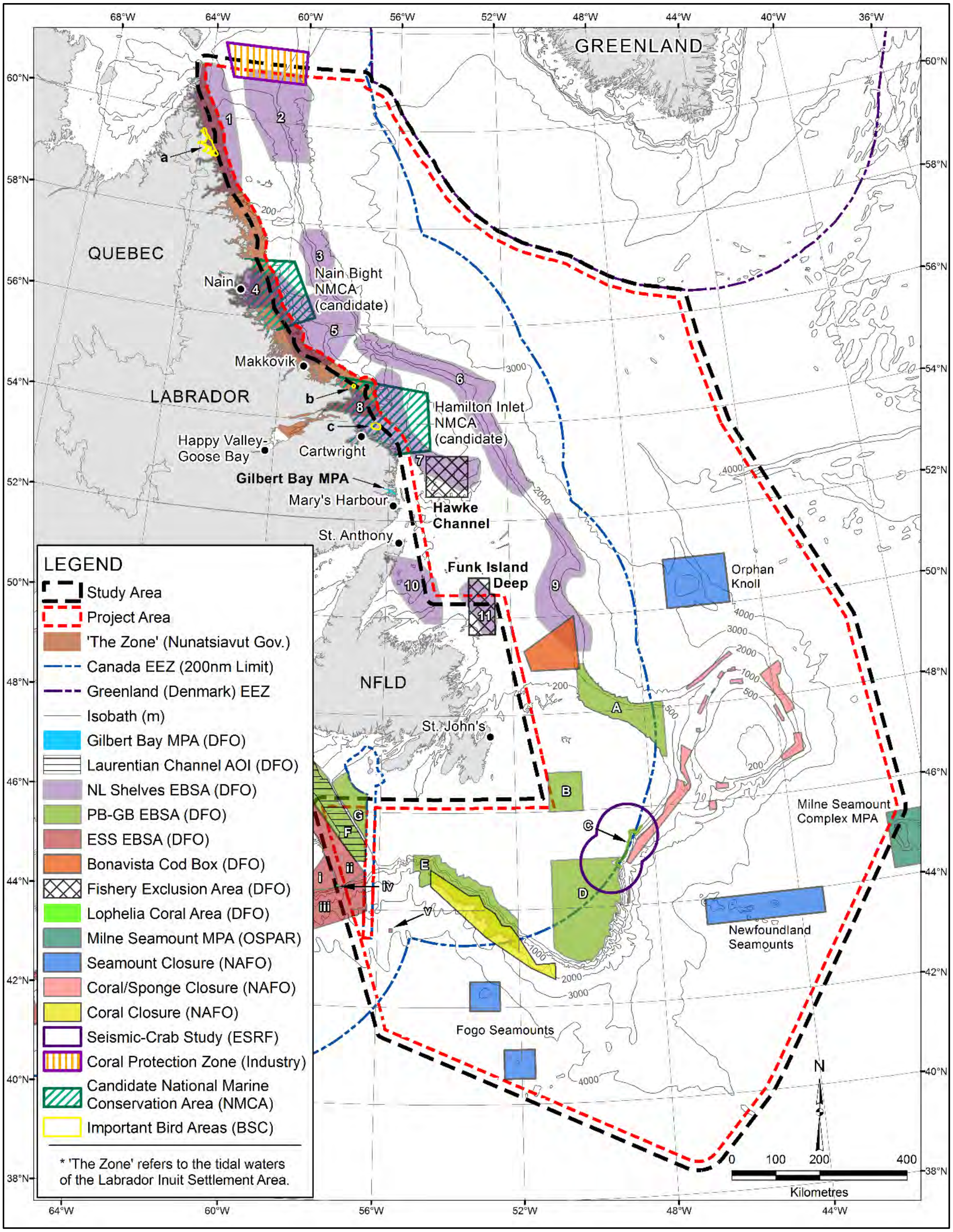


Figure 4.40 Location of Sensitive Areas that Overlap the MKI Study Area.

The Milne Seamount Complex MPA (Milne), which encompasses an area of 20,914 km^2, is a component of the Oil Spill Prevention, Administration and Response (OSPAR) Network of MPAs (MPAtlas n.d.; OSPAR 2015). Designated in 2010 with the goal to "protect and conserve the biodiversity and ecosystems of the seabed and superjacent waters of the site," Milne consists of near-pristine oceanic seamount ecosystems (OSPAR 2010; MPAtlas n.d.), including coral gardens, deep-sea sponge aggregations, *Lophelia pertusa* reefs and seamounts (OSPAR 2016). This MPA serves as habitat for numerous species of marine fishes, mammals, sea turtles and seabirds, including orange roughy (*Hoplostethus atlanticus*), gulper shark (*Centrophorus granulosus*), leafscale gulper shark (*Centrophorus squamosus*), Portuguese dogfish (*Centroscymnus coelolepis*), sperm whale (*Physeter macrocephalus*), leatherback sea turtle (*Dermochelys coriacea*) and Cory's Shearwater (*Calonectris diomedea*) (OSPAR 2016). No area within Milne has been closed to bottom fisheries or exploratory/extraction activities of non-living resources (OSPAR 2015, 2016).

The Southeast Shoal of the Grand Bank has been recommended and proposed for MPA designation since the early 2000s (Coughlan 2002; Fuller and Myers 2004). This highly productive area consists of a relatively shallow and sandy plateau where numerous species of fishes (e.g., redfishes, tunas, halibuts, flounders, wolffishes, sand lance, grenadiers, skates and sharks), invertebrates (e.g., northern shrimp, snow crab, ocean quahog [*Arctica islandica*] and Arctic surf clam [*Mactromeris polynyma*]), marine mammals (e.g., blue, north Atlantic right, minke, fin, humpback, sperm, northern bottlenose, killer and pilot whales, bottlenose, Atlantic white-sided, white-beaked and common dolphins, and harbour porpoise) and seabirds (e.g., Black-legged Kittiwake, murres, Dovekie, gulls, petrels, skuas, shearwaters, jaegers, Northern Fulmar and Northern Gannet) congregate to feed and breed (Coughlan 2002; Fuller and Myers 2004; Hoyt 2011). The Southeast Shoal, the only known offshore spawning site for capelin (an important forage species), represents habitat for several species of deep-sea coral and offshore relict populations of blue mussel (*Mytilus edulis*) and wedge clam (*Donax* sp.), a key seasonal foraging area for cetaceans (especially humpback whales), and part of the migratory pathway for leatherback and loggerhead sea turtles (Fuller and Myers 2004; Hoyt 2011). The Southeast Shoal also provides nursery habitat for several commercially-important species, including Atlantic cod, American plaice and yellowtail flounder (Fuller and Myers 2004).

The *Lophelia* Coral Conservation Area, established by DFO in June 2004, consists of a 15 km^2 area surrounding the only known living *Lophelia pertusa* colonies on Canada's Atlantic coast (DFO 2015c). This area, located at the Stone Fence southeast of Cape Breton, NS, is closed to all bottom fisheries with the goal of protecting the reef complex from further damage and allowing for recovery (DFO 2015c).

4.7.2 Data Gaps associated with the Sensitive Areas VEC

The following data gaps associated with the Sensitive Areas VEC were identified in the Labrador Shelf SEA (§ 4.7.1, § 4.11.2.1, § 4.11.4.1, § 4.11.5.2 and § 4.11.9.1 of C-NLOPB 2008):

- Mapping of deep-sea coral distribution and diversity;
- Understanding deep-sea coral and sponge ecology, life history and ecological role(s);
- Impacts of fishing on deep-sea coral communities in Canadian waters;
- Species distributions, life histories, migrations, habitat preference and critical habitats within the candidate National Marine Conservation Areas;
- Complete details regarding spawning, nursery areas, migrations and species distributions within Gilbert Bay, including which species are resident, migratory or seasonal;
- Effect of climate change on species distribution and ecosystems, including offshore areas and IBAs;
- Locations of enhanced production and/or foraging aggregations for marine mammals and seabirds within Hawke Channel and other banks off Labrador;
- Spawning, nursery areas, migrations and species distribution for various banks off Labrador, including Hamilton, Nain and Saglek Banks;
- Understanding the interactions between ecosystems offshore Labrador and other areas, such as the Grand Banks;
- Dated data for various IBAs in Labrador; and
- Species distribution and abundance for certain IBAs in Labrador;

No data gaps associated with the Sensitive Areas VEC were specifically identified in the Eastern Newfoundland SEA (§ 5.4.8 of C-NLOPB 2014). However, the same data gaps identified from the SEA for the Species at Risk VEC (see § 4.6) are applicable to the Sensitive Areas VEC.

The following data gaps associated with the Sensitive Areas VEC were identified in the Southern Newfoundland SEA (§ 3.8.8 of C-NLOPB 2010):

- Detailed delineation of special areas, their relative importance and their eventual legal status; and
- Future uncertainty regarding special areas, some of which overlap biologically, geographically and jurisdictionally.

All of the data gaps indicated above still exist, although there have been data updates regarding deep-sea coral and sponge distribution (see § 4.2.1.2), and the Government of Canada has recently committed to "establishing a more systematic approach to MPA planning and establishment," "enhance collaboration for management and monitoring of MPAs," "increase awareness, understanding and participation of Canadians in the MPA network," and "link Canada's network of MPAs to continental and global networks" (DFO 2016l). Any new information that has been made available since the three SEAs were completed and for areas that were beyond the scope of the SEAs is noted throughout § 4.2.

The above data gaps constrain the assessment of potential interactions between the Sensitive Areas VEC and the Project, owing particularly to the limited ecological and distributional knowledge of various species which utilize these areas. MKI will continue to monitor for updated information, including the modification of existing and the establishment of new Sensitive Areas in the vicinity of the Study Area, and include newly available data in future EA Updates.

5.0 Effects Assessment

The various aspects of the effects assessment methodology have been recently described in the MKI Labrador Sea EA (§ 5.0 of LGL 2014), WesternGeco Eastern Newfoundland EA (§ 5.0 of LGL 2015a), WesternGeco Southeastern Newfoundland EA (§ 5.0 of LGL 2015b) and Seitel East Coast Offshore EA (§ 5.0 of LGL 2016).

Two general types of effects are considered in this document:

1. Effects of the environment on the Project; and
2. Effects of the Project on the environment, particularly the biological environment.

5.1 Scoping

The C-NLOPB provided a Final Scoping Document (C-NLOPB 2017; dated January 24, 2017) for the Project which outlined the factors to be considered in the assessment. In addition, various stakeholders were contacted for input (see § 5.1.1 below). Another aspect of scoping for the effects assessment involved reviewing relevant SEAs (C-NLOPB 2008, 2010, 2014) and EAs (LGL 2014, 2015a,b, 2016).

5.1.1 Consultations

5.1.1.1 MKI's Consultation Approach

MKI's approach to consultation on marine seismic projects is to, whenever possible, consult (primarily through in-person meetings) with relevant agencies, stakeholders and rights-holders (e.g., beneficiaries) during the pre-survey and survey stages. MKI will initiate meetings and respond to requests for meetings with the interested groups throughout this period. After the survey is complete MKI will conduct follow-up communications. The same approach would be followed before, during and after any survey work conducted in 2017–2026. In summary, each year MKI will consult with stakeholders before the survey is permitted, during survey activities, and after survey completion as outlined below.

- Before the survey is permitted: provide Project information, gather information about area fisheries, determine issues or concerns, and discuss communications and mitigation measures, and discuss potential solutions;
- During survey activities: provide forward looking acquisition plans for discussion in a weekly meeting, communicate current and projected vessel positions every 12 hours via email, maintain communication with active stakeholders to ensure concerns are addressed rapidly; and
- After the survey is completed: provide an update on the Project, discuss any issues that arose, and present results of the MMO and FLO reports.

The in-person meetings included the direct participation of MKI's Marine Shore Manager.

5.1.1.2 Program Consultations

Consultations were held with groups in both St. John's and at various locations in Labrador in January and February 2017. More face-to-face consultation meetings will be held in Labrador in March 2017. Results of the meetings in March will be included in the Addendum to this EA.

St. John's

Stakeholder groups in St. John's that were initially contacted by email are listed below.

- Environment Canada (EC);
- Nature Newfoundland and Labrador (NNL);
- One Ocean;
- Fish, Food and Allied Workers Union (FFAW)/Unifor;
- Association of Seafood Producers (ASP);
- Ocean Choice International (OCI);
- Groundfish Enterprise Allocation Council (GEAC) Ottawa;
- Canadian Association of Prawn Producers;
- Clearwater Seafoods;
- Icewater Fisheries; and
- Newfound Resources Ltd. (NRL).

The face-to-face consultations held in St. John's were organized and coordinated by MKI. Those that requested face-to-face meetings are indicated below. Topics raised at each meeting after the MKI presentation are bulleted below.

Environment Canada (31 January 2017)

- Source array ramp up protocol was explained;
- MARPOL reporting was clarified;
- After-dark lighting on Project vessels was described; and
- Provided details on a typical acquisition season and how weather affects operations.

FFAW/Unifor (31 January 2017)

- Discussion about the post-season snow crab survey, particularly regarding the addition of sampling stations.

Newfound Resources Ltd. (2 February 2017)

- Shrimp harvesting season is complete by the time of onset of seismic activity.

One Ocean (2 February 2017)

- No details from the meeting.

Nature Newfoundland and Labrador (2 February 2017)

- Question about minimizing the level of light being emitted during seismic operation – MKI indicated that lighting on the outside of the seismic vessel is limited to navigation lights and lights in the back deck work areas;
- Question about the effectiveness of source ramp-up to motivate marine mammals to move away from the sound source – MKI indicated that data collected thus far indicates that marine mammals are observed farther from the sound source when it is active than when it is inactive; and
- Request that MKI make metadata collected during seismic operations available for metocean research – MKI indicated that it would look into what archived metadata are available for release.

MKI intends to provide more details about its 2017 activities to all consultees once they are finalized in March 2017.

More details regarding the St. John's consultations in late January/early February 2017 are included in the full consultation report in Appendix 1.

Labrador

Stakeholder groups in Labrador that were initially contacted by either email or phone in January 2017 are listed below.

- Cartwright Town Council;
- Town of Charlottetown;
- Labrador Choice Seafoods Inc., Charlottetown;
- Forteau Town Council;
- Town of Happy Valley-Goose Bay (HV-GB);
- NunatuKavut Community Council, HV-GB;
- Nunacor Development Corporation, HV-GB;
- Torngat Fish Producers Co-operative Society Inc., HV-GB;
- Torngat Secretariat, HV-GB;

- Town of L’Anse au Loup;
- Labrador Fishermen’s Union Shrimp Company Ltd., L’Anse au Loup;
- Town of Mary’s Harbor;
- Mary’s Harbour Fishers’ Committee, Mary’s Harbour;
- Nunatsiavut Government (Department of Lands and Natural Resources), Nain;
- Nain Inuit Community Government, Nain;
- Town of North West River;
- Community of Pinsent’s Arm;
- Town of Port Hope Simpson;
- Sheshatshiu First Nation Innu Band Council; and
- Innu Nation, Sheshatshiu.

The face-to-face consultations held in Mary’s Harbour and HV-GB in late January were organized and coordinated by LGL. Topics raised at each meeting after the MKI presentation are bulleted below.

Labrador Fishermen’s Union Shrimp Company Ltd. (24 January 2017)

- General concern about the Hawke Channel DFO Fisheries Closure Area.

Mayor of Mary’s Harbour (24 January 2017)

- General concern about the Hawke Channel DFO Fisheries Closure Area.

Mary’s Harbour Public Information Session (24 January 2017)

- General concern about the Hawke Channel DFO Fisheries Closure Area;
- Comment that an area in the northern part of the Project Area has concentration of corals and could become a marine sensitive area; and
- Discussion about the potential effects of seismic sound on fishes.

Torngat Secretariat (25 January 2017)

- Many questions regarding Marine mammal Observers, particularly from the perspective of possible employment.

Torngat Fish Co-op (26 January 2017)

- Most discussion focused on the commercial fishery (shrimp, turbot) and how to minimize interaction between the fishery and the seismic operations.

Happy Valley-Goose Bay Public Information Session (26 January 2017)

- Effects of seismic sound on marine life;
- Frequency range of seismic sound;
- How is something determined to be ‘environmentally-sensitive;
- What sensitive areas have been identified?

Innu Nation (27 January 2017)

- Questions about the size of the marine mammal/sea turtle safety zone; and
- Questions about employment opportunities.

MKI intends to provide more details about its 2017 activities to all Labrador consultees once they are finalized in March 2017.

More details regarding the Labrador consultations in late January 2017 are included in the full consultation report in Appendix 1.

5.1.1.3 Consultation Follow-Up

As described above, MKI will conduct follow-up discussions with all interested groups during and after the survey. This would include reporting on the progress of the survey, monitoring the effectiveness of the mitigations, determining if any survey-related issues had arisen, and presenting monitoring results.

5.2 Valued Environmental Components

The VEC approach was used to focus the assessment on those biological resources of most potential concern and value to society. Descriptions of these VECs are provided in § 5.2 of LGL (2014, 2015a,b, 2016).

5.3 Boundaries

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

5.3.1 Temporal

The temporal boundaries of the Project are May 1 to November 30, 2017–2026.

5.3.2 Spatial

5.3.2.1 Project Area

The 'Project Area' is defined as the area within the C-NLOPB jurisdiction where seismic data could be acquired and all vessel movements with deployed equipment will occur (see Figure 1.1). The coordinates of the Project Area (WGS84, unprojected geographic coordinates) are provided in § 2.1.

5.3.2.2 Affected Area

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

5.3.2.3 Study Area

The 'Study Area' is an area larger than the Project Area that encompasses routine potential effects reported in the literature. The coordinates of the Study Area (WGS84, unprojected geographic coordinates) are provided in § 2.1.

5.3.2.4 Regional Area

The 'Regional Area' is an area larger than the Study Area and is typically used when assessing cumulative effects.

5.4 Effects Assessment Procedures

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

1. Preparation of interaction matrices (i.e., interactions of Project activities and the environment);
2. Identification and evaluation of potential effects, including description of mitigation measures and residual effects; and
3. Preparation of residual effects summary tables, including evaluation of cumulative effects.

More details on the effects assessment procedures are provided in § 5.4 of LGL (2014, 2015a,b, 2016).

5.5 Mitigation Measures

The effects assessments that follow (see § 5.7) consider the potential effects of the proposed Newfoundland offshore seismic program in light of the specific mitigation measures that will be applied during this Project. The purpose of these measures is to eliminate or reduce the potential effects on VECs. MKI recognizes that the careful and thorough implementation of, and adherence to, these measures will be critical for ensuring that the Project does not result in unacceptable environmental consequences.

This section details the various measures that will be established and applied for this Project. Collectively, they are based on several sources, including:

- Discussions and advice received during consultations for this Project (§ 5.1.1 and Appendix 1), and for other relevant EAs;
- The C-NLOPB Final Scoping Document (C-NLOPB 2017), and the Environmental Planning, Mitigation and Reporting guidance in Appendix 2 of the Board's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2016);
- DFO's *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment;*
- National and international acts, regulations or conventions, such as the *Fisheries Act* and Regulations, *International Convention for the Prevention of Pollution from Ships* (MARPOL), and International Maritime Organization (IMO) standards;
- Other standards and guidance, such as the One Ocean *Protocol for Seismic Survey Programs in Newfoundland and Labrador* (One Ocean 2013);
- Industry best practices; and
- Expert judgement/experience from past surveys.

Proposed mitigations are organized under the following principal categories:

- Survey layout and location;
- Communications and liaison;
- Fisheries avoidance;
- Fishing gear damage program;
- Marine mammal, sea turtle, and seabird monitoring and mitigation; and
- Pollution prevention and emergency response.

Several of the mitigation measures listed under these categories are designed to mitigate potential effects on more than one VEC (e.g., seismic array ramp-up/soft start can deter marine mammals and fish). Table 5.1 summarizes the measures by VEC and type of effect. These measures will be adhered to during each survey year, with necessary adjustments based on monitoring and follow-up.

Table 5.1 Summary of Mitigations Measures by Potential Effect.

Potential Effects	Primary Mitigations
Interference with fishing vessels/mobile and fixed gear fisheries	• Pre-survey communications, liaison and planning to avoid fishing activity • Continuing communications throughout the program • FLOs • SPOC • Advisories and communications • VMS data • Avoidance of actively fished areas • Start-up meetings on ships that discuss fishing activity and communication protocol with fishers
Fishing gear damage	• Pre-survey communications, liaison and planning to avoid fishing gear • Use of escort vessel • SPOC • Advisories and communications • FLOs • Compensation program • Reporting and documentation • Start-up meetings on ships that discuss fishing activity, communication protocol with fishers, and protocol in the event of fishing gear damage
Interference with shipping	• Advisories and at-sea communications • FLOs (fishing vessels) • Use of escort vessel • SPOC (fishing vessels) • VMS data
Interference with DFO/FFAW research program	• Communications and scheduling • 7-day/30-km temporal/spatial avoidance protocol
Temporary or permanent hearing damage/disturbance to marine animals (marine mammals, sea turtles, seabirds, fish, invertebrates)	• Pre-watch (30 minute) of 500 m safety zone • Delay start-up if any marine mammals or sea turtles are within 500 m • Ramp-up of airguns • Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m • Use of experienced, qualified MMO(s) to monitor for marine mammals and sea turtles during all daylight periods when airguns are in use and the 30-minutes preceding ramp up
Temporary or permanent hearing damage/ disturbance to Species at Risk or other key habitats	• Pre-watch (30 minute) of 500 m safety zone • Delay start-up if any marine mammals or sea turtles are within 500 m • Ramp-up of airguns • Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m • Use of experienced, qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations. [No critical habitat has been identified in or near the Study Area.]
Injury (mortality) to stranded seabirds	• Daily search of seismic and support vessels • Implementation of handling and release protocols • Minimize lighting if safe
Seabird oiling	• Adherence to MARPOL • Adherence to conditions of CWS migratory bird permit • Spill contingency and response plans • Use of solid streamer

There will be full opportunity for adaptive mitigation during MKI's proposed 10-year program. If there are any new techniques developed during the 10-year period that may help to further mitigate environmental effects, they will be investigated and incorporated into the program if deemed useful. Annual updates of the EA that will be prepared during the 10-year scope of the Project will include any relevant new information related to mitigation not provided in the EA.

Details of the seven mitigation categories are provided in § 5.5 of LGL (2014, 2015a,b, 2016).

5.5.1 Summary of Mitigation Measures

Table 5.1 summarizes mitigation measures by potential effect on the VECs.

5.6 Effects of the Environment on the Project

The physical environment is summarized in § 3.0 of this EA and the reader is referred to this section to assist in determining the effects of the environment on the Project. Furthermore, safety issues are assessed in detail during the permitting and program application processes established by the C-NLOPB. Nonetheless, effects on the Project are important to consider, at least on a high level, because they may sometimes cause effects on the environment. For example, accidental spills may be more likely to occur during rough weather.

Given the Project time window of May 1 to November 30 for seismic operations and the requirement of a seismic survey to avoid periods and locations of sea ice, sea ice should have little or no effect on the Project (see § 3.4.1). Icebergs in the spring and early summer may cause some survey delays if tracks have to be altered to avoid them (see Table 3.19 and Figure 3.10 in § 3.4.2). Within the Project time frame, icebergs may require the vessels to detour in May and June when almost 45% of the yearly total of icebergs are expected to occur, based on monthly iceberg distribution data (see Table 3.19 in § 3.4.2).

Most environmental constraints on seismic surveys on the Grand Banks are those imposed by wind and wave conditions. If the Beaufort wind scale is seven or greater, there is generally too much noise for seismic data to be of use. A Beaufort wind scale of seven is equivalent to wind speeds of 33 knots (13.9–17.1 m/s), and is associated with wave heights ranging from 4.0–5.5 m. In the Study Area, these conditions are not uncommon in the late autumn and winter months. If the sea state exceeds 3.0 m or wind speed exceeds 40 kt (20.6 m/s), then continuation/termination of seismic surveying will be evaluated. Based on multi-year data at eight grid points in the Study Area (see Figure 3.1 in § 3.2), these wave limits are typically approached during the October–April period.

Poor visibility can constrain helicopter operations and streamer repair. It also may hinder sightings of other vessels and fishing gear. These constraints are alleviated somewhat by state of the art forecasting, and the use of radar and FLOs to detect fishing vessels and gear.

The Project scheduling avoids most of the continuous extreme weather conditions. Seismic vessels typically suspend surveys once wind and wave conditions reach certain levels because the ambient noise affects the data. They also do not want to damage towed gear which would cause costly delays.

Environmental effects on other Project vessels (e.g., escort and supply vessels) are likely less than on the seismic vessel which is constrained by safety of towed gear and data quality issues.

Effects of the biological environment on the Project are unlikely although there are accounts of sharks attacking and damaging streamers.

The Department of National Defense (DND) records indicate that there are at least 27 shipwrecks and five legacy sites present within the Study Area. Due to the inherent dangers of associated UXO and the fact that the northwest Atlantic Ocean was exposed to many naval engagements during WWII, any suspected UXO encountered during the course of the operations will be geo-referenced, immediately reported to the Coast Guard, and left undisturbed.

Effects of the environment on the Project are predicted to be *not significant* for the reasons discussed above.

5.7 Effects of the Project Activities on the Environment

This effects assessment is organized so that issues generic to any type of ship activity in the Study Area (e.g., seismic operations vessels, fisheries vessels, DFO research vessels, military ships, marine transporters) are discussed first. The detailed effects assessment that follows focuses on the effects of noise (primarily on marine mammals, fish and fisheries) from the airgun array(s) and the towed seismic streamers (primarily on fishing gear), which is the major distinction between the effects of seismic surveys versus those of other marine vessels. The applicable mitigation measures (§ 5.5) are also noted for the relevant activity. The detailed assessment includes the generic effects in the ratings and predictions tables but does not discuss these generic issues in any detail.

5.7.1 Generic Activities - Air Quality

The atmospheric emissions from Project activities will be those from the Project vessels' engines, generators, and incinerators. Project atmospheric emissions will be within the range of emissions from typical marine vessels on the east coast, such as fishing, research, or offshore supply vessels. As such, there will be no particular health or safety concerns associated with Project emissions.

Given that the Project will use low sulphur content (no more than 1%) fuel (following Canadian 2012 ECA regulations) and that it will add negligible atmospheric emissions (relative to total northwest Atlantic ship traffic) to a windy oceanic environment, there will be no measureable adverse effect on air quality or human health in the Project Area.

5.7.2 Generic Activities - Marine Use

Project-related traffic will include one seismic survey vessel and one escort vessel. A supply vessel will not necessarily be required in all instances. The seismic and support vessels will operate within the Project Area (see Figure 1.1), except when transiting to or from the survey area. The seismic and/or support vessels may operate occasionally to and from the Project Area for re-provisioning, re-fuelling, and crew changes.

Other ships operating in the area could include freighters, tankers, fishing vessels, research vessels, naval vessels, and private yachts. Mitigation measures (detailed in § 5.5) intended to minimize potential conflicts and any adverse effects with other vessels include the following.

- At sea communications (VHF, HF, Satellite, radar etc.);
- Utilization of FLOs for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- Support vessel to alert other vessels of towed gear in water;
- Posting of advisories with the Canadian Coast Guard and the CBC Fisheries Broadcast;
- Compensation program in the event any project vessels damage fishing gear; and
- Single Point of Contact (SPOC).

MKI will also coordinate with DFO, St. John's, to avoid any potential conflicts with research vessels that may be operating in the area. Given the expected number of vessels in the Project Area and mitigation measures described above, there should be *negligible* adverse effects on other marine users of the Project Area.

5.7.3 Generic Activities - Waste Handling

Project waste will be generated by about 55–85 personnel. Waste will include the following.

- Gray/black water;
- Galley waste; and
- Solid waste.

Vessel discharges will not exceed those of standard vessel operations and will adhere as a minimum to all applicable regulations and applicable international standards. The main discharges include grey water (wastewater from washing, bathing, laundry, and food preparation), black water (human wastes), bilge water, deck drainage and discharges from machinery spaces. Wastes produced from the seismic and support vessels, including hazardous and non-hazardous waste material, will be managed in accordance with MARPOL and with the vessel specific waste management plans.

Waste produced by the Project will be handled and treated appropriately and, therefore, will have *negligible* effect on the environment in the Project Area.

5.7.4 Fish and Fish Habitat VEC

Despite the certainty of interaction between Project activities and the 'fish habitat' component of the Fish and Fish Habitat VEC (i.e., water and sediment quality, phytoplankton, zooplankton, and benthos) (Table 5.2), the residual effects are predicted to be *negligible* and *not significant*. The seismic program will not result in any direct physical disturbance of the bottom substrate. Also, there is a very low probability of any accidental event (i.e., hydrocarbon release) large enough to cause a significant effect on fish habitat. Therefore, other than its inclusion in Table 5.2, no further reference to the 'fish habitat' component of the Fish and Fish Habitat VEC is made in this assessment subsection. Note that ichthyoplankton, invertebrate eggs and larvae, and macrobenthos are considered part of the 'fish' component of the Fish and Fish Habitat VEC.

Table 5.2 Potential Interactions of the Project Activities and the Fish and Fish Habitat VEC.

Valued Environmental Component: Fish and Fish Habitat							
Project Activities	Non-Biological Environment	Feeding		Reproduction		Adult Stage	
	Water and Sediment Quality	Plankton	Benthos	Eggs and Larvae	Juveniles [a]	Pelagic Fish	Groundfish
Sound							
Airgun Array (2D, 3D and 4D)		X	X	X	X	X	X
Seismic Vessel		X	X	X	X	X	X
Supply Vessel		X	X	X	X	X	X
Escort Vessel		X	X	X	X	X	X
Helicopter							
Echo Sounder						X	
Side Scan Sonar						X	
Vessel Lights		X				X	
Vessel/Equipment Presence							
Seismic Vessel and Equipment							
Supply Vessel							
Escort Vessel							
Sanitary/Domestic Waste	X	X		X		X	
Atmospheric Emissions	X	X		X		X	
Garbage [b]							
Helicopter Presence							
Shore Facilities [c]							
Accidental Releases	X	X	X	X	X	X	X
Other Projects and Activities in Regional Area							
Oil and Gas Activities	X	X	X	X	X	X	X
Fisheries	X	X	X	X	X	X	X
Marine Transportation	X	X	X	X	X	X	X

[a] Juveniles are young fish that are no longer planktonic and are often closely associated with the sea bottom.
[b] Not applicable as garbage will be brought ashore.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

5.7.4.1 Sound

The potential effects of exposure to airgun sound on invertebrates and fishes can be categorized as either physical (includes both pathological and physiological) or behavioural. Pathological effects include lethal and sub-lethal damage; physiological effects include temporary primary and secondary stress responses; and behavioural effects refer to deviations from normal behavioural activity. Physical and behavioural effects are very likely related in some instances and should therefore not be considered as completely independent of one another.

Information related to interactions between underwater sound and invertebrates and fishes is available in § 5.7.4 and Appendices 2 and 3 of the MKI project-specific Labrador Sea EA (LGL 2014), WesternGeco Eastern Newfoundland EA (LGL 2015a), and the WesternGeco Southeastern Newfoundland EA (LGL 2015b); § 5.1.2 of the Labrador Shelf SEA (C-NLOPB 2008), § 5.1 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 5.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010). Topics in these subsections and appendices include sound detection and production by marine invertebrates and fishes, and the potential effects of exposure to underwater sound, particularly seismic airgun sound, on marine invertebrates and fishes.

The assessment in this subsection is structured such that the reader should first refer to the interactions table (e.g., Table 5.2) to determine the interactions of the Fish and Fish Habitat VEC with project activities, secondly to the assessment table (e.g., Table 5.3) which contains criteria ratings, including those for magnitude, geographic extent, and duration, and thirdly to the significance predictions table (e.g., Table 5.4).

Sound Exposure Effects Assessment

It is not practical to assess in detail the potential effects of every type of sound on every species in the Study Area. The best approach in environmental assessment is to provide focus by selecting (1) the sound source with the highest sound level, in this case the seismic airgun sound, and (2) example species that are both representative of the different types of sensitivities to underwater sound and have been scientifically studied with respect to interaction with underwater sound (e.g., snow crab and Atlantic cod).

The primary factors considered in the assessment include (1) distance between airgun array and animal under normal conditions (post-larval snow crabs remain on bottom, post-larval cod occur in the water column, and larvae of both snow crab and cod are planktonic in upper water column), (2) motility of the animal (post-larval snow crabs are much less motile than post-larval cod, and larvae of both are essentially passive drifters), (3) absence or presence of a swim bladder (i.e., auditory sensitivity) (snow crabs without swimbladder and cod with swimbladder), and (4) reproductive strategy (snow crabs carry fertilized eggs at the bottom until larval hatch, and cod eggs are planktonic).

Potential effects on other marine invertebrate and fish species are inferred from the assessment using snow crab and Atlantic cod as representative species of the Fish and Fish Habitat VEC. Potential interactions between the proposed Project activities and the Fish and Fish Habitat VEC are shown in Table 5.2.

Although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, several data gaps remain (Hawkins et al. 2015).

Physical and Physiological Effects

Available experimental data suggest that there may be physical effects on the fertilized eggs of snow crab and on the egg, larval, juvenile and adult stages of cod at very close range (Booman et al. 1996; Christian et al. 2003; Sierra-Flores et al. 2015). Considering the typical source levels associated with commercial seismic airgun arrays, an invertebrate or fish close to the source could be exposed to very high sound levels. While egg and larval stages are unable to actively move away from the sound source, juvenile and adult cod can. Developing embryos, juvenile and adult snow crab are benthic and generally far enough from the sound source to receive energy levels well below levels that may have an effect. However, there remains a lack of knowledge regarding exposure of benthic organisms to substrate vibration and energy waves associated with the water-substrate interface and substrate. In the case of eggs and larvae, it is likely that the numbers negatively affected by exposure to seismic sound would be negligible when compared to those succumbing to natural mortality (Saetre and Ona 1996). Atlantic cod do have swim bladders and are therefore generally more sensitive to underwater sounds than fishes without swim bladders. Spatial and temporal avoidance of critical life history events (e.g., unique spawning aggregations, particularly in terms of location) and ramp-up of the airgun array should theoretically mitigate the population-level effects of exposure to airgun sound.

Particle motion is the component of underwater acoustic stimuli generated partly by hydrodynamic flow near the acoustic stimulus source and partly by the oscillations associated with the sound pressure waves as they propagate from the acoustic source as a cyclic compression and rarefaction of water molecules (Higgs et al. 2006). Snow crab, thought to be sensitive to the particle motion component of sound only (Popper et al. 2001) will be a considerable distance from the airguns and will not likely be affected by any particle motion in the water column resulting from airgun discharge. However, as stated above, there is a lack of knowledge regarding exposure of benthic organisms to substrate vibration and energy waves associated with the water-substrate interface and substrate.

Limited data regarding physiological effects on fish and invertebrates suggest that these effects are both short-term and most obvious after exposure at close range. The physical effects of exposure to sound with frequencies >500 Hz are *negligible*, based on the available information from the scientific literature. Effects of exposure to <500 Hz sound and marine vessel sound appear to be primarily behavioural and somewhat temporary.

A more comprehensive discussion regarding the physical and physiological effects of exposure to seismic sound on fishes is contained in the appendices of recently completed seismic EAs (e.g., LGL 2015a,b).

Behavioural Effects

Studies suggest that effects on fish behaviour due to exposure to airgun sound are temporary in nature, and that response thresholds for various demersal and pelagic species are quite variable. Numerous studies have reported startle/alarm responses by fish (Pearson et al. 1992; Fewtrell and McCauley 2012). Pearson et al. (1992) also reported observations of localized distributional shifts, tightening of schools, and random movement and orientation. Løkkeborg et al. (2012) reported differences between species in terms of catchability after being exposed to seismic sound. They observed higher catches in gill nets but lower catches on baited hooks, possibly resulting from increased random movement by the fish causing a higher incidence of fish being caught up in gill nets but a lower incidence of fish targeting baited hooks. There is some thought that the degree of behavioural response by fishes to exposure to anthropogenic sounds such as seismic airgun sound depends on what natural behaviour the fish is exhibiting at the time of exposure. For example, fish exhibiting reproductive and/or feeding behaviour may have a higher response threshold to anthropogenic sound than fish exhibiting migratory behaviour. More study is required to test this hypothesis.

A more comprehensive discussion regarding the behavioural effects of exposure to seismic sound on fishes is contained in the appendices of recently completed seismic EAs (e.g., LGL 2015a,b).

New Literature

Recently published review papers related to the potential effects of exposure to anthropogenic sound on invertebrates and fishes include Aguilar de Soto (2016), Carroll et al. (2016) and Edmonds et al. (2016). Another recently-published paper by Hawkins and Popper (2016) provides a recommended approach to assessing the impact of underwater noise on marine fishes and invertebrates. Hawkins and Popper (2016) point out the existing hurdles that limit one's ability to assess these impacts with more certainty.

A recently released report on a study conducted in Tasmanian waters during 2013–2015 (Day et al. 2016) describes the results of exposure of captive adult southern rock lobsters (*Jasus edwardsii*), including berried females, and adult commercial scallops (*Pecten fumatus*) to seismic sound in a field setting. Sound measurement instrumentation was deployed throughout the experimentation to record both sound pressure and ground borne vibration. The number of airgun pulses per exposure replicate for the lobster and scallop experiments ranged from 110–126, and 51–167, respectively. The lobsters were exposed to two types of passes: (1) a control pass of a non-operating airgun; and (2) a pass of an operating airgun. The scallops were exposed to four types of passes: (1) a control pass of a non-operating airgun; (2) one pass of an operating airgun; (3) two passes of an operating airgun; and (4) four passes of an operating airgun. Maximum received SEL_{cum} for the lobster experiments ranged from 192–199 dB re 1 µ$Pa^2 \cdot$ s, while maximum received SEL_{cum} for the scallop experiments ranged from 189–198 dB re 1 µ$Pa^2 \cdot$ s. Various parameters for the lobsters were measured at four sampling times between Day 0 (exposure day) and Day 120 (120 days post-exposure). Some lobsters were assessed at 365 days post-exposure. Various parameters for the scallops were measured at three sampling times between Day 0 and Day 120.

The key findings of Day et al. (2016) during the lobster experiments include:

1. No mortality observed;
2. Two reflexes, tail extension and righting, showed responses following exposure to airgun sound. Tail extension was reduced in lobsters exposed during the lone summer exposure for 14 days, and righting was compromised in three of the four exposure experiments and persisted to 120 days post-exposure in all experiments and to 365 days post-exposure in the one experiment conducted for that duration;
3. Damage to the statocyst sensory hairs was observed in lobsters exposed in three of the four experiments;
4. Haemolymph biochemistry showed little effect from exposure;
5. Counts of the number of circulating haemocytes showed a significant reduction in all four experiments; and
6. Embryos exposed to airgun sound and subsequently hatched showed neither qualitative nor quantitative effects.

The key findings of Day et al. (2016) during the scallop experiments include:

1. Acute mass mortality was not observed but repeated exposure significantly increased mortality. The risk of mortality increased with time, based on the fact that the majority of mortality was recorded at the Day 120 sample points;
2. Substantial disruptions in haemolymph biochemistry were observed. A range of electrolytes, minerals and metabolites showed disrupted levels through to Day 120 post-exposure;
3. Haemolymph pH was affected in two of the three experiments. A slight but persistent alkalosis was observed at Day 14 post-exposure;
4. Scallops demonstrated a reduction of classic behaviours during exposure. In addition, it seemed that airgun exposure elicited a novel velar flinch behaviour; and
5. Scallop reflexes were affected, with exposures resulting in faster recessing times and some indication that righting time was reduced.

Day et al. (2016) concluded that until the full scope of these observed changes and their ecological effects are thoroughly investigated, caution must be taken against extrapolating the results of this study. This study's results provide further direction for subsequent research.

Assessment of Effects of Exposure to Sound

Table 5.3 provides the details of the assessment of the effects of exposure to Project-related sound on the Fish and Fish Habitat VEC, including appropriate mitigation measures. As indicated in Table 5.3, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual effects on the Fish and Fish Habitat VEC that are *negligible* to *medium* in magnitude for a duration of *<1 month* to *1– 12 months* over a geographic area of *<1* to *101–1,000 km²*. If two seismic vessels are operating concurrently, then the geographic area rating will be *<1* to *1,001–10,000 km²*. Based on these criteria ratings, the *reversible* residual effects of sound associated with MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.4). The level of confidence associated with this prediction is *medium* (Table 5.4).

5.7.4.2 Effects Assessment of other Routine Project Activities

Vessel Lights

As indicated in Tables 5.2 to 5.4, vessel lights may attract plankton and pelagic fishes towards the upper water column. However, seismic vessels are typically travelling at a high enough rate so that the attraction effect is not spatially static. Therefore, the overall effect of vessel lights on the Fish and Fish Habitat VEC is somewhat neutral. Therefore, the effects of vessel lights associated with MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.4). The level of confidence associated with this prediction is *medium* to *high* (Table 5.4).

Table 5.3 Assessment of Effects of Project Activities on the Fish and Fish Habitat VEC.

Valued Environmental Component: Fish and Fish Habitat								
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Environmental Effects					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Sound								
Airgun Array (2D, 3D and 4D)	Physical effects (N); Disturbance (N)	Ramp-up of array; Spatial & temporal avoidance	0-2	1-4[a]	6	1-2	R	2
Seismic Vessel	Disturbance (N)	Spatial & temporal avoidance	0-1	1-2	6	1-2	R	2
Supply Vessel	Disturbance (N)	Spatial & temporal avoidance	0-1	1-2	1	1	R	2
Escort Vessel	Disturbance (N)	Spatial & temporal avoidance	0-1	1-2	6	1-2	R	2
Echo Sounder	Disturbance (N)	Spatial & temporal avoidance	0-1	1	6	1	R	2
Side Scan Sonar	Disturbance (N)	Spatial & temporal avoidance	0-1	1	6	1	R	2
Vessel Lights	Attraction (Neutral)	-	-	-	-	-	-	-
Sanitary/Domestic Waste	Pathological effects (N); Contamination (N)	Treatment	0	1	4	1-2	R	2
Atmospheric Emissions	Pathological effects (N); Contamination (N)	Equipment maintenance	0	1	6	1-2	R	2
Accidental Releases	Pathological effects (N); Contamination (N)	Prevention protocols; Response plan	0-1	1-2	1	1	R	2

Key:

Magnitude:
0 = Negligible
1 = Low
2 = Medium
3 = High

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

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

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

Geographic Extent:
1 = < 1-km^2
2 = 1-10-km^2
3 = 11-100-km^2
4 = 101-1,000-km^2
5 = 1,001-10,000-km^2
6 = > 10,000-km^2

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

[a] If two seismic vessels are operating concurrently in the Project Area, then the geographic extent rating associated with seismic sound will be '1-5'

Table 5.4 Significance of Potential Residual Environmental Effects of Project Activities on the Fish and Fish Habitat VEC.

Valued Environmental Component: Fish and Fish Habitat				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood[a]	
	Significance Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D)	NS	2-3	-	-
Seismic Vessel	NS	2-3	-	-
Supply Vessel	NS	2-3	-	-
EscortVessel	NS	2-3	-	-
Echo Sounder	NS	2-3	-	-
Side Scan Sonar	NS	2-3	-	-
Vessel Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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
2 = Medium
3 = High

[a] Considered only in the case where 'significant negative effect' is predicted.

Sanitary/Domestic Waste

Table 5.3 provides the details of the assessment of the effects of exposure to Project-related sanitary and domestic waste on the Fish and Fish Habitat VEC, including appropriate mitigation measures. As indicated in § 5.7.3, appropriate treatment of wastes produced by the Project will result in residual effects that are *negligible* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* km^2 (see Table 5.3). Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic wastes produced during MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.4). The level of confidence associated with this prediction is *high* (see Table 5.4).

Atmospheric Emissions

Table 5.3 provides the details of the assessment of the effects of exposure to Project-related atmospheric emissions on the Fish and Fish Habitat VEC, including appropriate mitigation measures. As indicated in § 5.7.1, atmospheric emission levels produced by the Project will be similar to those produced by other marine vessels not directly related to the Project. Residual effects of Project-related atmospheric emissions will be *negligible* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* km^2. Based on these criteria ratings, the *reversible* residual effects of atmospheric emissions produced during MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.4). The level of confidence associated with this prediction is *high* (see Table 5.4).

Accidental Releases

Planktonic invertebrate and fish eggs and larvae are less resistant to effects of contaminants than are adults because they are not physiologically equipped to detoxify them or to actively avoid them. In addition, many eggs and larvae develop at or near the surface where hydrocarbon exposure may be the greatest (Rice 1985). Generally, fish eggs appear to be highly sensitive at certain stages and then become less sensitive just prior to larval hatching (Kühnhold 1978; Rice 1985). Larval sensitivity varies with yolk sac stage and feeding conditions (Rice et al. 1986). Eggs and larvae exposed to high concentrations of hydrocarbons generally exhibit morphological malformations, genetic damage, and reduced growth. Damage to embryos may not be apparent until the larvae hatch. The natural mortality rate in fish eggs and larvae is extremely high and very large numbers would have to be destroyed by anthropogenic sources before effects would be detected in an adult population (Rice 1985).

There is an extensive body of literature regarding the effects of exposure to hydrocarbons on juvenile and adult fish. Although some of the literature describes field observations, most refers to laboratory studies. Reviews of the effects of hydrocarbons on fish have been prepared by Rice et al. (1986), Armstrong et al. (1995), Payne et al. (2003) and numerous other authors. If exposed to hydrocarbons in high enough concentrations, fish may suffer effects ranging from direct physical effects (e.g., coating of gills and suffocation) to more subtle physiological and behavioural effects. Actual effects depend on a variety of factors such as the amount and type of hydrocarbon, environmental conditions, species and life stage, lifestyle, fish condition, degree of confinement of experimental subjects, and others.

As indicated in Table 5.2, there are potential interactions of accidental releases and components of the Fish and Fish Habitat VEC that occur near surface. The effects of hydrocarbon spills on marine invertebrates and fish have been discussed and assessed in numerous recent environmental assessments of proposed offshore drilling programs and assessments have concluded that the residual effects of accidental hydrocarbon releases on the Fish and Fish Habitat VEC are predicted to be *not significant*. With proper mitigation measures in place (see Table 5.3), the residual effects of an accidental release associated with MKI's proposed seismic program on the Fish and Fish habitat VEC would be *negligible* to *low* in magnitude for a duration of *<1 month* over an area of *<1* to *1–10* km^2 (see Table 5.3). Based on these criteria ratings and consideration that the probability of accidental hydrocarbon releases during the proposed seismic program are low, the *reversible* residual effects of accidental releases associated with MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.4). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.4).

5.7.5 Fisheries VEC

The potential interactions of the Project activities and the Fisheries VEC are indicated in Table 5.5. DFO and joint DFO/Industry Research Surveys are included in the assessment of the Fisheries VEC.

Table 5.5 Potential Interactions of Project Activities and the Fisheries VEC.

Valued Environmental Component: Fisheries			
Project Activities	**Mobile Invertebrates and Fishes (fixed [e.g., gillnet] and mobile gear [e.g., trawls])**	**Sedentary Benthic Invertebrates (fixed gear [e.g., crab pots])**	**Research Surveys (mobile gear-trawls; fixed gear-crab pots)**
Sound			
Airgun Array (2D, 3D and 4D)	X	X	X
Seismic Vessel	X	X	X
Supply Vessel	X	X	X
EscortVessel	X	X	X
Helicopter			
Echo Sounder	X		
Side Scan Sonar	X		X
Vessel Lights			
Vessel/Equipment Presence			
Seismic Vessel/Gear	X	X	X
Supply Vessel	X	X	X
Escort Vessel	X	X	X
Sanitary/Domestic Waste	X	X	X
Atmospheric Emissions			
Garbage[a]			
Helicopter Presence			
Shore Facilities[b]			
Accidental Releases	X	X	X
Other Projects and Activities in Regional Area			
Oil and Gas Activities	X	X	X
Marine Transportation	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b] There will not be any new onshore facilities. Existing infrastructure will be used.

Behavioural changes relating to catchability of commercial species, and conflict with harvesting activities, fishing gear and lost fishing time have been raised as potential issues either during consultations and issues scoping for this assessment (§ 5.1.1) or during consultations for recent EAs for offshore Labrador and eastern and southern offshore Newfoundland (e.g., § 5.1.1 of LGL 2016). Conflicts between seismic vessels and associated gear and fishing activities/gear have occurred in the past in Atlantic Canada when seismic vessels were operating in areas with high levels of fishing activity. This is particularly relevant in relation to fixed gear, such as crab pots and gillnets within the Study Area. Other potential sources of interference from seismic activities may include temporal and spatial conflicts with DFO and DFO/Industry research surveys if both are being conducted concurrently in the same general area, and an accidental release of petroleum hydrocarbons, which may result in tainting (or perceived tainting) and affect product quality and marketing.

The primary means of mitigating potential impacts on the Fishery VEC is to avoid active fishing areas, particularly fixed gear zones. For the commercial fisheries, compensation for damaged gear provides a means of final mitigation of impacts, in the event a conflict occurs (e.g., accidental contact of fishing gear with the survey airgun array, seismic vessel or streamers). Information regarding mitigation measures, including those associated with the Fisheries VEC, is provided in § 5.5.

The document *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2016) provides guidance aimed at minimizing any impacts of petroleum industry geophysical surveys on commercial fish harvesters and other marine users. The mitigations provided below are also relevant to DFO and joint DFO/Industry research surveys. Development of the guidelines was based on best practices applied during previous geophysical surveys in Atlantic Canada, as well as guidelines from other national jurisdictions.

The following subsections assess the potential effects of Project activities on the Fisheries VEC.

5.7.5.1 Sound

The potential for impacts on fish harvesting are dependent on the location and timing of the surveying activities in relation to fishing areas, and the type of fishing gear used in any given season. If the survey work is situated away from active fishing areas or occurs at different times, the likelihood of any impacts on commercial harvesting will be greatly reduced.

The DFO and joint DFO/Industry research surveys are also conducted using fishing gear. As such, the issues related to potential interference with DFO and joint DFO/Industry research surveys are much the same as for commercial fish harvesting (i.e., potential effects on catch rates and conflicts with research vessel operations).

Potential effects on marine fish behaviour are assessed in § 5.7.4.1. While adult fish could be injured by airgun sound if they are within a few metres of a sound source, this is unlikely since fish may disperse during array ramp-up or vessel approach. Therefore, the most likely type of effect will be behavioural. Seismic surveys could cause reduced trawl and longline catches during and following a survey if the fish exhibit behavioural changes (e.g., horizontal and vertical dispersion). There are various research studies on this subject as discussed in § 5.7.4.1. While some of the behavioural effects studies report decreases in catch rates near seismic survey areas, there is some disagreement on the duration and geographical extent of the effect.

Mitigations are discussed in § 5.5. The primary measures intended to minimize the effects of Project activities on the Fisheries VEC include:

- Good communication between the Operator and fishers/researchers;
- Spatial and temporal avoidance of areas where concentrated fishing is occurring; and
- Deployment of at least one FLO on each seismic vessel.

It is imperative that detailed temporal and spatial information regarding seismic and fishing/research surveying operations be exchanged between the various parties. This will allow the establishment of temporal and spatial separation plan, as has been successfully done with DFO Newfoundland and Labrador in past seasons. With application of the mitigation measures indicated in § 5.5 and above, the residual effects of Project-related sound (airgun array sound being the worst-case scenario) on the Fisheries VEC are predicted to have a *negligible* to *low* magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *101–1,000* km^2 (Table 5.6). Based on these criteria ratings, the *reversible* residual effects of sound associated with MKI's proposed 2D/3D/4D seismic program on the Fisheries VEC are predicted to be *not significant* (Table 5.7). The level of confidence associated with this prediction is *medium* to *high* (Table 5.7).

Table 5.6 Assessment of Effects of Project Activities on the Fisheries VEC.

Valued Environmental Component: Fisheries								
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Environmental Effects					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Sound								
Airgun Array (2D, 3D and 4D)	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0-1	1-4	6	1-2	R	2
Seismic Vessel	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	6	1-2	R	2
Supply Vessel	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	1	1	R	2
Escort Vessel	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	6	1-2	R	2
Echo Sounder	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	6	1	R	2
Side Scan Sonar	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	6	1	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Conflict with gear (N)[a]	FLO; communication	0-1	1-3	6	1-2	R	2
Supply Vessel	Conflict with gear (N)[a]	FLO; communication	0-1	1-3	1	1	R	2
Escort Vessel	Conflict with gear (N)[a]	FLO; communication	0-1	1-3	6	1-2	R	2
Sanitary/Domestic Wastes	Taint (N); Perceived taint (N)	Treatment	0-1	1	4	1-2	R	2
Accidental Releases	Taint (N); Perceived taint (N)	Preventative protocols; response plan; communications	0-1	1-2	1	1	R	2

Key:

Magnitude:
0 = Negligible
1 = Low
2 = Medium
3 = High

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

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

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

Geographic Extent:
1 = < 1-km^2
2 = 1-10-km^2
3 = 11-100-km^2
4 = 101-1,000-km^2
5 = 1,001-10,000-km^2
6 = > 10,000-km^2

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

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

Table 5.7 Significance of Potential Residual Environmental Effects on the Fisheries VEC.

Valued Environmental Component: Fisheries				
Project Activity	**Significance Rating**	**Level of Confidence**	**Likelihood[a]**	
	Significance of Predicted Residual Environmental Effects		**Probability of Occurrence**	**Scientific Certainty**
Sound				
Airgun Array (2D, 3D and 4D)	NS	2-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Echo Sounder	NS	2-3	-	-
Side Scan Sonar	NS	2-3	-	-
Vessel/Equipment Presence				
Seismic Vessel (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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

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

[a] Considered only in the case where 'significant negative effect' is predicted.

5.7.5.2 Vessel/Equipment Presence

Commercial fish harvesting activities occur throughout the May–November temporal scope period for the proposed Project. Fishing with fixed gear (e.g., pot fishery for snow crab, and to a lesser extent the yellowtail flounder and Greenland halibut gillnet fisheries) poses the highest potential for conflict. During 2D/3D/4D seismic surveying, operations will be conducted continuously unless weather or technical issues cause interruptions. The length of the seismic streamers (maximum of 12,000 m) used during MKI's seismic operations during 2017–2026 will restrict the maneuverability of the seismic vessel, such that other mobile vessels must give way. As already noted in the EA, the turning radius required between each track line extends the assessment area beyond the actual survey area. Gear deployment will be conducted within the Project Area only. If conflict events occur resulting in gear damage or loss, compensation will be paid.

Mitigations relevant to Fisheries VEC are discussed in § 5.5. Mitigations measures intended to minimize the effects of vessel and equipment presence on the Fisheries VEC include:

- Good communication between the Operator and fishers/researchers;
- Spatial and temporal avoidance of areas where concentrated fishing is occurring;
- Deployment of at least one FLO on each seismic vessel;
- Single Point of Contact (SPOC); and
- Compensation for gear damage and/or loss.

With application of the mitigations discussed in § 5.5 and above, the residual effects of vessel and equipment presence on the Fisheries VEC are predicted to have a *negligible* to *low* magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *11–100* km^2 (see Table 5.6). Based on these criteria ratings, the *reversible* residual effects of vessel/gear presence associated with MKI's proposed 2D/3D/4D seismic program on the Fisheries VEC are predicted to be *not significant* (see Table 5.7). The level of confidence associated with this prediction is *high* (see Table 5.7).

5.7.5.3 Sanitary/Domestic Wastes

As indicated in § 5.7.3, appropriate treatment of wastes produced by the Project will result in residual effects that are *negligible* to *low* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* km^2 (see Table 5.6). Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic wastes produced during MKI's proposed 2D/3D/4D seismic program on the Fisheries VEC are predicted to be *not significant* (see Table 5.7). The level of confidence associated with this prediction is *high* (see Table 5.7).

5.7.5.4 Accidental Releases

In the event of an accidental release of hydrocarbons (e.g., fuel spill), there is the possibility of the perception of tainting of invertebrate and fish resources in the proximity of a release, even if there is no actual tainting. Perception alone can have economic effects if the invertebrates and fish lose marketability. Preventative measures/protocols, response plans and good communications are essential mitigations to minimize the effects of any accidental hydrocarbon release. In the event of a release, the length of time that fish are exposed is a determining factor in whether or not their health is substantially affected or if there is an actual or perceived tissue tainting. Any effect on access to fishing grounds would be of relatively short duration. In the unlikely event of a substantial hydrocarbon release, the need of compensation for commercial fishers will be determined through the C-NLOPB's Guidelines (C-NLOPB 2016).

With application of the mitigations discussed above, the residual effects of accidental hydrocarbon releases on the Fisheries VEC are predicted have a *negligible* to *low* magnitude for a duration of *<1 month* over a geographic area of *<1* to *1–10* km^2 (see Table 5.6). Based on these criteria ratings, the *reversible* residual effect of accidental releases associated with MKI's proposed 2D/3D/4D seismic program on the Fisheries VEC is predicted to be *not significant* (see Table 5.7). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.7).

5.7.6 Marine-associated Bird VEC

All potential interactions of the Project activities and the Marine-associated Bird VEC are indicated in Table 5.8. The routine Project activity that has the highest probability of affecting marine-associated birds is 'vessel lights'.

Table 5.8 Potential Interactions between Project Activities and the Marine-associated Bird VEC.

Project Activities	Valued Environmental Component: Marine-associated Birds
Sound	
Airgun Array (2D, 3D and 4D)	X
Seismic Vessel	X
Supply Vessel	X
Escort Vessel	X
Helicopter	X
Echo Sounder	X
Side Scan Sonar	X
Vessel Lights	X
Vessel/Equipment Presence	
Seismic Vessel and Equipment	X
Supply Vessel	X
Escort Vessel	X
Sanitary/Domestic Waste	X
Atmospheric Emissions	X
Garbage[a]	
Helicopter Presence	X
Shore Facilities[b]	
Accidental Releases	X
Other Projects and Activities in Regional Area	
Oil and Gas Activities	X
Fisheries	X
Marine Transportation	X

[a] Not applicable as garbage will be brought ashore.
[b] There will not be any new onshore facilities. Existing infrastructure will be used.

5.7.6.1 Sound

The effect of exposure to anthropogenic underwater sound on birds has not been well studied. Subsections 5.8.6.4 of LGL (2014) and 5.7.6.1 of LGL (2015a), and LGL (2015b) describe the interaction between birds and sound.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related sound on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* to *low* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *1–10 km^2*. Based on these criteria ratings, the *reversible* residual effects of sound associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (Table 5.10). The level of confidence associated with this prediction is *medium* to *high* (Table 5.10).

5.7.6.2 Vessel Lighting

Artificial lighting on ships at sea, offshore oil and gas drilling and production structures, coastal communities, and oceanic island communities is known to interact with marine-associated birds (see Table 5.8) and has often been implicated in the stranding of nocturnally-active seabirds and nocturnally-migrating land- and water-birds (Montevecchi et al. 1999; Gauthreaux and Belser 2006; Montevecchi 2006; Ronconi et al. 2015). Subsections 5.8.6.1 of LGL (2014) and 5.7.6.2 of LGL (2015a,b) describe the interaction between birds and artificial light.

Bird attraction to artificial lighting at sea may be mitigated in a variety of ways. Recovering grounded seabirds and returning them to sea after their plumage has sufficiently dried greatly reduces mortality (Telfer et al. 1987; Le Corre et al. 2002; Abgrall et al. 2008b; Rodríguez and Rodríguez 2009; EC 2015b). Reducing, shielding or eliminating skyward radiation from artificial lighting also appears to reduce the number of stranded birds (Reed et al. 1985; Rodríguez and Rodríguez 2009; Miles et al. 2010). A preliminary study of the effect of replacing white and red lights with green lights on an offshore natural gas production platform suggested that there was a reduction in the number of nocturnally-migrating birds attracted to the artificial lighting (Poot et al. 2008).

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related vessel lighting on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, artificial light produced by the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *11–100 km^2*. Based on these criteria ratings, the *reversible* residual effects of artificial light associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (Table 5.10). The level of confidence associated with this prediction is *medium* to *high* (Table 5.10).

Table 5.9 Assessment of Potential Effects of Project Activities on the Marine-associated Bird VEC.

Valued Environmental Component: Marine-associated Birds								
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Environmental Effects					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Sound								
Airgun Array (2D, 3D and 4D)	Disturbance (N)	Ramp up of array	0-1	1-2	6	1-2	R	2
Seismic Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Supply Vessel	Disturbance (N)		0	1	1	1	R	2
Escort Vessel	Disturbance (N)		0	1	6	1-2	R	2
Helicopter	Disturbance (N)		0-1	2	1	1	R	2
Echosounder	Disturbance (N)		0-1	1	6	1	R	2
Side Scan Sonar	Disturbance (N)		0-1	1	6	1	R	2
Vessel Lights	Attraction (N)	Reduce lighting (if possible); Monitoring; Seabird handling and release	1	1-3	2-3	1-2	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0	1-3	6	1-2	R	2
Supply Vessel	Disturbance (N)		0	1	1	1	R	2
Escort Vessel	Disturbance (N)		0	1	6	1-2	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment	0	1	4	1-2	R	2
Atmospheric Emissions	Air Contaminants (N)	Equipment maintenance	0	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1-2	R	2
Accidental Releases	Mortality (N)	Solid streamer; spill response	1-2	1-2	1	1	R	2

Key:

Magnitude:
0 = Negligible
1 = Low
2 = Medium
3 = High

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

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

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

Geographic Extent:
1 = < 1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

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

Table 5.10 Significance of the Potential Residual Effects of the Project Activities on the Marine-associated Bird VEC.

Valued Environmental Component: Marine-associated Birds				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Sound				
Airgun Array (2D, 3D and 4D)	NS	2-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Vessel Lights	NS	2-3	-	-
Vessel/Equipment Presence				
Seismic Vessel and Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Accidental Releases	NS	2	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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
2 = Medium
3 = High

[a] Considered only in the case where 'significant negative effect' is predicted.

5.7.6.3 Effects Assessment of other Routine Project Activities

Vessel/Equipment Presence

The potential effects of the physical presence of vessels and seismic gear are likely to be minimal. Seabirds may be attracted to the seismic, escort or supply vessel while prospecting for fish wastes associated with fishing vessels. Since there is little or no food made available by these vessels, seabirds are temporarily interested in the vessels and soon move elsewhere in search of food. Seabirds sitting on the water in the path of these vessels can easily evade the vessels and any equipment associated with the vessels.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related vessel/equipment presence on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, the presence of vessels and equipment associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *11–100 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of the presence of vessels and equipment associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Sanitary/Domestic Waste

Sanitary waste generated by the vessels will be macerated before subsurface discharge (see § 5.7.3). While it is possible that seabirds, primarily gulls, may be attracted to the sewage particles, the small amount discharged below surface over a limited period of time will not likely increase the far-offshore gull populations. Thus, any increase in gull predation on Leach's Storm-Petrels, as suggested by Wiese and Montevecchi (1999), is likely to be minimal. If this event occurs, the number of smaller seabirds involved will likely be low.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related sanitary and domestic waste on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, sanitary/domestic waste associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic waste associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Atmospheric Emissions

Although atmospheric emissions could, in theory, affect the health of some resident seabirds, these effects will be *negligible* considering that emissions consisting of potentially harmful materials will be low and will rapidly disperse to undetectable levels. As indicated in § 5.7.1, atmospheric emission levels produced by the Project will be similar to those produced by other marine vessels not related to the Project.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related atmospheric emissions on the Marine-associated Bird VEC, including appropriate mitigations.

As indicated in Table 5.9, atmospheric emissions associated with the Project are predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *1–10* km^2. Based on these criteria ratings, the *reversible* residual effects of atmospheric emissions associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Helicopter Presence

The potential effects of helicopters on the marine environment are mainly related to the sound they generate (see a review of the effects of sound on seabirds above) and not their physical presence.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related helicopter presence on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, helicopter presence associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* to *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *1–10* km^2. Based on these criteria ratings, the *reversible* residual effects of the presence of helicopters associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Accidental Releases

All seabirds expected to occur in the Study Area, except Arctic Tern, spend considerable time resting on the water. Birds that spend most of their time on water, such as the murres, Dovekie and Atlantic Puffin, are the species most likely to suffer negative effects from an accidental release of hydrocarbons. Northern Fulmar, the shearwaters and storm-petrels are attracted to sheens. The visual appearance of a hydrocarbon sheen would resemble a sheen of biological origin and may initially attract such species. However, these species also search for food by olfaction, relying on the smell of chemicals found in their foods, such as dimethyl sulfide (e.g., Leach's Storm-Petrel; Nevitt and Haberman 2003). Upon investigation of a visually identified hydrocarbon sheen, such birds would find that its odour does not resemble that of any food item. As a result, these birds would be unlikely to come in contact with a sheen during foraging. However, flocks of seabirds resting on the water would not necessarily leave the water if they drifted into an area with hydrocarbons.

An exposure to a surface release of hydrocarbons under calm conditions may harm or kill individual birds. Morandin and O'Hara (2016) demonstrated that it requires only a small amount of oil (e.g., 10 ml) to affect the feather structure of Common Murre and Dovekie with potential to lethally reduce thermoregulation. Such modifications to feather structure cause a loss of insulation, which in turn can result in mortality. However, the potential of accidental releases of hydrocarbons during the proposed seismic program is low and the evaporation/dispersion rate of any released hydrocarbons would be high.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related accidental releases of hydrocarbons on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, accidental releases of hydrocarbons associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *low* to *moderate* in magnitude for a duration of *<1 month* over a geographic area of *<1* to *1–10 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of the accidental release of hydrocarbons associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

5.7.7 Marine Mammal and Sea Turtle VEC

The potential effects of seismic activities on marine mammals and sea turtles have previously been reviewed in the Labrador Shelf, Eastern Newfoundland and Southern Newfoundland SEAs (C-NLOPB 2008, 2010, 2014), previous EAs for seismic programs offshore Newfoundland and Labrador (e.g., LGL 2014, 2015a,b), and literature reviews (e.g., Richardson et al. 1995; Gordon et al. 2004; Stone and Tasker 2006; Nowacek et al. 2007; Southall et al. 2007; Abgrall et al. 2008b; Gomez et al. 2016). Only new or updated information from these documents have been included in the impact assessment of the Project activities on marine mammals and sea turtles.

The assessment of impacts is based on the best available information. However, there are data gaps that limit the certainty of these impact predictions. We have discussed potential impacts separately for toothed whales, baleen whales, seals, and sea turtles given their different hearing abilities and sensitivities to sound. Potential interactions between Project activities and marine mammals and sea turtles are shown in Table 5.11.

5.7.7.1 Sound

The potential effects of sound from airgun arrays on marine mammals and sea turtles constitute a common concern associated with seismic programs. Airgun arrays used during marine seismic operations introduce strong sound pulses into the water. These sound pulses could have several types of effects on marine mammals and sea turtles, and are the main issues associated with the proposed seismic surveys. The effects of human-generated noise on marine mammals are quite variable and depend on numerous factors, including species, activity of the animal when exposed to the noise, and distance of the animal from the sound source. This section includes only a review of new information regarding the potential effects of airgun sounds on marine mammals and sea turtles. More comprehensive reviews of the relevant background information for marine mammals and sea turtles are provided in § 5.8.7.1 and Appendices 4 and 5 of LGL (2014), § 5.7.7.1 and Appendices 4 and 5 of LGL (2015a,b), § 5.3.1 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 4.5.1.5 and 4.5.1.6 of the Southern Newfoundland SEA (C-NLOPB 2010). The characteristics of airgun sounds are also summarized in Appendix 4 of LGL (2014, 2015a,b). Descriptions of the hearing abilities of marine mammals and sea turtles are also provided in Appendices 4 and 5, respectively, of LGL (2014, 2015a,b).

Table 5.11 Potential Interactions of the Project Activities and the Marine Mammal and Sea Turtle VEC.

Valued Environmental Component - Marine Mammal and Sea Turtle					
Project Activities	**Toothed Whales**	**Baleen Whales**	**Seals**	**Polar Bear**	**Sea Turtles**
Sound					
Airgun Array (2D, 3D and 4D)	X	X	X	X	X
Seismic Vessel	X	X	X	X	X
Supply Vessel	X	X	X	X	X
Escort Vessel	X	X	X	X	X
Helicopter	X	X	X	X	X
Echo Sounder	X	X	X	X	X
Side Scan Sonar	X	X	X	X	X
Vessel/Equipment Presence					
Seismic Vessel/Gear (2D, 3D and 4D)	X	X	X	X	X
Supply Vessel	X	X	X	X	X
Escort Vessel	X	X	X	X	X
Vessel Lights					
Helicopter Presence	X	X	X	X	X
Sanitary/ Domestic Wastes	X	X	X	X	X
Atmospheric Emissions	X	X	X	X	X
Accidental Releases	X	X	X	X	X
Garbage[a]					
Shore Facilities[b]					
Other Projects and Activities in Regional Area					
Oil and Gas Activities	X	X	X	X	X
Fisheries	X	X	X	X	X
Marine Transportation	X	X	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b] There will not be any new onshore facilities. Existing infrastructure will be used.

The potential effects of airgun sounds considered in this assessment include: (1) masking of natural sounds; (2) behavioural disturbance; (3) non-auditory physical or physiological effects; and (4) at least in theory, temporary or permanent hearing impairment (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007; Peng et al. 2015). Although the possibility cannot be entirely excluded, it is unlikely that the program would result in any cases of permanent hearing impairment or any significant non-auditory physical or physiological effects. If marine mammals or sea turtles encounter the survey while it is underway, behavioural effects may occur but effects are generally expected to be localized and short-term.

Masking

Erbe et al. (2015) recently reviewed communication masking in marine mammals. Guerra et al. (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Guan et al. (2015) indicated that, in very shallow water environments (<15 m), the airgun inter-pulse sound field can exceed ambient noise levels by as much as 9 dB during relatively quiet conditions. The inter-pulse noise levels can also be related to the distance to the source, probably as a result of higher reverberant conditions in shallow water. Based on preliminary modeling, Wittekind et al. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales occurring 2,000 km from a seismic source. However, based on past and current reviewed research, the potential for masking of marine mammal calls and/or important environmental cues from the proposed seismic program is considered low. Thus, masking is unlikely to be a significant issue for either marine mammals or sea turtles exposed to the sounds from the proposed seismic survey. Some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behaviour in response to airgun sounds (e.g., Blackwell et al. 2015).

In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behaviour (e.g., Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Heiler et al. 2016; O'Brien et al. 2016; Parks et al. 2016a,b). Nonetheless, for humpback whales, Dunlop (2015) suggested a potential for masking with an increase in anthropogenic noise. Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016). Harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016).

Disturbance

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. If a marine mammal or sea turtle does react briefly to an underwater sound by changing its behaviour or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals or sea turtles from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (Nowacek et al. 2015).

Although baleen whales generally tend to avoid operating airguns, avoidance radii are variable. Stone (2015) examined data from 1,196 seismic surveys in the UK and adjacent waters and reported significant responses to airgun arrays of 500 in^3 or more in volume for minke and fin whales. This included lateral displacement, change in swimming or surfacing behaviour, and indications that cetaceans remained near the water surface. Dunlop et al. (2015, 2016) reported that humpback whales responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration. However, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway during ongoing seismic surveys outside of the fjord. Similarly, no large changes in grey whale movement, respiration, or distribution patterns were observed during a 4D seismic survey off Sakahlin Island, Russia (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible avoidance response to high sound levels in the area (Muir et al. 2016). Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, given that spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). Bowhead whales continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2015). Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2015).

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive mysticetes and some other odontocetes. Small and medium-sized odontocetes, including beaked whales, showed a significant response (e.g., lateral displacement, localized avoidance, or change in behaviour) to large airgun arrays of 500 in^3 or more in volume, with the exception of Risso's dolphin (Stone 2015). When investigating the auditory effects of multiple underwater impulses on bottlenose dolphins, Finneran et al. (2015) reported that at the highest exposure condition (peak sound pressure levels from 196 to 210 dB re 1 μPa), two of three dolphins tested exhibited anticipatory behavioural reactions to impulse sounds presented at fixed time intervals. Preliminary data from the Gulf of Mexico showed a correlation between reduced sperm whale acoustic activity during periods with airgun operations (Sidorovskaia et al. 2014). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbour porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013).

Pinnipeds tend to be less responsive to airgun sounds than many cetaceans and are not likely to show a strong avoidance reaction to the airgun array. Stone (2015) found that grey seals were displaced by large airgun arrays of 500 in^3 or more in volume as indicated by the lower detection rate during periods of seismic activity. Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3,090 in^3 airgun array in New Zealand during 2009. The results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds. When Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses, only mild behavioural responses were observed.

Based on available data, it is likely that sea turtles would exhibit behavioural changes and/or localized avoidance near a seismic vessel. In addition, Nelms et al. (2016) suggested that sea turtles could be excluded from critical habitats. However, turtles are considered rare in the Study Area.

Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels. Historically, research has focused on the low-frequency component of ship noise. Recent studies have also examined the medium- to high-frequency components of ship noise on small toothed whales (Hermannsen et al. 2014; Dyndo et al. 2015; Li et al. 2015). Hermannsen et al. (2014) reported that the noise from vessels passing at a distance of 1,190 m can result in a reduction of the hearing range of >20 dB for harbour porpoise (at 1 and 10 kHz) and >30 dB (at 125 kHz) from vessels passing at a distance of 490 m or less. Dyndo et al. (2015) showed that low levels of high frequency components in vessel noise can result in stereotyped porpoising behavioural responses in harbour porpoise in almost 30% of passages. Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair et al. 2016) and porpoise (Teilmann et al. 2015).

In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behaviour (e.g., Luís et al. 2014; Sairanen 2014;

Papale et al. 2015; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Heiler et al. 2016; O'Brien et al. 2016; Parks et al. 2016a,b). Nonetheless, for humpback whales, Dunlop (2015) suggested a potential for masking with an increase in anthropogenic noise. Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016). Harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016).

There are few systematic studies on sea turtle reactions to ships and boats but it is thought that response would be minimal relative to responses to seismic sound.

Hearing Impairment

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Temporary Threshold Shift (TTS) has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (recently reviewed in Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage (i.e., Permanent Threshold Shift (PTS)), in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

There is recent evidence supporting the idea that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (e.g., Finneran 2015; Kastelein et al. 2015, 2016; Supin et al. 2016). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioural tests, Finneran et al. (2015) reported no measurable TTS in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun. However, auditory evoked potential measurements were more variable, with one dolphin showing a small (9 dB) threshold shift at 8 kHz.

Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbour porpoise. Several studies on TTS in porpoises indicate that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes (e.g., Kastelein et al. 2015; Tougaard et al. 2016). Popov et al. (2017) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2014, 2015).

When Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 µPa, no low-frequency TTS was observed. Hermannsen et al. (2015) concluded that there is little risk of hearing damage to pinnipeds and porpoises when using a single airgun in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns.

There is substantial overlap in the frequencies that sea turtles detect vs. the frequencies in airgun pulses. Sounds from an airgun array might cause temporary hearing impairment in sea turtles if they do not avoid the immediate area around the airguns. However, monitoring studies show that some sea turtles exhibit localized movement away from approaching airguns.

According to Nowacek et al. (2013), current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals and sea turtles occurring near the airgun array and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. In addition, many cetaceans and, to a limited degree, pinnipeds and sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves will reduce the possibility of hearing impairment.

Non-auditory Physical Effects

Non-auditory physical effects may also occur in marine mammals and sea turtles exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might theoretically occur include stress (e.g., Lyamin et al. 2016), neurological effects, and organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, there is no definitive evidence that any of these effects occur even for marine mammals or sea turtles in close proximity to large arrays of airguns. Nonetheless, 10 cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016).

Sound Criteria for Assessing Impacts

Impact zones for marine mammals are commonly defined by the areas within which specific received sound level thresholds are exceeded. For the last two decades, the U.S National Marine Fisheries Service regulated that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa_{rms}. The corresponding limit for seals was set at 190 dB re 1 μPa_{rms} (NMFS 1995, 2000). According to NMFS, these sound levels were the received levels above which one cannot be certain that there will be no injurious effects, auditory or otherwise, to marine mammals. Since these regulations came into effect, it has been common for marine seismic surveys conducted in U.S. waters and some areas of Canada (Canadian Beaufort Sea and the Scotian Shelf) to include a "shutdown" requirement for cetaceans based on the distance from the airgun array at which the received level of underwater sounds is expected to diminish below 180 dB re 1 μPa_{rms}. An additional criterion that is often used in predicting "disturbance" impacts is 160 dB re 1 μPa. At this received level, some marine mammals exhibit behavioural effects.

Recommendations for science-based noise exposure criteria for marine mammals were published by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations were taken into account in certain environmental impact statements and small-take authorizations. However, new guidance for assessing the effects of anthropogenic sound on marine mammals has now been released by NMFS (2016). The new noise exposure criteria for marine mammals account for the now-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sounds, such airgun pulses, the thresholds use dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). DFO has not yet adopted any noise exposure criteria (DFO 2015d; Theriault and Moors-Murphy 2015).

For marine seismic programs in Newfoundland and Labrador, the C-NLOPB (2016) requires that seismic operators follow the "Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment" (hereafter referred to as the Statement) issued by the DFO. The Statement does not include noise criteria as part of the recommended mitigation measures; rather it defines (see Point 6.a) a safety zone as "a circle with a radius of at least 500 metres as measured from the centre of the air source array (s)".

Assessment of Effects of Sound on Marine Mammals

The marine mammal effects assessment is discussed in detail below. The effects of underwater sound from vessels, the echo sounder, and the side scan sonar are not further discussed as their effects are generally considered minimal relative to sounds from airgun arrays.

Toothed Whales

Despite the relatively poor hearing sensitivity of toothed whales (at least the smaller species that have been studied) at the low frequencies that contribute most of the energy in seismic pulses, sounds are sufficiently strong that they remain above the hearing threshold of odontocetes at tens of kilometres from the source. Species of most concern are those that are designated under *SARA* Schedule 1 and that may occur in and near the Project Area (i.e., northern bottlenose and Sowerby's beaked whales). The killer whale, beluga whale, and harbour porpoise have special status under COSEWIC (the harbour porpoise is also listed as threatened under Schedule 2 of *SARA*), but are not expected to occur in large numbers in the Project Area. Until recently (July 2016), the received sound level of 180 dB re 1 μPa_{rms} criterion was accepted by NMFS as a level that below which there is no physical effect on toothed whales. The new PTS onset acoustic thresholds for impulsive sounds for mid-frequency (MF) cetaceans consist of a peak SPL_{flat} of 230 dB and a SEL_{cum} of 185 dB. The PTS onset thresholds for high-frequency (HF) cetaceans are a peak SPL_{flat} of 202 dB and a SEL_{cum} of 155 dB. NMFS assume that disturbance effects for toothed whales may occur at received sound levels at or above 160 dB re 1 μPa_{rms}. However, there is no good scientific basis for using this 160 dB criterion for odontocetes, rather 170 dB re 1 μPa_{rms} is likely a more realistic indicator of the isopleth within which disturbance is possible, at least for delphinids.

Hearing Impairment and Physical Effects

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals, including appropriate mitigations. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual hearing impairment/physical effects on toothed whales that are *negligible* to *low* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *1–10* km^2. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with MKI's proposed 2D/3D/4D seismic program on toothed whales are predicted to be *not significant* (Table 5.13). The level of confidence associated with this prediction is *medium* (Table 5.13).

Table 5.12 Assessment of Effects of Project Activities on Marine Mammals.

Valued Environmental Component: Marine Mammals								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Sound								
Airgun Array (2D, 3D and 4D)	Hearing Impairment (N) Physical Effects (N)	Pre-watch; Ramp-up; Delay start[a]; Shutdown[b]	0-1	1-2	6	1-2	R	2
Airgun Array (2D, 3D and 4D)	Disturbance (N)	Pre-watch; Ramp-up; Delay start[a]; Shutdown[b]	1-2	1-4	6	1-2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1-2	1	1	R	2
EscortVessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Helicopter	Disturbance (N)		0-1	1-2	1	1	R	2
Echo Sounder	Disturbance (N)		0-1	1	6	1-2	R	2
Side Scan Sonar	Disturbance (N)		0-1	1	6	1-2	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0-1	1	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0	1	1	1	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment; containment	0	1	4	1-2	R	2
Atmospheric Emissions	Surface Contaminants (N)	Low sulphur fuel	0	1	6	1-2	R	2
Accidental Releases	Injury/Mortality (N)	Solid streamer[c]; Spill response	1	1-2	1	1	R	2

Key:

Magnitude:
0 = Negligible
1 = Low
2 = Medium
3 = High

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

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

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

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

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

[a] Ramp-up will be delayed if any marine mammal is sighted within the 500 m safety zone.
[b] The airgun arrays will be shutdown if an *endangered* (or *threatened*) marine mammal is sighted within 500 m of the array.
[c] A solid streamer will be used for all seismic surveys

Table 5.13 Significance of Potential Residual Environmental Effects of Project Activities on the Marine Mammal VEC.

Valued Environmental Component: Marine Mammals				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood[a]	
	Residual Environmental Effect Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D) – hearing/physical effects	NS	2	-	-
Airgun Array (2D, 3D and 4D) – behavioural effects	NS	2	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echo Sounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter Presence	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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
2 = Medium
3 = High

[a] Considered only in the case where 'significant negative effect' is predicted.

Disturbance

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals, including appropriate mitigations. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual disturbance effects on toothed whales that are *low* to *medium* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *101–1,000 km²*. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with MKI's proposed 2D/3D/4D seismic program on toothed whales are predicted to be *not* significant (see Table 5.13). The level of confidence associated with this prediction is *medium* (see Table 5.13).

Baleen Whales

Baleen whales are thought to be sensitive to low-frequency sounds such as those that contribute most of the energy in seismic pulses. Species of most concern are those that are designated under *SARA* Schedule 1 and that may occur in and near the Project Area (i.e., North Atlantic right, blue, and fin whale). Until recently, as with toothed whales, the 180 dB re 1 μPa_{rms} criterion was used by NMFS when estimating the area within which hearing impairment and/or physical effects may occur for baleen whales (although there are no data to support this criterion for baleen whales). The new PTS onset acoustic thresholds for impulsive sounds for low-frequency (LF) cetaceans consist of a peak SPL_{flat} of 219 dB and a SEL_{cum} of 183 dB. For all baleen whale species, NMFS assumes that disturbance effects (avoidance) may occur at sound levels greater than 160 dB re 1 μPa_{rms}.

Hearing Impairment and Physical Effects

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals, including appropriate mitigations. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual hearing impairment/physical effects on baleen whales that are *negligible* to *low* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *1–10 km²*. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with MKI's proposed 2D/3D/4D seismic program on baleen whales are predicted to be *not significant* (see Table 5.13). The level of confidence associated with this prediction is *medium* (see Table 5.13).

Disturbance

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals, including appropriate mitigations. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual disturbance effects on baleen whales that are *low* to *medium* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *101–1,000 km^2*. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with MKI's proposed 2D/3D/4D seismic program on baleen whales are predicted to be *not* significant (see Table 5.13). The level of confidence associated with this prediction is *medium* (see Table 5.13).

Seals

Until recently, the 190 dB re 1 μPa_{rms} criterion was used by NMFS when estimating the area within which hearing impairment and/or physical effects may occur for pinnipeds. The new PTS onset acoustic thresholds for impulsive sounds for pinnipeds in water (PW) consist of a peak SPL_{flat} of 218 dB and a SEL_{cum} of 185 dB. For all pinnipeds, NMFS assumes that disturbance effects (avoidance) may occur at sound levels greater than 160 dB re 1 μPa_{rms}. However, seals are not expected to be abundant within the Study Area, particularly during the time period when seismic operations will likely occur.

Hearing Impairment and Physical Effects

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals, including appropriate mitigations. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual hearing impairment/physical effects on seals that are *negligible* to *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *1–10 km^2*. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with MKI's proposed 2D/3D/4D seismic program on seals are predicted to be *not significant* (see Table 5.13). The level of confidence associated with this prediction is *medium* (see Table 5.13).

Disturbance

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals, including appropriate mitigations. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual disturbance effects on seals that are *low* to *medium* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *11–100 km^2*. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with MKI's proposed 2D/3D/4D seismic program on seals are predicted to be *not significant* (see Table 5.13). The level of confidence associated with this prediction is *medium* (see Table 5.13).

Assessment of Effects of Sound on Sea Turtles

Sea turtles have received very little research attention when compared to marine mammals and fishes (Nelms et al. 2016). Although it is possible that exposure to airgun sounds could cause either mortality or mortal injuries in sea turtles close to the source, this has not been demonstrated and seems highly unlikely (Popper et al. 2014). Nonetheless, Popper et al. (2014) proposed sea turtle mortality/mortal injury criteria of 210 dB SEL or >207 dB_{peak} for sounds from seismic airguns. The effects of underwater sound from vessels, the echo sounder, and the side scan sonar are not further discussed as their impact is minimal relative to airguns.

<u>Hearing Impairment and Physical Effects</u>

Table 5.14 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals, including appropriate mitigations. As indicated in Table 5.14, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual hearing impairment/physical effects on sea turtles that are *negligible* to *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *1–10* km^2. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with MKI's proposed 2D/3D/4D seismic program on sea turtles are predicted to be *not significant* (Table 5.15). The level of confidence associated with this prediction is *medium* (Table 5.15).

<u>Disturbance</u>

Table 5.14 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals, including appropriate mitigations. As indicated in Table 5.14, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual disturbance effects on sea turtles that are *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *11–100* km^2. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with MKI's proposed 2D/3D/4D seismic program on sea turtles are predicted to be *not significant* (Table 5.15). The level of confidence associated with this prediction is *medium* to *high* (Table 5.15).

Table 5.14 Assessment of Effects of Project Activities on the Sea Turtle VEC.

Valued Environmental Component: Sea Turtles								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Sound								
Airgun Array (2D, 3D and 4D)	Hearing Impairment (N); Physical Effects (N)	Pre-watch; Ramp-up; Delay start[a]; Shutdown[b]	0-1	1-2	6	1-2	R	2
Airgun Array (2D, 3D and 4D)	Disturbance (N)	Pre-watch; Ramp-up; Delay start[a]; Shutdown[b]	1	1-3	6	1-2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1-2	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Helicopter	Disturbance (N)		0-1	1-2	1	1	R	2
Echo Sounder	Disturbance (N)		0-1	1	6	1-2	R	2
Side Scan Sonar	Disturbance (N)		0-1	1	6	1-2	R	2
Vessel Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0-1	1	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0	1	1	1	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment; containment	0	1	4	1-2	R	2
Atmospheric Emissions	Surface Contaminants (N)	Low sulphur fuel	0	1	6	1-2	R	2
Accidental Releases	Injury/Mortality (N)	Solid streamer[c]; Spill response	1	1-2	1	1	R	2

Key:

Magnitude:
0 = Negligible
1 = Low
2 = Medium
3 = High

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

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

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

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

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

[a] Ramp-up will be delayed if a sea turtle is sighted within the 500 m safety zone.
[b] The airgun arrays will be shutdown if an *endangered* or *threatened* sea turtle is sighted within 500 m of the array.
[c] A solid streamer will be used for all seismic surveys.

Table 5.15 Significance of Potential Residual Environmental Effects of Project Activities on Sea Turtles.

Valued Environmental Component: Sea Turtles				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood[a]	
	Residual Environmental Effect Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D) – hearing/physical effects	NS	2	-	-
Airgun Array (2D, 3D and 4D) – behavioural effects	NS	2-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echo Sounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter Presence	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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
2 = Medium
3 = High

[a] Considered only in the case where 'significant negative effect' is predicted.

5.7.7.2 Helicopter Sound

Information on interactions between helicopter sound and marine mammals and sea turtles is available in § 5.8.7.2 of the MKI Labrador Sea EA (LGL 2014), § 5.7.7.2 of the WesternGeco Eastern Newfoundland EA (LGL 2015a) and WesternGeco Southeastern Newfoundland EA (LGL 2015b), and § 5.3.1 of the Eastern Newfoundland SEA (C-NLOPB 2014).

Tables 5.12 and 5.14 provide the details of the assessment of the effects of exposure to Project-related helicopter sound on marine mammals and sea turtles, respectively, including appropriate mitigations. As indicated in Tables 5.12 and 5.14, sound produced by helicopters associated with the proposed Project is predicted to have residual disturbance effects on marine mammals and sea turtles that are *negligible* to *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *1–10* km^2. Based on these criteria ratings, the *reversible* residual disturbance effects of helicopter sound associated with MKI's proposed 2D/3D/4D seismic program on marine mammals and sea turtles are predicted to be *not significant* (see Tables 5.13 and 5.15 The level of confidence associated with this prediction is *high* (see Tables 5.13 and 5.15).

5.7.7.3 Vessel/Equipment Presence

Information on interactions between vessel/equipment presence and marine mammals and sea turtles is available in § 5.7.7.3 of the WesternGeco Eastern Newfoundland EA (LGL 2015a) and WesternGeco Southeastern Newfoundland EA (LGL 2015b), § 5.3.1 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 4.5.9.3 of the Southern Newfoundland SEA (C-NLOPB 2010). This section includes only a review of new information regarding the potential effects of vessel/equipment presence on marine mammals and sea turtles.

During the proposed seismic program, there will be one seismic ship and an escort vessel on site during most of the program. A supply vessel will also regularly be present during the program. There is some risk for collision between marine mammals and vessels, but given the slow surveying speed (~4.5 knots; 8.3 km/h) of the seismic vessel (and its support vessels), this risk is likely to be minimal in spite of the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species (McKenna et al. 2015). Wiley et al. (2016) also concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. Marine mammal responses to ships are presumably responses to noise.

Sea turtles may also become entangled with seismic gear, such as cables, buoys, or streamers (Nelms et al. 2016) or collide with the vessel.

Tables 5.12 and 5.14 provide the details of the assessment of the effects of exposure to Project-related vessel/equipment presence on marine mammals and sea turtles, respectively, including appropriate mitigations. As indicated in Tables 5.12 and 5.14, vessel/equipment presence associated with the proposed Project is predicted to have residual effects on marine mammals and sea turtles that are *negligible* to *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1 km²*. Based on these criteria ratings, the *reversible* residual effects of vessel/equipment presence associated with MKI's proposed 2D/3D/4D seismic program on marine mammals and sea turtles are predicted to be *not significant* (see Tables 5.13 and 5.15). The level of confidence associated with this prediction is *high* (see Tables 5.13 and 5.15).

5.7.7.4 Other Project Activities

There is potential for marine mammals and sea turtles to interact with domestic and sanitary wastes, and atmospheric emissions from the seismic ship and the support vessels. Any effects from these interactions are predicted to be *negligible* (see Tables 5.13 and 5.15).

Accidental Releases

All petroleum hydrocarbon handling and reporting procedures on board will be consistent with MKI's policy, and handling and reporting procedures. A fuel spill may occur from the seismic ship and/or the support vessels. Spills would likely be small and quickly dispersed by wind, wave, and ship's propeller action. The effects of hydrocarbon spills on marine mammals and sea turtles were reviewed in § 5.7.7.4 of the WesternGeco Eastern Newfoundland EA (LGL 2015a), § 5.7.7.5 of the WesternGeco Southeastern Newfoundland EA (LGL 2015b), § 5.8.7.4 of the MKI Labrador Sea EA (LGL 2014), § 5.3 of the Eastern Newfoundland SEA (C-NLOPB 2014), § 4.6.4.5 and 4.6.4.6 of the Southern Newfoundland SEA (C-NLOPB 2010). Dupuis and Ucan-Marin (2015) and Helm et al. (2015) also reviewed the effects of oil on marine mammals and/or sea turtles. Whales and seals generally do not exhibit large behavioural or physiological responses to limited surface oiling, incidental exposure to contaminated food, or ingestion of oil. However, lung disease, adrenal toxicity, and low reproductive success were reported for bottlenose dolphins exposed to oil during the Deepwater Horizon spill (Schwacke et al. 2014; Lane et al. 2015; Venn-Watson et al. 2015). Acoustic data suggests that sperm whales foraged farther away from the spill site than before the spill, whereas Ziphiidae returned to the spill site to feed (Sidorovskaia et al. 2016). Sea turtles are thought to be more susceptible to the effects of oiling than marine mammals, but effects are believed to be primarily sublethal. Biomarkers showed that loggerhead turtles remained in the oiled areas after the Deepwater Horizon spill (Vander Zanden et al. 2016).

Tables 5.12 and 5.14 provide the details of the assessment of the effects of exposure to Project-related accidental releases of hydrocarbons on marine mammals and sea turtles, respectively, including appropriate mitigations. As indicated in Tables 5.12 and 5.14, accidental releases of hydrocarbons associated with the proposed Project are predicted to have residual effects on marine mammals and sea turtles that are *low* in magnitude for a duration of *<1 month* over a geographic area of *<1* to *1–10 km²*. Based on these criteria ratings, the *reversible* residual effects of accidental releases of hydrocarbons associated with MKI's proposed 2D/3D/4D seismic program on marine mammals and sea turtles are predicted to be *not significant* (see Tables 5.13 and 5.15). The level of confidence associated with this prediction is *medium* (see Tables 5.13 and 5.15).

5.7.8 Species at Risk VEC

Biological summaries of all species with an *endangered* or *threatened* status under Schedule 1 of the *SARA* and with reasonable likelihood of occurrence in the Study Area were provided in § 4.6, while overviews of species with *special concern* status under Schedule 1 of *SARA* were provided in § 4.2, § 4.4 and § 4.5 on fish and fish habitat, marine-associated birds and marine mammals and sea turtles, respectively. No critical habitat for any of these species/populations has been identified within the Study Area. As indicated in Table 4.16 in § 4.6, the 16 *SARA* Schedule 1 species/populations of relevance to the Study Area include:

- White Shark (Atlantic population), and northern, spotted and Atlantic wolffishes;
- Ivory Gull, Red Knot *rufa* spp., Harlequin Duck (Eastern population), and Barrow's Goldeneye (Eastern population);
- Blue whale (Atlantic population), North Atlantic right whale, northern bottlenose whale (Scotian Shelf population), fin whale (Atlantic population), Sowerby's beaked whale, polar bear, and beluga whale (St. Lawrence Estuary population); and
- Leatherback sea turtle.

Species/populations currently without status on Schedule 1 of *SARA*, but listed on Schedules 2 or 3 or being considered for addition to Schedule 1 (as per their current COSEWIC listing of *endangered*, *threatened* or *special concern*), are not included in this assessment of potential effects on the Species at Risk VEC. Instead, potential effects on these species/populations have been assessed in the appropriate VEC assessment section (i.e., § 5.7.4 [Fish and Fish Habitat], § 5.7.6 [Marine-associated Birds] and § 5.7.7 [Marine Mammals and Sea Turtles]) of this EA.

If species/populations currently without status do become listed on Schedule 1 of *SARA* during the temporal scope of the Project (2017 to 2026), the Proponent will re-assess these species/populations considering the prohibitions of *SARA* (including *SARA* sections 32(1) [Killing, harming, etc., listed wildlife species], 33 [damage or destruction of residence], and 58(1) [Destruction of critical habitat]), and any recovery strategies or action plans that may be in place. Possible mitigation measures as they relate to species at risk will be reviewed with DFO and Environment Canada (EC). Potential interactions between Project activities and the Species at Risk VEC are indicated in Table 5.16. Only those ten species species/populations with either *endangered* or *threatened* status under Schedule 1 of *SARA* (see Table 4.20) are included in the interactions table (Table 5.16). The potential effects of activities associated with MKI's seismic program are not expected to contravene the aforementioned prohibitions of *SARA*.

Table 5.16 Potential Interactions of Project Activities and the Species at Risk VEC.

Valued Environmental Component: Species at Risk					
Project Activities	**White Shark**	**Northern Wolffish** **Spotted Wolffish**	**Ivory Gull** **Red Knot**	**Blue Whale** **North Atlantic Right Whale** **Northern Bottlenose Whale** **Beluga Whale**	**Leatherback Sea Turtle**
Sound					
Airgun Array (2D, 3D and 4D)	X	X	X	X	X
Seismic Vessel	X	X	X	X	X
Supply Vessel	X	X	X	X	X
Escort Vessel	X	X	X	X	X
Helicopter			X	X	X
Echosounder	X	X	X	X	X
Side Scan Sonar	X	X	X	X	X
Vessel Lights	X		X		
Vessel/Equipment Presence					
Seismic Vessel/Gear (2D, 3D and 4D)			X	X	X
Supply Vessel			X	X	X
Escort Vessel			X	X	X
Sanitary/ Domestic Waste	X	X	X	X	X
Atmospheric Emissions	X	X	X	X	X
Garbage[a]					
Helicopter Presence			X	X	X
Shore Facilities[b]					
Accidental Releases	X	X	X	X	X
Other Projects and Activities in Regional Area					
Oil and Gas Activities	X	X	X	X	X
Fisheries	X	X	X	X	X
Marine Transportation	X	X	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b] There will not be any new onshore facilities. Existing infrastructure will be used.

5.7.8.1 Fish Species at Risk

The mitigation measure of ramping up the airgun array over a 30 minute period is expected to minimize the potential effects on white sharks and wolffishes. As per the detailed effects assessment contained in § 5.7.4, physical effects of Project activities on the various life stages of the white shark and wolffishes will have *negligible* to *low* magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* km^2 (Table 5.17). Based on these criteria ratings, the residual physical effects of activities associated with MKI's proposed seismic program on white sharks and wolffishes are predicted to be *not significant* (Table 5.18). The level of confidence associated with this prediction is *high* (Table 5.18).

Behavioural effects of Project activities on the various life stages of the white shark and wolffishes will have *negligible* to *low* magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1 to 11–100* km^2 (Table 5.17). Based on these criteria ratings, the residual behavioural effects of activities associated with MKI's seismic program on white sharks and wolffishes are predicted to be *not significant* (Table 5.18). The level of confidence associated with this prediction is *medium* to *high* (Table 5.18).

5.7.8.2 Marine-associated Bird Species at Risk

Ivory Gull and Red Knot foraging behaviour would not likely expose them to underwater sound, and these species are unlikely to occur in the Study Area, particularly during the time when seismic surveys are likely to be conducted. Furthermore, Ivory Gulls and Red Knots are not known to be prone to stranding on vessels. The mitigation measures of monitoring the seismic vessel, releasing stranded birds (in the unlikely event that an Ivory Gull or Red Knot did strand on the vessel) and ramping up the airgun array will minimize the potential effects on these seabird species at risk. With mitigation measures in place and as per the detailed effects assessment in § 5.7.6, the predicted effects of the Project on Ivory Gull and Red Knot will range from *negligible* to *medium* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *11–100* km^2 (Table 5.17). Based on these criteria ratings, the predicted effects of activities associated with MKI's proposed seismic program on Ivory Gull and Red Knot are predicted to be *not significant* (Table 5.18). The level of confidence associated with this prediction is *medium* to *high* (Table 5.18).

5.7.8.3 Marine Mammal and Sea Turtle Species at Risk

Based on available information, blue whales, North Atlantic right whales, northern bottlenose whales (Scotian Shelf population), belugas and leatherback sea turtles are not expected to occur regularly in the Study Area. No critical habitat for these species/populations has been identified in the Study Area. Mitigation and monitoring designed to minimize potential effects of airgun array noise on *SARA*-listed marine mammals and sea turtles will include:

- Ramp-up of the airgun array over a 30 min period;
- Monitoring by MMO(s) (with assistance from a FLO) during daylight hours that the airgun array is active;
- Shutdown of the airgun array when an *endangered* or *threatened* marine mammal or sea turtle is sighted within the 500 m safety zone; and
- Delay of ramp-up if any marine mammal or sea turtle is sighted within the 500 m safety zone.

Table 5.17 Assessment of Effects of Project Activities on the Species at Risk VEC.

Valued Environmental Component: Species At Risk								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Sound								
Airgun Array (2D, 3D and 4D)	Disturbance (N) Hearing Impairment (N) Physical Effects (N)	Ramp-up; delay start[a]; shutdown[b]	0-2	1-4	6	1-2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1-2	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Helicopter	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1	R	2
Echosounder	Disturbance (N)		0-1	1	6	1	R	2
Side Scan Sonar	Disturbance (N)		0-1	1	6	1	R	2
Vessel Lights	Attraction (N); Mortality (N)	Reduce lighting (if safe); release protocols	0-1	1-2	2-3	1-2	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0-1	1	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Sanitary/Domestic Waste	Increased food (N/P)	-	0-1	1	4	1-2	R	2
Atmospheric Emissions	Surface contaminants (N)	-	0	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1	R	2
Accidental Releases	Injury/Mortality (N)	Solid Streamer[c]; Spill Response	0-2	1-2	1	1	R	2

Key:

Magnitude:
0 = Negligible
1 = Low
2 = Medium
3 = High

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

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

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

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

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

[a] Ramp-up will be delayed if a sea turtle is sighted within the 500 m safety zone.
[b] The airgun arrays will be shutdown if an *endangered* (or *threatened*) marine mammal or sea turtle is sighted within 500 m of the array.
[c] A solid streamer will be used for all seismic surveys.

Table 5.18 Significance of Potential Rsidual Environmental Effects of Project Activities on the Species at Risk VEC.

Valued Environmental Component: Species At Risk				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood [a]	
	Significance Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D)	NS	2-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Vessel Lights	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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
2 = Medium
3 = High

[a] Considered only in the case where 'significant negative effect' is predicted.

With these mitigation measures in place and as per the detailed effects assessment in § 5.7.7, the predicted effects of the Project on blue whales, North Atlantic right whales, northern bottlenose whales, belugas and leatherback sea turtles will range from *negligible* to *medium* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *101–1,000 km^2* (see Table 5.17). Based on these criteria ratings, the predicted effects of activities associated with MKI's proposed seismic program on blue whales, North Atlantic right whales, northern bottlenose whales, belugas and leatherback sea turtles are predicted to be *not significant* (see Table 5.18). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.18).

5.7.9 Sensitive Areas VEC

An overview of sensitive areas located either entirely or partially within the Study Area was provided in § 4.7. The habitat preferences of biota potentially inhabiting these sensitive areas, including invertebrates, fishes, marine mammals, sea turtles and marine-associated birds, were detailed in § 4.2 to 4.5, and species at risk were described in § 4.6.

Based on the conclusions of § 5.7.4 to 5.7.8, the residual effects of activities associated with MKI's seismic program on the Sensitive Areas VEC within the Study Area are predicted to be *not significant*. The level of confidence associated with this prediction is *medium* to *high*.

5.8 Cumulative Effects

This EA has assessed cumulative effects within the Project and thus, the residual effects described in preceding sections include any potential cumulative effects resulting from the MKI seismic program activities in the Project Area. This includes the residual effects of two concurrent seismic surveys being conducted by MKI (see § 2.0). Considering the size of the Project Area, the likely considerable separation of the two concurrent surveys, and the predictions of significance presented in § 5.7, the within-Project cumulative residual effects associated with two concurrent MKI seismic surveys are predicted to be *not significant*. The level of confidence associated with this prediction is *medium* to *high*.

It is also necessary to assess cumulative effects when considering other non-Project activities that are occurring or planned for the Regional Area. These activities include:

- Fisheries (commercial and research survey fishing);
- Marine transportation (e.g., cargo, defense, yachts); and
- Offshore oil and gas industry activities.

Duinker et al. (2012), in their review of work to date on the scientific dimensions of cumulative effects assessment (CEA), concluded that it is particularly difficult to properly implement CEA in project-specific EAs. They made several recommendations regarding revisions to guidance materials for science in CEA, including the following:

- A much richer and nuanced conceptual framework for a cumulative effect is required in order to describe how effects become cumulative;
- Clearer guidance regarding CEA analytical methods is required; and
- Better definitions of thresholds, without which it is really impossible to judge the significance of cumulative effects.

Duinker et al. (2012) concluded by saying that lack of competent CEA impairs our ability to determine the degree to which particular activities jeopardize the sustainability of Valued

Environmental Components (VECs), and that improvements in CEA practice are desperately needed.

Until more robust methods of CEA are developed, the qualitative method used for EAs to date is again applied in this EA.

5.8.1 Fisheries

Fishing has been discussed and assessed in detail in § 4.3 and § 5.7.5. Fishing activities, by their nature, cause mortality and disturbance to fish populations and may cause incidental mortalities or disturbance to seabirds, marine mammals, and sea turtles. It is predicted that the seismic surveys will not cause any mortality to these VECs (with the potential exception of small numbers of petrels) and thus, there will be *negligible* cumulative mortality effect. There is some potential for cumulative disturbance effect (e.g., fishing vessel noise) but there will be directed attempts by both industries to mitigate such effects by avoiding each other's active areas and times as much as possible. The seismic surveying will also spatially and temporally avoid DFO research vessels during multi-species trawl surveys. Any cumulative effects associated with fisheries are predicted to be *not significant*. The level of certainty associated with this prediction is *medium*.

5.8.2 Marine Transportation

Marine transportation within the Study Area is discussed in the Eastern Newfoundland SEA (§ 4.3.5.1 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 5.3 of C-NLOPB 2010), and the two WesternGeco EAs (§ 5.8.2 of LGL 2015a,b).

The seismic survey vessels are not likely to add much marine traffic congestion. Ships may need to divert around the immediate seismic survey area, but this will not prevent or impede the passage of either vessel as the *Shipping Act* and standard navigation rules will apply. Thus, potential for cumulative effects with other shipping is predicted to be *low* and *not significant*. The level of certainty associated with this prediction is *medium*.

5.8.3 Other Oil and Gas Activities

Potential offshore oil and gas industry activities in the Regional Area during 2017, based on current completed 'in-effect' EAs listed on the C-NLOPB public registry (www.cnlopb.nl.ca) include the following:

- Seitel Canada Ltd. East Coast Offshore Seismic Program, 2016–2025;
- CGG Services (Canada) Inc. Newfoundland Offshore 2D, 3D and 4D Seismic Program, 2016–2025;

- ExxonMobil Canada Ltd. Eastern Newfoundland Offshore Geophysical, Geochemical, Environmental and Geotechnical Program, 2015–2024;
- WesternGeco Canada Eastern Newfoundland Offshore Seismic Program, 2015–2024;
- WesternGeco Canada Southeastern Newfoundland Offshore Seismic Program, 2015–2024;
- Suncor Energy Eastern Newfoundland Offshore Area 2D/3D/4D Seismic Program, 2014–2024;
- Bridgeporth Holdings Ltd. and JEBCO Seismic Company North Flemish Pass Gravity Survey, 2015–2019;
- MG3 (Survey) UK Limited Offshore Labrador Geochemical and Seabed Sampling Program, Newfoundland and Labrador Offshore Area, 2015–2024;
- HMDC Ltd. 2D/3D/4D Seismic Projects for the Hibernia Oil and Gas Production Field, 2013 to Remaining Life of Field;
- GXT Technology Canada Ltd. GrandSPAN Marine 2D Seismic, Gravity and Magnetic Survey, 2014–2018;
- TGS NOPEC Geophysical Company ASA and MultiKlient Invest AS Offshore Labrador Seafloor and Seabed Sampling Program, Newfoundland and Labrador Offshore Area, 2014–2019;
- Electromagnetic Geoservices Canada Inc. East Canada Controlled Source Electromagnetic Survey, 2014–2018;
- Husky Energy Jeanne d'Arc Basin/Flemish Pass Regional Seismic Program, 2012–2020;
- Statoil Canada Limited 2011-2019 Jeanne d'Arc and North Ridge/Flemish Pass Basin Geophysical Program;
- Chevron Northern Grand Banks Regional Seismic Program, 2011–2017;
- ExxonMobil Canada Properties Hebron Development Project;
- Investcan Energy Labrador Seismic Program, 2010–2017;
- Husky Energy Sydney Basin Seismic Program, 2010–2018;
- Husky Energy Labrador Shelf Seismic Program, 2009–2017;
- Petro-Canada Jeanne d'Arc Basin Exploration Drilling Program, 2009–2017;
- Hibernia Drill Centres Construction and Operations Program, 2009–2036;
- Husky Energy Delineation/Exploration Drilling Program for Jeanne d'Arc Basin Area, 2008–2017;

Statoil are currently in the process of proposing a three-year extension to its EA of exploration and appraisal/delineation drilling program for offshore Newfoundland, 2008–2016. If the EA Amendment receives a positive determination from the C-NLOPB, the temporal scope will be extended to 2019.

In addition, there are three existing offshore production developments (Hibernia, Terra Nova, and White Rose) on the northeastern part of the Grand Banks. A fourth development (Hebron) is anticipated to commence installation in 2017. The existing developments fall inside of the boundaries of MKI's Regional Area but do not create the same types and levels of underwater noise as seismic, geohazard, or VSP programs.

There is potential for cumulative effects with other seismic programs that could operate in 2017 (see above list). Different seismic programs could potentially be operating in relatively close proximity. During these periods, VECs may be exposed to noise from more than one of the seismic survey programs. It will be in the interests of the different parties to arrange for good coordination between programs in order to provide sufficient buffers and to minimize acoustic interference. Assuming maintenance of sufficient separation of seismic vessels operating concurrently in the Project Area, cumulative effects of seismic sound on fish and fish habitat, fisheries, Marine-associated birds, marine mammals, sea turtles, species at risk and sensitive areas are predicted to be *not significant*. However, there are uncertainties regarding this prediction, particularly regarding effects of masking on marine mammals from sound produced during multiple seismic surveys. The potential for temporal and spatial overlap of future activity of seismic programs (2017 and beyond) in the area will be considered in the EA update process. Uncertainty due to the large identified Study Areas will be reduced as specific survey designs that likely cover smaller areas become available.

As discussed in this EA, negative effects (auditory, physical, and behavioural) on key sensitive VECs, such as marine mammals, appear unlikely beyond a localized area from the sound source. In addition, all programs will use mitigation measures such as ramp-ups, delayed startups, shutdowns of the airgun arrays, and spatial separation between seismic surveys.

Any cumulative effects associated with other oil and gas activities in the Regional Area are predicted to be *not significant*. The level of certainty associated with this prediction is *medium*. The cumulative effects associated with this Project will be re-visited in each subsequent EA Update.

5.9 Mitigation Measures and Follow-up

Project mitigations are summarized in this section, both in the text and in Table 5.19. MKI will adhere to mitigations detailed in Appendix 2 of the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2016) including those in the *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*.

Fishers who may be operating in the area will be notified of the timing and location of planned activities by means of a CCG "Notice to Mariners". If necessary, individual fixed gear fishers will be contacted to arrange mutual avoidance. Any incidents of contact with fishing gear with any identifiable markings will be reported to the C-NLOPB within 24 h of the contact (in accordance with the C-NLOPB Incident Reporting and Investigation Guidelines). Fishing gear may only be retrieved from the water by the gear owner (i.e., fishing license owner). This includes buoys, radar reflectors, ropes, nets, pots, etc., associated with fishing gear and/or activity. If gear contact is made during seismic operations, it should not be retrieved or retained by the seismic vessel. There are conditions that may warrant gear being retrieved or retained if it becomes entangled with seismic gear, however, further clarification on rules and regulations regarding fishing gear should be directed to the Conservation and Protection Division of Fisheries and Oceans Canada (NL Region). MKI will advise the C-NLOPB prior to compensating and settling all valid lost gear/income claims promptly and satisfactorily.

Specific mitigations to minimize potential conflicts and any negative effects with other vessels include:

- Timely and clear communications (VHF, HF Satellite, etc.);
- Utilization of FLOs during 2D/3D/4D seismic programs for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- Utilization of experienced, qualified MMO(s);
- Posting of advisories with the Canadian Coast Guard;
- Compensation program in the event any project vessels damage fishing gear; and
- Single Point of Contact (SPOC).

MKI will also coordinate with the FFAW/Unifor and DFO to avoid any potential conflicts with fishing and research surveys that may be operating in the area. MKI commits to ongoing communications with other operators with active seismic programs within the general vicinity of its seismic program to minimize the potential for cumulative effects on VECs.

As stated earlier in this EA, there will be full opportunity for adaptive mitigation during MKI's proposed 10-year program. If there are any new techniques developed during the 10-year period that may help to further mitigate environmental effects, they will be investigated and incorporated into the program if deemed useful. Annual updates of the EA that will be prepared during the 10-year scope of the Project will include any relevant new information related to mitigation not provided in the EA.

Table 5.19 Summary of Mitigations Measures by Potential Effect.

Potential Effects	Primary Mitigations
Interference with fishing vessels/mobile and fixed gear fisheries	• Pre-survey communications, liaison and planning to avoid fishing activity • Continuing communications throughout the program • FLOs • SPOC • Advisories and communications • VMS data • Avoidance of actively fished areas • Start-up meetings on ships that discuss fishing activity and communication protocol with fishers
Fishing gear damage	• Pre-survey communications, liaison and planning to avoid fishing gear • Use of escort vessel • SPOC • Advisories and communications • FLOs • Compensation program • Reporting and documentation • Start-up meetings on ships that discuss fishing activity, communication protocol with fishers, and protocol in the event of fishing gear damage
Interference with shipping	• Advisories and at-sea communications • FLOs (fishing vessels) • Use of escort vessel • SPOC (fishing vessels) • VMS data
Interference with DFO/FFAW research program	• Communications and scheduling • 7-day/30-km temporal/spatial avoidance protocol
Temporary or permanent hearing damage/disturbance to marine animals (marine mammals, sea turtles, seabirds, fish, invertebrates)	• Pre-watch (30 minute) of 500 m safety zone • Delay start-up if any marine mammals or sea turtles are within 500 m • Ramp-up of airguns • Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m • Use of experienced, qualified MMO(s) to monitor for marine mammals and sea turtles during all daylight periods when airguns are in use and the 30-minutes preceding ramp up
Temporary or permanent hearing damage/ disturbance to Species at Risk or other key habitats	• Pre-watch (30 minute) of 500 m safety zone • Delay start-up if any marine mammals or sea turtles are within 500 m • Ramp-up of airguns • Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m • Use of experienced, qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations. [No critical habitat has been identified in or near the Study Area.]
Injury (mortality) to stranded seabirds	• Daily search of seismic and support vessels • Implementation of handling and release protocols • Minimize lighting if safe
Seabird oiling	• Adherence to MARPOL • Adherence to conditions of CWS migratory bird permit • Spill contingency and response plans • Use of solid streamer

Mitigation measures designed to reduce the likelihood of impacts on marine mammals and sea turtles will include ramp ups, no initiation of airgun array if a marine mammal or sea turtle is sighted 30 min prior to ramp up within 500 m safety zone of the energy source, and shutdown of the energy source if an *endangered* or *threatened* whale or sea turtle is observed within the 500 m safety zone. Prior to the onset of the seismic survey, the airgun array will be gradually ramped up. One airgun will be activated first and then the volume of the array will be increased gradually over a recommended 30 min period. An MMO aboard the seismic ship will watch for marine mammals and sea turtles 30 min prior to ramp up. If a marine mammal or sea turtle is sighted within 500 m of the array, then ramp up will not commence until the animal has moved beyond the 500 m zone or 30 min have elapsed since the last sighting. The observers will watch for marine mammals and sea turtles during daylight periods and note the location and behaviour of these animals. Only visual monitoring is planned. The aspects of the monitoring and mitigation plan include the use of the ship's bridge for MMOs from which to conduct observations (i.e., good sight lines all around the vessel), and the use of reticle binoculars and other distance estimators to accurately estimate the location of the animal with respect to the safety zone. The seismic array will be shut down whenever marine mammals or sea turtles with either *endangered* or *threatened* statuses under Schedule 1 of *SARA* are observed within the safety zone. Additionally, shut downs will be implemented for loggerhead sea turtles which are considered endangered by COSEWIC. The planned monitoring and mitigation measures will minimize the already low probability of exposure of marine animals to sounds strong enough to induce hearing impairment. Any dead or distressed marine mammals or sea turtles will be recorded and reported to the C-NLOPB.

Any seabirds that become stranded on a vessel (most likely Leach's Storm-petrel) will be released using the mitigation methods consistent with *The Leach's Storm-Petrel: General Information and Handling Instructions* by U. Williams (Petro-Canada) and J. Chardine (CWS) (n.d.), and *Best Practices for Stranded Birds Encountered Offshore, Atlantic Canada [Draft]* (EC 2015b). Data collection for seabirds at sea will be in accordance with Gjerdrum et al. (2012). It is understood by MKI that a CWS *Migratory Birds Permit* will be required and that it will be secured as it has been in the past. MKI will adhere to the conditions stipulated on the CWS permit. In the unlikely event that marine mammals, sea turtles or seabirds are injured or killed by Project equipment or accidental releases of hydrocarbons, a report will immediately be filed with the appropriate agencies (CWS, C-NLOPB) and the need for follow-up monitoring will be assessed.

Marine mammal and seabird observations will be made during ramp-ups and data acquisition periods, as well as at other times on an opportunistic basis. As per the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2016), monitoring protocols for marine mammals and sea turtles will be consistent with those developed by LGL and outlined in Moulton and Mactavish (2004). Seabird data collection protocols will be consistent with those provided by CWS in Gjerdrum et al. (2012). Data will be collected by qualified and experienced MMOs and a monitoring report will be submitted to the C-NLOPB.

MKI will also coordinate with DFO, St. John's, and the FFAW/Unifor to avoid any potential conflicts with either survey vessels that may be operating in the area or survey stations in the area (e.g., Industry-DFO-FFAW/Unifor Collaborative Post-Season Trap Survey for Snow Crab. MKI commits to ongoing communications with other operators with active seismic programs within the general vicinity of its seismic program to minimize the potential for cumulative effects on the VECs.

5.10 Assessment Summary

A summary of the significance ratings of residual effects of MKI's proposed seismic program on the environment are shown in Table 5.20. The levels of confidence are also provided in the table. In summary, the residual effects of MKI's proposed seismic program on the VECs are predicted to be *not significant*.

Table 5.20 Significance of Potential Residual Environmental Effects of MKI's Proposed Seismic Program on VECs in the Study Area.

Valued Environmental Components: Fish and Fish Habitat, Fisheries, Marine-associated Birds, Marine Mammals and Sea Turtles, Species at Risk, Sensitive Areas				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Sound				
Airgun Array (2D, 3D and 4D)	NS	2-3	-	-
Seismic Vessel	NS	2-3	-	-
Escort vessel	NS	2-3		
Supply Vessel	NS	2-3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	2-3	-	-
Side Scan Sonar	NS	2-3	-	-
Vessel Lights	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Valued Environmental Components: Fish and Fish Habitat, Fisheries, Marine-associated Birds, Marine Mammals and Sea Turtles, Species at Risk, Sensitive Areas				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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
2 = Medium
3 = High

[a] Considered only in the case where 'significant negative effect' is predicted.

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Personal Communication

D. Fifield – Environment Canada, Canadian Wildlife Service

J. Lawson – Fisheries and Oceans Canada.

H. Moors-Murphy – Fisheries and Oceans Canada.

C. Morris – Fisheries and Oceans Canada.

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Appendix 1

Consultations Report

Labrador

As part of the environmental assessment of Multiklient Invest's (MKI) proposed 2017–2026 seismic program, consultations were undertaken with relevant Labrador government agencies, representatives of the fishing industry and other interest groups. The objectives of these consultations were to describe the proposed seismic program, identify any issues and concerns, and gather additional information relevant to the EA process.

MKI has been operating in the Labrador Sea offshore since 2011 and communication with interested groups has been maintained over this time. Relevant agencies, municipal governments and industry stakeholder groups contacted by either phone or email in mid-January 2017 are listed below. The link to MKI's Project Description document on the C-NLOPB website was provided to the contacted consultees.

- Cartwright Town Council;
- Town of Charlottetown;
- Labrador Choice Seafoods Inc, Charlottetown;
- Forteau Town Council;
- Town of Happy Valley-Goose Bay (HV-GB);
- NunatuKavut Community Council, HV-GB;
- Nunacor Development Corporation, HV-GB;
- Torngat Fish Producers Co-operative Society Inc., HV-GB;
- Torngat Secretariat, HV-GB;
- Town of L'Anse au Loup;
- Labrador Fishermen's Union Shrimp Company Ltd., L'Anse au Loup;
- Town of Mary's Harbor;
- Mary's Harbour Fishers' Committee, Mary's Harbour;
- Nunatsiavut Government (Department of Lands and Natural Resources), Nain;
- Nain Inuit Community Government, Nain;
- Town of North West River;
- Community of Pinsent's Arm;
- Town of Port Hope Simpson;
- Sheshatshiu First Nation Innu Band Council; and
- Innu Nation, Sheshatshiu.

During the period of 24–27 January 2017, both face-to-face meetings and public information sessions were held in two Labrador communities: (1) Mary's Harbour and (2) Happy Valley-Goose Bay. More consultations in Labrador (e.g., Nunatsiavut Government in Nain) are planned for March 2017. Table 1 provides more information on these consultations.

Table 1. Labrador Consultations

Date	Community	Type of Consultation	Consultee
January 24, 2016	Mary's Harbour	Face-to-Face	Labrador Fishermen's Union Shrimp Company Ltd. (LFUSCL)
January 24, 2016	Mary's Harbour	Face-to-Face	Mayor
January 24, 2016	Mary's Harbour	Public Information Session	Public
January 25, 2016	HV-GB	Face-to-Face	Torngat Secretariat
January 26, 2016	HV-GB	Face-to-Face	Torngat Fish Co-op
January 26, 2016	HV-GB	Public Information Session	Public
January 27, 2016	HV-GB	Face-to-Face	Innu Nation

Issues and Concerns

Comments and responses received to date from various stakeholders are provided below.

Mary's Harbour

Labrador Fishermen's Union Shrimp Company Ltd. (LFUSCL)

LFUSCL's Fisheries Advisor attended the consultation meeting with MKI. He expressed general concerns about the Hawke Channel DFO Fisheries Closure Area and indicated that he would return at the public information session that evening to further discuss the proposed program with other community members.

Mayor

Like the LFUSCL's Fisheries Advisor, the Mayor of Mary's Harbour (and FFAW Inshore Council Member – Henley Harbour to Cartwright) expressed general concerns about the Hawke Channel DFO Fisheries Closure Area and indicated that he would return at the public information session that evening to further discuss the proposed program with other community members. This was agreed to be the best forum for an open discussion.

Public Information Session

Following a presentation by MKI's representative, attending participants had comments and questions. The main concern regarded plans for the Hawke Channel DFO Fisheries Closure Area. MKI indicated that it has no intention of collecting seismic data in this area. Their activities are driven by interest in the data and this does not appear to be an area of interest.

Question: How large are the areas up for bids?
Response: Typically 3,000–4,000 km^2.

Question: Do you get all the data from a ship or any from satellite?
Response: All the data is collected from a ship.

Question: How deep are you looking?
Response: A deep well could be 5 km deep.

Question: How deep are the streamers? Are they at the surface?
Response: The streamers are 20 m below the surface. Only the tailboys at the end of the streamers are at the surface.

Question: In the past, we've asked you guys to stay outside of The Box (Hawke Channel DFO Fisheries Closure Area).
Response: We won't be looking to acquire in The Box. There is no anticipated interest or activity planned in The Box.

Question: The area in the northern part of the project area might have some corals. It could become a marine sensitive area.
Response: Nalcor has a desire to get some information in the northern portion of the Project Area so that educated decisions can be made in the future if an area is closed and inaccessible down the line.

Question: The work planned, it seems far off The Box.
Response: Yes, and most interest moving forward will be 3D-based. So it's a much smaller area being surveyed and over Exploration Licences.

Question: Is the work you are showing close to past work, like the Petro-Canada work in the 70s?
Response: We did some work there in the past, but there is little interest now.

Question: Husky, Chevron and another company bid on blocks that did nothing. Could they get extensions? Is the money lost?
Response: They did not ask for extensions. The money is indeed lost. That's part of the gamble. It's a numbers game.

Question: The biggest concern is what is the ping doing to the fish?
Response: Unless the fish are very near to the source, the main effect tends to be minor movement away from the source and vessel. We coordinate our activities to minimize the impact on the fisheries. There is a fund, the Environmental Studies Research Funds (ESRF), that funds this type of study, including a study on snow crab. The data will come out soon. Also, the EA will include a summary of studies looking at the impact of seismic on fish.

Question: Any work on shrimp? That could be a more important species moving forward. Is there any movement up the water column?

Response: Not yet, but some species show temporary vertical movement up and down the water column.

Question: How fast does the ship steam when collecting data?

Response: The sails at a speed of 4–5 knots when acquiring data.

Question: Anything at the end to float the streamer?

Response: Yes, there are tailboys with GPS at the end so we can position the streamers properly.

Question: Do you have a website that you have this on?

Response: All of the documents relevant to the program, including consultations, comments and responses are on the C-NLOPB website.

Happy Valley-Goose Bay

Torngat Secretariat

Following MKI's presentation, representatives of the Torngat Secretariat offered comments and questions, mainly regarding marine mammal observers (MMOs). In general, it was acknowledged that the program was similar to other recent seismic programs offshore Labrador. Questions/comments from the representatives and MKI's responses are provided below:

Question: Who do you use for trained MMOs? Local and trained observers?

Response: We will try to get all NL personnel. In the past, we always had an Inuit MMO onboard. There is no reason Inuit MMOs can't act as MMOs with the right training.

Question: Who did you get last year as MMO contractor?

Response: RPS. Most of the MMOs were from NL. One was from Nova Scotia.

Comment: Ensure we maintain our communication as the program moves forward.

Torngat Fish Co-op

Following MKI's presentation, representatives of the Torngat Fish Co-op offered comments and questions. Questions/comments from the representatives and MKI's responses are provided below:

Comment: In our area, there is no affiliation with the FFAW. In the past, we reported to the Single Point of Contact (SPOC).

Comment: In earlier programs, there was an interaction with our fishery, there was no communication, no SPOC. But from that issue, the communication improved and things are good now.

Question: Your plan in our area isn't until the end of July?
Response: Yes, the ice would prevent us from coming earlier.

Comment: Our fishing is focused between your areas of interest for 2D and 3D this year, so we see no conflict.

Comment: Hopedale to Nain is the main turbot area, focused on the shelf and coming closer inshore.

Comment: Your plans work out well for us this year.

Comment: There is a quota for the inshore shrimp fishery for Areas 4 and 5. That's for July through September.

Comment: Our board meeting is at the end of March. If there is updated program information, it would be nice to receive it before this time so that we can pass on the information.
Response: MKI agreed to provide the Torngat Fish Co-op, when submitting the application, with an updated map indicating plans and more defined areas of interest for 2017.

Public Information Session

Five people attended the HV-GB public meeting. Many questions and discussions were asked at the prior to MKI's presentation. Most of the discussions and concerns were not oriented at the proposed program, but focused primarily on general concerns regarding the global need and desire for energy development projects, notably Muskrat Falls, and the resulting destruction of the environment.

Question: How close to shore do you come?
Response: Most of the activity is at least 60–70 miles offshore.

Question: Most of the fishing activity is more inshore.
Response: Yes and we are in constant communication with them. We wouldn't come up until about the last week of July because of ice.

Question: Is it similar to GPR (Ground Penetrating Radar)?
Response: Yes and no. Seismic involves sound waves rather than radio waves. The sound waves are low frequency waves.

Question: Is it like an explosion?
Response: Back in the day, seismic exploration used to use explosives.

Question: What is the frequency range?
Response: Seismic uses frequencies in the order of 2 Hz to 150–250 Hz.

Question: What kind of effect on sea life?
Response: In general, the effects on sea life are behavioural in nature. This usually involves small and temporary localized displacements. There haven't been any long-term effects recorded in past seismic programs. The EA will include summaries of the known literature on the effects of seismic activity on fish, invertebrates, marine mammals and seabirds.

Question: Are there times of year you can't go?
Response: There are no restrictions with respect to wildlife, within the temporal scale of the approved program. Most of the limitations are a result of ice and weather conditions.
Question: Did the Strategic Environmental Assessment (SEA) approve the activity?
Response: With the right mitigation measures in place, the SEA did not indicate any significant effects to populations from seismic exploration.

Question: How do you determine what is environmentally sensitive?
Response: Through consultations with the public, stakeholder groups and regulators.

Question: Would you be willing to wait for stakeholders to voice an opinion?
Response: We will follow the process. This is what meetings like these are for, for stakeholders to voice an opinion.

Question: So the environmental assessment is just starting?
Response: Yes.

Question: Can you still work off the old EAs?
Response: Yes, until they expire.

Comment: The problem is that we lose our power as you move out to sea. Nalcor is poisoning that area with its activities. Is the gas more important than the fish?

Question: Who makes sure mitigations are followed?
Response: Observers onboard the vessel.

Question: Who pays for them? Are they on your payroll?
Response: Ultimately, we end up paying for everything, yes.

Comment: All these energy development projects are destroying the planet. You're destroying the environment and the planet.

Question: What's the public involvement? How can I determine the parameters of the EA?
Response: We have to follow guidelines set by the C-NLOPB.

Comment: We don't want any more oil.

Comment: I'm concerned about the fish and invertebrates that can't move away. Fish don't stand a chance. Seismic will kill fish eggs and larvae.
Response: The assessment recognizes that some injury or mortality to fish eggs and larvae could occur during seismic surveys, but only if the eggs and larvae were very close to the airguns. The potential numbers would be very low and have no impact on populations.

Comment: I have a copy of a letter sent to President Obama signed by 75 research scientists saying that seismic is bad and should not be happening.
Response: Our guess is that this letter is related mainly to right whale critical habitat and the risk that it would pose to this endangered population in and near its critical habitat. The proposed survey does not occur over an area having been identified as critical to a marine mammal species. There are no sensitive areas offshore Labrador like there is for right whale in the U.S. Atlantic offshore. The endangered status of right whales, however, is recognized in the assessment and mitigation measures such as ramp up and shutdowns will be put in place.

[Note: MKI was not shown the letter during the meeting. MKI followed up by e-mail with the participant to get a copy of the letter in question. The letter in question was not the one originally thought (dated 14 April 2016), but an earlier version (dated 5 March 2015) that did not include references to studies supporting the statements. While some scientific statements presented in the letter appear factual, they are mostly taken out of context where controlled exposure laboratory studies of invertebrates have been extrapolated to field conditions. Other statements, however, present hypothetical statements that have not been documented during past seismic surveys such as "surveys could increase the risk of calves being separated from their mothers, the effects of which can be lethal".]

Comment: Maybe seismic isn't serious, but drilling is.

Question: Any sensitive areas identified?
Response: Hawke Channel DFO Fisheries Closure Area has been identified by groups consulted as a sensitive area and it will be avoided, but there are no other specific exclusion zones identified within the Project Area.

Innu Nation

Following MKI's presentation, the representative of Innu Nation offered comments and questions. These are provided below:

Question: What size is the exclusion zone again?
Response: It is 500 m. It applies to the pre-ramp up watch and during airgun activities for endangered and threatened species.

Question: Will there be opportunities for work, including observers?
Response: Yes, but the Benefit Plan will deal with this. Essentially, the EA and the Benefit Plan are two separate things. With regards to local benefits, there are other positions available on the vessel as well, in addition to observers.

Agency/Stakeholder Individuals Involved in the Labrador Face-to-Face Consultations

The individuals associated with the Labrador agencies, managers and fishing industry participants consulted during the preparation of MKI's Environmental Assessment are indicated below. Further Labrador consultations are planned for March 2017.

Labrador Fishermen's Union Shrimp Company Ltd. (LFUSCL)

Claude Rumbolt, Fisheries Advisor

Mary's Harbour Mayor

Alton Rumbolt, Mayor; Chair of Mary's Harbour Fishers Committee; FFAW Inshore Council Member (Henley Harbour to Cartwright)

Mary's Harbour (Public Meeting)

Three participants at the Riverlodge Hotel meeting room.

Torngat Secretariat

Victoria Neville, Fisheries Research Program Director
Robyn Morris, Policy Analyst

Torngat Fish Co-op

Keith Watts, General Manager; Torngat Joint Fisheries Board (Nunatsiavut Appointee)
Ron Johnson, Assistant General Manager

<u>Town of Happy Valley-Goose Bay</u>

Five participants at the Labrador Friendship Centre.

<u>Innu Nation</u>

Paula Reid, Environmental Advisor

St. John's

As part of the environmental assessment of Multiklient Invest's (MKI) proposed 2017–2026 seismic program, consultations were undertaken with relevant government agencies, representatives of the fishing industry and other interest groups based in St. John's. The objectives of these consultations were to describe the proposed seismic program, identify any issues and concerns, and gather additional information relevant to the EA process.

Relevant agencies, municipal governments and industry stakeholder groups contacted by MKI in January 2017 are listed below.

- Environment Canada (EC);
- Nature Newfoundland and Labrador (NNL);
- One Ocean;
- Fish, Food and Allied Workers Union (FFAW)/Unifor;
- Association of Seafood Producers (ASP);
- Ocean Choice International (OCI);
- Groundfish Enterprise Allocation Council (GEAC) Ottawa;
- Canadian Association of Prawn Producers;
- Clearwater Seafoods;
- Icewater Seafoods; and
- Newfound Resources Ltd. (NRL).

The face-to-face consultations held in St. John's during 31 January-2 February 2017 were organized and coordinated by MKI. Those that requested face-to-face meetings are indicated below. Topics raised at each meeting after the MKI presentation are bulleted below.

Environment Canada (31 January 2017)

- Source array ramp up protocol was explained;
- MARPOL reporting was clarified;
- After-dark lighting on Project vessels was described; and

- Provided details on a typical acquisition season and how weather affects operations.

FFAW/Unifor (31 January 2017)

- Discussion about the post-season snow crab survey, particularly regarding the addition of sampling stations.

Newfound Resources Ltd. (2 February 2017)

- Shrimp harvesting season is complete by the time of onset of seismic activity.

One Ocean (2 February 2017)

- No details from the meeting.

Nature Newfoundland and Labrador (2 February 2017)

- Question about minimizing the level of light being emitted during seismic operation – MKI indicated that lighting on the outside of the seismic vessel is limited to navigation lights and lights in the back deck work areas;
- Question about the effectiveness of source ramp-up to motivate marine mammals to move away from the sound source – MKI indicated that data collected thus far indicates that marine mammals are observed farther from the sound source when it is active than when it is inactive; and
- Request that MKI make metadata collected during seismic operations available for metocean research – MKI indicated that it would look into what archived metadata are available for release.

MKI intends to provide more details about its 2017 activities to all consultees once they are finalized in March 2017.

Agency/Stakeholder Individuals Involved in the St. John's Consultations

The following agencies, managers and fishing industry participants in St. John's were consulted during the preparation of MKI's Environmental Assessment.

<u>Environment Canada</u>

Glenn Troke

Nature Newfoundland and Labrador

Len Zedel

One Ocean

Maureen Murphy-Rustad, Director

FFAW/Unifor

Dwan Street, Petroleum Industry Liaison
Johan Joensen, Industry Liaison

Association of Seafood Producers

Derek Butler, Executive Director

Ocean Choice International

Rick Ellis, Director of Operations

Groundfish Enterprise Allocation Council

Kris Vascotto, Executive Director

Canadian Association of Prawn Producers

Bruce Chapman, Executive Director

Clearwater Seafoods

Catherine Boyd, Acting Director/Sustainability and Public Affairs

Icewater Seafoods Inc.

Alberto Wareham, President

Newfound Resources Ltd.

Joel Hickey, Operations Manager