4.2 Biological Environment

The following sections present an overview of relevant aspects of the biological environment of the Study Area, including Fish and Fish Habitat, Marine / Migratory Birds, Marine Mammals and Sea Turtles.

4.2.1 Marine Fish and Fish Habitat

Key elements of the Study Area's marine ecosystem range from primary producers such as phytoplankton to consumers such as zooplankton, benthic invertebrates and fish. The following includes a discussion of relevant fish species, as well as plankton, algae and benthos and relevant components of their habitats, given the clear interrelationships between these components of the marine environment.

4.2.1.1 Approach, Key Data Sources and Administrative Considerations

The following sections provide an overview of the existing ecological setting of the Study Area and describe the associated faunal assemblages, Species at Risk (SAR) and ecologically sensitive areas. In addition, ecological information is summarized for many of the taxa that characterize the habitats of the Study Area. While the bulk of this information is compiled from existing and on-going Strategic Environmental Assessments (SEAs) for the offshore areas off southern and eastern Newfoundland (LGL 2010; AMEC 2014), additional information has been obtained from new scientific literature and supplemental analysis has been conducted to present ecological data in a manner that is consistent across the Study Area.

A number of regulatory jurisdictions occur within or immediately adjacent to the Study Area. The Canadian and French governments have jurisdiction over fish and invertebrate stocks within their offshore areas (EEZs), and the Canadian government has jurisdiction over benthic invertebrates (e.g. crab) that extend beyond the 200 nautical mile EEZ limit, to the edge of the continental shelf. The North Atlantic Fisheries Organization (NAFO) manages groundfish activities beyond the 200 mile limit and other resources beyond the continental shelf (e.g. invertebrates; NAFO 2013). The available data from Canada's DFO (up to 2012) are based on random, stratified sampling methodologies and provide the most up-to-date information available (within the area sampled) that can be applied in a consistent manner across a large portion of the Study Area. As a result, these data are used as the foundation for defining focal species and for describing contemporary distributions. It is recognized that the sampling approach does not include all portions of the Study Area (e.g. those under NAFO and French jurisdiction) and that certain taxa (e.g. pelagic, abyssal and infaunal species) are poorly represented. Nonetheless, the approach provides useful information for a considerable portion of the Study Area on many ecologically and commercially important taxa.

Both of the current SEAs for the Study Area (LGL 2010; AMEC 2014) draw conclusions on species distributions and abundance from standardized, trawl-based scientific surveys collected by DFO Research Vessels (RV). However, the data and the analytical methods used in these SEAs differ. To ensure compatibility of results, descriptions of species distributions in this assessment were based on the GIS (SPANS - Spatial Analysis System) potential mapping surface methods used in the Eastern Newfoundland Offshore SEA (AMEC 2014). These methods, which have distinct advantages for spatial analysis (AMEC 2014), were applied to the entire Study Area for the purposes of this EA.

The Newfoundland and Labrador Region surveys take place in different but overlapping areas, in the spring (NAFO Divisions 3LNOPs) and in the fall (NAFO Divisions 2HJ3KLMNO) (See later Figures 4.66 and 4.67) using the Campelen-1800 shrimp trawl. Data from the most recent period available (2008-2012) were used to describe distributions of fish in the Study Area. Where available, both spring and fall survey data (3LNMO) where used to characterize fish distributions. However, mapping of fish distributions in 3K were derived from fall data only. Qualitative examination suggests that for most species, distributions are similar for the spring and fall survey in 3LMNO.

The data from the survey were further screened to identify key species that occurred in high abundance (cumulatively exceeded more than 95 percent of individuals captured). From this process, 16 focal taxa (13 fish and 3 invertebrate species) were identified, and their distributions are described in further detail and mapped in the following sections. The SPANS potential mapping surface function was used to produce generalized species distribution maps. The method is well suited for spatially analyzing research survey data because it converts point estimates (in this case individual survey set catch rates) into continuous surfaces. Extent and location of density-constant subareas is allowed to vary according to distributional changes of the fish. That is, the technique makes use of the geo-referenced survey catch rate data to define spatial differences in fish density. Creation of a surface representative of the data is superior to simple expanding symbol plots because it avoids the problem of masking of patterns in the data when the circles overlap. This is a well established approach and has been used to describe fish distribution and populations in numerous studies (Kulka 1998a, b; Kulka et al 2003a, b; Kulka et al 2007; Han and Kulka 2007; Kulka 2009; AMEC 2013; 2014). These maps are displayed and described for focal benthic and finfish species.

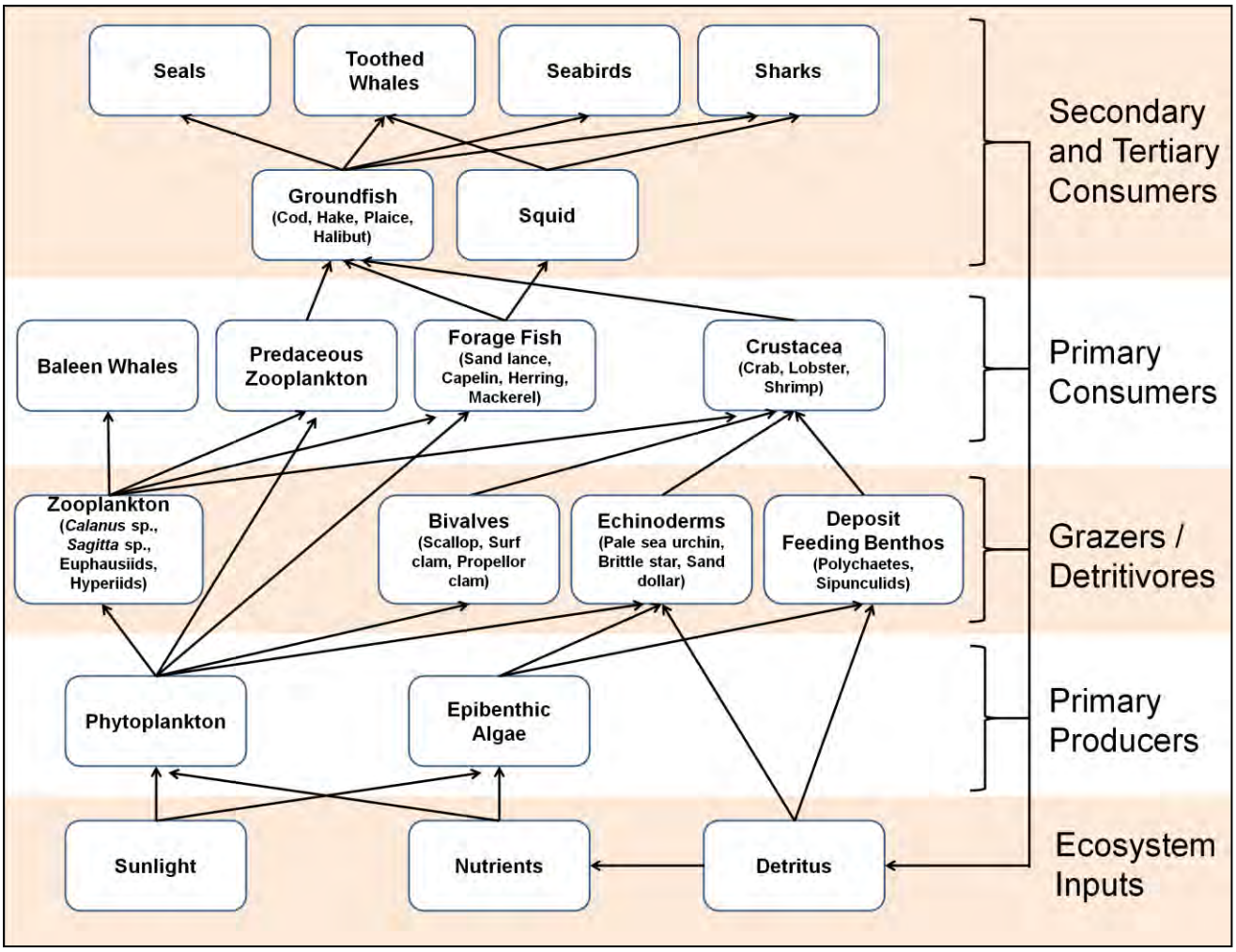
4.2.1.2 Key Taxa, Assemblages, Ecological Regimes

All species in the Study Area play an ecosystem role through which they interact with many other species, either directly or indirectly (e.g. Gomes et al 1992; Templeman 2010; Dawe et al 2012; Figure 4.13). For example, in the Study Area, primary production is predominantly derived through phytoplankton and epibenthic algae. These tiny photosynthetic organisms form the base of the food chain which feed energy to higher trophic levels (fish, marine mammals and birds), through zooplankton, planktivorous fish and invertebrates. Detritivores, which return nutrients from dead organisms back into the food chain (Figure 4.13), complete the energy cycle. Perturbations to some species (e.g. overfishing, climate change) are therefore transferred across the ecosystem through ecological processes and interactions such as predation and competition (e.g. Rose 2004; Koen-Alonso et al 2010; Devine and Haedrich 2011; Dawe et al 2012).

Consequently, overfishing of some commercial species coupled with climate change has created widespread change in the Study Area's ecosystem, which included increases in primary production, shrimp and crab and reductions of long lived groundfish species (deYoung et al 2004; Koen-Alonso et al 2010; Dawe et al 2012). To compound the colder environmental conditions that favoured invertebrate species such as snow crab and shrimp (deYoung et al 2004), the collapse of groundfish stocks also released some species such as shrimp from predation, further augmenting their abundance (Worm and Myers 2003; Dawe et al 2012). During this same period, declines in capelin, an important prey species along the Newfoundland Shelf, also forced species like cod to rely more heavily on lower quality prey such as shrimp (Dawe et al 2012) and deepwater species such as Greenland halibut to resort to feeding on alternate prey species such as grenadier. Currently, waters in the Study Area are on a warming trend, which is coinciding with reports from fishermen and scientists of declines

in snow crab and signs that some groundfish species are showing signs of recovery (Koen-Alonso et al 2010; Templeman 2010; Dawe et al 2012).

Figure 4.13 Major Ecosystem Elements of the Study Area and Key Trophic Links



Source: Adapted from Gomes et al (1992) and Templeman (2010)

Assemblages and Taxonomic Groups in the Study Area

Flora and fauna distribute themselves across the Study Area in a manner that reflects environmental and habitat preferences as well as interactions within and across species (e.g. competition and predation). When species overlap consistently in time space, they form assemblages (Haedrich and Merritt 1990). Assemblages across much of the Study Area are described in AMEC (2014) where:

- The "warm water" assemblages (e.g. white hake, argentine, silver hake, Atlantic halibut, longfin hake, butterfish, billfish), resembling those of the Scotian Shelf, occupy Gulf stream influenced waters along the south coast of Newfoundland;

- The northern Grand Banks, influenced by the cold Labrador Current is characterized by species usually found further north along the shelf (e.g. Arctic sculpin, Arctic cod, Northern shrimp and snow crab);

- Depth segregated assemblages with shallow water groups (yellowtail flounder, sea ravens and longhorn sculpin) give way to slope assemblages (Greenland halibut, wolffish and redfish) and finally to deep slope-abyssal assemblages (lanternfish, grenadiers, blue hake, deepwater eels, rocklings, Bean's saw-toothed eels, deep sea lizardfish);

- Within depth zones, habitat complexity can also be a discriminating factor of assemblages. For example, spotted wolffish and some invertebrate species are found primarily associated with structured habitats (e.g. Beazley et al 2013), whereas other species avoid habitat complexity (e.g. snub-nosed eels); and

- Some species are widely spread across the Study Area (e.g. American plaice, Atlantic cod, thorny skate and striped wolffish).

Key species from each assemblage are described in further detail in the sections that follow.

4.2.1.3 Plankton

Plankton are small free floating organisms that include microscopic marine plants (phytoplankton), invertebrates (zooplankton), vertebrate eggs and larvae (ichthyoplankton), bacteria, fungi, and even viruses. These organisms make up the dominant group in the ocean, both in terms of diversity and biomass and consequently play an important role as the base layers of most food webs (primary and secondary production). Therefore, areas of high plankton abundance typically correspond with aggregations of animals higher in the food chain (Beazley et al 2013). In addition to being a food source, most commercial finfish and invertebrate species spend at least one of their life stages in the water column as plankton. Recent studies (e.g. Morales 1999) have also shown the importance that zooplankton play in the carbon and nitrogen cycle in terms of creating a biological pump transferring organic matter from depth to the surface (benthic-pelagic coupling).

Phytoplankton

The distribution of phytoplankton (primary producers) in the Study Area is typically enhanced in the frontal zones and areas of upwelling, which transport nutrients to the illuminated surface waters and fuel population growth of autotrophic organisms. Topography and currents create conditions for upwelling, which are often found on the shelf break and within the thermal gradients between the shelf and slope waters (Anderson and Gardner 1986; Templeman 2007). Frontal zones are created by converging currents (e.g. where the Labrador Current and the Gulf Stream meet) and serve to concentrate plankton. Such areas of particularly high production can be found at the Southeast Shoal and Tail of the Grand Banks (Templeman 2007).

Newfoundland waters are characterized by a spring and fall bloom. Increased sunlight and surface waters infused with nutrients create conditions for the spring bloom, which usually occurs in April (Maillet et al 2004). However a thermocline is created as waters warm, above which plankton production is stunted due to depleting nutrients and increased zooplankton grazing. The arrival of autumn winds breaks down the thermocline and replenishes nutrients in surface waters and permits a second, weaker bloom (Maillet et al 2004).

Phytoplankton communities are dynamic and exhibit both seasonal and decadal variability. For example, plankton abundance has been decreasing since a peak in the 1990s in the North Atlantic (Maillet et al 2004; Head and Sameoto 2007). It is believed that these changes are linked with the Northern Atlantic Oscillation (NAO), which indicates the intensification of northwestern atmospheric flows that cause increased mixing and sea ice extent and colder, fresher ocean conditions. Such conditions correspond to elevated nutrient levels that enhance primary productivity (Maillet et al 2004). Diatoms are the dominant primary producer, with mean annual densities of 10,000 to 30,000 cells per cubic meter, but they typically dominate phytoplankton communities in the spring and are later supplanted by flagellates and dinoflagellates in the fall bloom.

Zooplankton

Zooplankton are a critical link between primary producers and the species that occupy higher trophic levels (e.g. fish, whales and seabirds) (Maillet et al 2004). Their population growth is dependent upon phytoplankton and as a result their abundance is closely associated with phytoplankton in both time and space. Peaks in zooplankton occur following the spring and decline afterward as the phytoplankton food base is depleted and the zooplankton community is preyed upon by planktivores such as other zooplankton, fish and marine mammals. Herbivorous copepods (e.g. *Calanus finmarchicus*) make up about 80 percent of the zooplankton species richness (Dalley et al 2001) in the Northwest Atlantic. Copepods are followed by cladocerans, Limacina, Larvaveans and bivalves (Dalley et al 2001; Table 4.5). Another phytoplankton herbivore, euphausiids (krill), can be locally abundant (e.g. the Laurentian Channel) and an important food item for large marine mammals (Plourde and McQuinn 2009).

As with phytoplankton, zooplankton show trends in community structure and abundance at several temporal and spatial scales (Morales 1999; Dalley et al 2001). For example, the copepod *Calanus hyperboreaus* has been increasing in the last few decades and within years can be found at its highest abundance in June (Maillet et al 2004). Numerous zooplankton species also exhibit diel vertical migrations (DVM); rising up in the water column at night (Dalley and Anderson 1998). In the Northwest Atlantic, *Euchaeta norvegica and C. Finmarchicus* are the most important contributors to total migrating biomass (Hays 1996). These migrations form a “biological pump” that transports organic carbon and nitrogen through the water column (e.g. thermoclines) and are an important component of benthic-pelagic coupling (Morales 1999). Surveys of the Grand Banks and Newfoundland Shelf indicate a north-south decline in total zooplankton biomass, with peaks in production occurring from inshore areas to the shelf edge depending on the year (Dalley and Anderson 1998). However, taxa-specific distributions vary by species. For example, jellyfish were predominantly found in inshore areas and on the northern Grand Banks (Dalley and Anderson 1998). Dominant zooplankton taxa are presented in Table 4.5

Table 4.5 Dominant Zooplankton Taxa from 1997 Invertebrate Zooplankton Survey on the Newfoundland Shelf and Grand Banks

Group	Taxa / Taxon	% Total Zooplankton
Copepods	**Total**	**86.8**
	Oithona similis	49.6
	Pseudocalanus sp.	11.8
	Centropages hamatus	6.7
	Calanus finmarchicus	4.8
	Temora longicornis	4.5
	Calanus hyperboreus	0.3
	Misc. Copepods	8.9
Other	**Total**	**13.2**
	Cladocerans	5.2
	Limacina	3.0
	Larvaveans	2.3
	Bivalve larvae	1.1
	Tomopteris	0.4
	Cnidarians	0.2
	Euphausids	0.2
	Chaetognaths	0.1
	Snow crab	0.1
	Hyperids	0.0
	Mysids	0.0
	Misc. Zooplankton	0.6
All Zooplankton	**Total**	**100.0**

Ichthyoplankton

The eggs of many marine fish species are released into the water column where they passively disperse while developing into larvae. Densities of fish larvae can vary by orders of magnitude from year to year (Dalley and Anderson 1998; Bradbury et al 1999) and within years are patchy in time and space (Frank et al 1992; Dalley and Anderson 1998; Bradbury et al 2008). Mortality of larval stages can be high and therefore the survival of this life stage often defines recruitment success (Cushing 1990). Synchrony of larval stages with plankton blooms is observed in many species, and is thought to be an adaptive trait that increases survival by providing access to an abundant food source.

While the passive movements of fish eggs and larvae are not well understood (LGL 2010), it is known that some oceanographic features such as thermoclines (Frank et al 1992), upwelling zones (Ings et al 2008) and gyres (Bradbury et al 2008) can retain ichthyoplankton. There is some evidence however, that the nature of ichthyoplankton drift differs across the Study Area. For example, coastal areas of the northeast coast of Newfoundland are receiving areas for drifting larvae originating from offshore, whereas Placentia Bay serves as a source of eggs and larvae, which upon exiting the bay are swept westward to offshore areas (Bradbury et al 1999; Bradbury et al 2008). Furthermore, the retentiveness of certain oceanic features can differ across seasons. In Placentia Bay, summer oceanographic conditions are more likely to retain cod larvae than those of the spring, which transport them offshore (Bradbury et al 2008).

The ichthyoplankton communities along the Northeast Newfoundland Shelf and the Grand Banks have been described by Dalley and Anderson (1998). While the abundance of most species differed across regions and years, capelin comprised of 68 percent of the ichthyoplankton, followed by sand lance (22 percent), lanternfish (11 percent) and Arctic cod (four percent) (Table 4.6). Other fish species that were regularly captured in tows included sculpins, blennies, Atlantic cod, wolffish, alligatorfish, shannies, seasnails, redfish and American plaice. Although not a fish, squid larvae were also noted for being widespread across the Grand Banks and Newfoundland Shelf. Spatial patterns were also apparent for many of these species. For example, blennies, sculpins, squid, seasnails, alligatorfish and wolffish were more abundant on the Newfoundland Shelf than on the Grand Banks, and among those species, blennies, sculpins and seasnails were generally found in inner shelf waters while wolffish were predominantly found over offshore banks. In contrast, sand lance and hake were found predominantly over the Grand Banks (Dalley and Anderson 1998).

Table 4.6 Relative Abundance of Dominant Fish Species Caught in the International Young Gadoid Pelagic Trawl during the Pelagic 0-Group Survey in 1998

Species	Scientific Name	Relative Abundance (%)
Capelin	*Mallotus villosus*	58.0
Sand lance	*Ammodytes* sp.	22.0
Lanternfish	Myctophidae	11.4
Arctic cod	*Boreogadus saida*	3.7
Squid	Cephalopoda	1.5
Alligatorfish	Agonidae	0.8
Shannies / Blennies	Stichaeidae	0.8
Sculpins	Cottidae	0.4
Redfish	*Sebastes* sp.	0.3
Atlantic cod	*Gadus morhua*	0.3
Seasnail	*Liparis* sp.	0.2
American plaice	*Hippoglossoides platessoides*	0.2
Haddock	*Melanogrammus aeglefinus*	0.1
Wolffish	*Anarhichas* sp.	0.1
Witch flounder	*Glyptocephalus cynoglossus*	less than 0.1
Greenland halibut	*Reinhardtius hippoglossoides*	less than 0.1
Hake	*Urophycis* sp.	less than 0.01
Yellowtail flounder	*Limanda ferruginea*	less than 0.01
Source: Dally et al (2001)		

4.2.1.4 Plants and Macroalgae

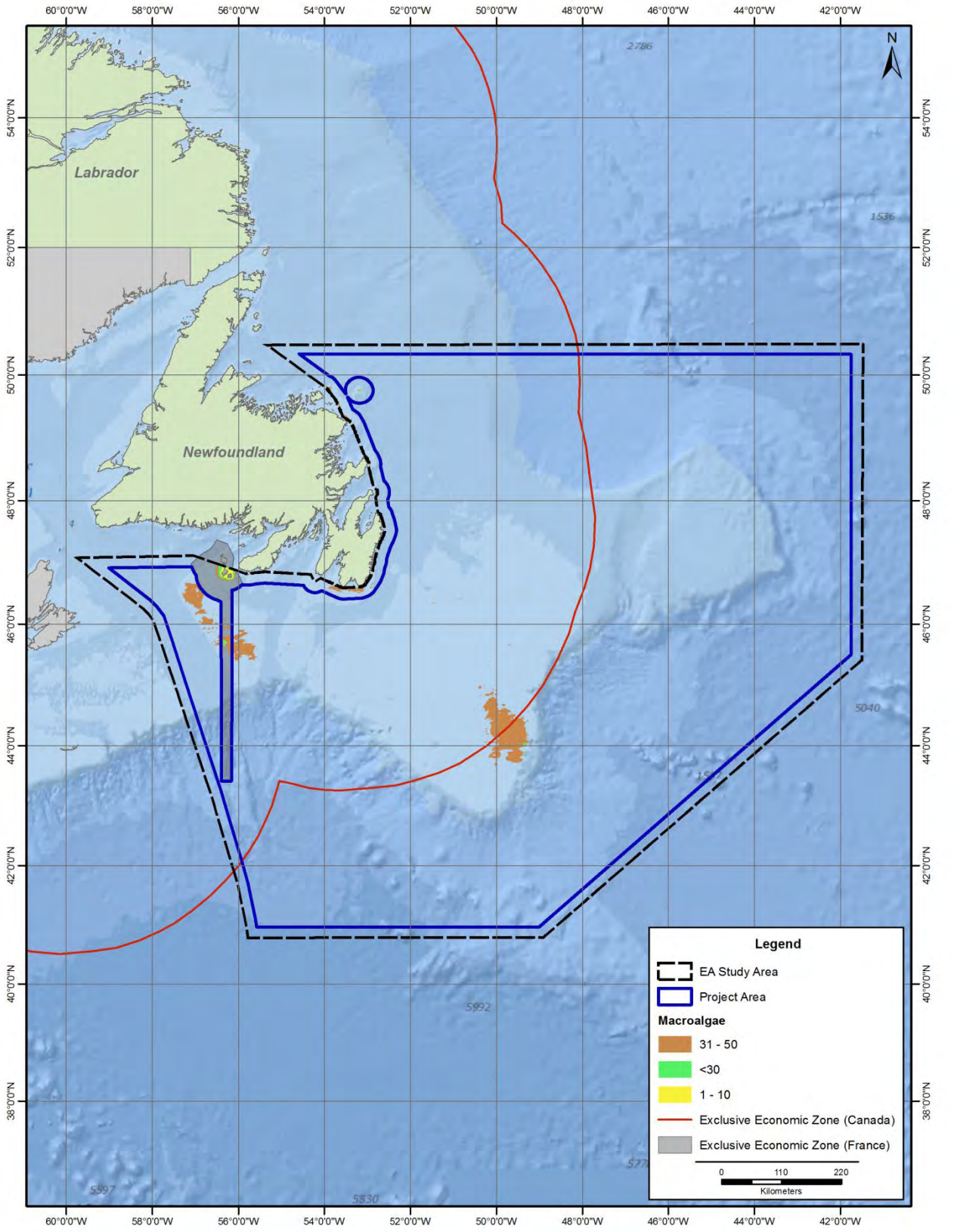
Macroalgae (e.g. *Laminaria*, *Agarum cribrosum*) and sea grasses (*Zostera marina*) create important habitat for marine animals in coastal areas of Newfoundland (Cote et al 2001; Cote et al 2013). Their distribution is typically limited, however, to depths less than 50 m (Dayton 1985; Gregory and Anderson 1997; Anderson et al 2002) as they are reliant on sunlight for photosynthesis. Other important factors that influence macroalgae distributions and species composition include substrate, sedimentation, nutrients, water motion, salinity and temperature (Dayton 1985). Ice scour is also an important process in shaping macroalgae communities and as

a result, south coast communities resemble those of Nova Scotia and New England, which are also under reduced influence of ice scour relative to the northeast coast of Newfoundland (LGL 2010).

As the Study Area does not include coastal environments, most areas are too deep to support macroalgae and plant growth, with exception of the Grand Banks, St. Pierre Bank and Fogo Bank (Figure 4.14). Accordingly, there are few accounts of macroalgae or sea grasses from other efforts to characterize offshore habitats (Houston and Haedrich 1984; Schneider et al 1987; Kenchington et al 2001). However, unpublished surveys (R. Hooper, pers. comm.) indicate that localized areas of macroalgae do exist in the offshore areas of the Study Area in depths of up to 100 m. At the extremes in depth, species diversity and biomass are low. In other areas, such as the Virgin Rocks, there is a diverse and profuse seaweed flora resembling that found in Labrador.

The dominant large seaweeds on the Virgin Rocks are the kelps (Phaeophyta: Laminariales): *Laminaria digitata*, *Alaria esculenta*, *Saccharina longicruris,* and *Agarum cribrosum*. Understory seaweeds include *Desmarestia viridis, D. aculeata, Palmaria* (Dulse), *Ptilota, Phycodrys, Membranoptera, Polysiphonia* and numerous other cold-water species. Almost all available substrate was covered by coralline seaweeds: *Lithothanionglaciale*, *L. lemoineae, Clathromorphum compactum, C. circumscriptum* and *Corallina*. The deepest seaweed was the coralline *Leptophyum leave*. This was still very abundant below 70 m (R. Hooper, pers. comm.).

Figure 4.14 Portions of the Study Area that could be Suitable for Macroalgae Based on Water Depth



4.2.1.5 Benthic Invertebrates

Benthic invertebrates are a diverse group of animals associated with the seafloor that play a variety of ecological roles in the ecosystem (e.g. detritivores, filter feeders, carnivores etc). They form an important part of the food chain (see previous Figure 4.13; Templeman 2010), generate habitat heterogeneity through excavations and castings (Hasemann and Soltwedel 2011), account for the bulk of commercial fisheries landings in the Study Area (Dawe et al 2012) and are considered especially sensitive to certain types of anthropogenic disturbance (Husky Energy 2010; Suncor Energy 2010; Warwick 1993; Beazley et al 2013).

Despite their ecological significance, benthic communities in the Study Area are generally poorly understood with the exception of research on a few commercially valued species (LGL 2003, 2010; Templeman 2010; Beazley et al 2013). Information on benthic communities is most rich on the Grand Banks, where contemporary research initiatives (e.g. Houston and Haedrich 1984; Schneider et al 1987; Kenchington et al 2001) and environmental effects studies (e.g. Husky Energy 2010; Suncor Energy 2010) have provided key information albeit over relatively small spatial scales. A third source, the DFO RV Surveys, provide more widespread information on benthic taxa accessible to trawls (e.g. LGL 2012, 2013). Studies to date indicate that benthic assemblages respond to environmental variables such as depth, substrate, bathymetry and flow field (Houston and Haedrich 1984; Schneider et al 1987; Desrosiers et al 2000) and also exhibit interannual variability (Kenchington et al 2001).

Video surveys of benthic communities on the northeastern part of the Grand Banks (Schneider et al 1987) identified echinoderms (brittlestars, urchins and sand dollars) as well as bivalves (primarily Icelandic scallop) as the dominant members of the epifaunal communities. Grab samples along the continental edge and slope (Carson Canyon on the southeastern Grand Banks) documented communities dominated by polychaetes, hooded shrimp, sipunculid worms, amphipods, echinoderms, isopods and bivalves (Houston and Haedrich 1984). Despite general habitat differences of benthic communities, polychaetes were common across all habitats (sand, gravel and silt).

In a depositional zone of the Cabot Strait, Desrosiers et al (2000) noted a prevalence of surface deposit feeding polychaetes and Gammarids that were complimented by smaller numbers of subsurface feeding molluscs. These communities differed from slope areas sampled in the Gulf and St. Lawrence and the Scotian Shelf which exhibited enhanced contributions of subsurface invertebrates.

Trawling impact studies have also been conducted on the northeast slopes of the Grand Banks using video and grabs (Kenchington et al 2001) and a benthic sled (Prena et al 1999). The results of these studies are very much influenced by sampling method. For example, Kenchington et al (2001) documented 246 benthic taxa (mostly echinoderms, polychaetes, crustaceans and molluscs), of which abundance was dominated by a polychaete (*Prionospio steenstrupi*) and a mollusc (*Macoma calcarea*) and biomass was dominated by propeller clams and sand dollars. Molluscs and echinoderms (brittle stars, sand dollars and urchins) also dominated epibenthic sled samples but these species were augmented by snow crab and soft corals (Prena et al 1999). The epibenthic samples were also characterized by a reduced taxonomic richness (115 taxa detected) relative to those collected with the grab / video system.

The effect of sampling methods on perceptions of benthic community structure is obvious. The dominance of polychaetes, amphipods and bivalves (more than 89 percent of individuals) collected during environmental

effects monitoring at the White Rose and Terra Nova rigs (Husky Energy 2010; Suncor Energy 2010) aligns well with conclusions from other studies employing benthic grab sampling. Similarly, DFO RV trawl surveys were dominated by sponges, anemones, shrimp, crab and echinoids (LGL 2012, 2013) and correspond to the taxa collected by Prena et al (1999) with epibenthic sampling techniques.

Ecology and Significance of Benthic Invertebrates

The ecology and significance of important benthic invertebrate taxa, as identified in the most recent Study Area SEAs (LGL 2010 and AMEC 2014) and other sources, are summarized in Table 4.7. Additional information on reproduction is provided in Figure 4.15 while regional distributions of key species are provided in subsequent sections.

Table 4.7 Overview of Marine Invertebrate Species Known or Likely to Occur in the Study Area

Species	Details[1]
American lobster (*Homarus americanus*)	**Typical Habitat** Preferred Substrate: gravel, cobble, boulder Preferred Depth: 2-145 m **Biology and Ecology** • Distribution from Southern Labrador to North Carolina • Offshore populations occur from 110-145 m depth on the outer edge of the continental shelf • Feeds on benthic invertebrates (crabs, sea urchins, mussels, polychaetes, periwinkles and seastars) and fish carcasses **Status and Use** • Commercial fishery
Amphipods (Amphipoda)	**Typical Habitat** Preferred Substrate: silt, sand, gravel (Houston and Haedrich 1984) Preferred Depth: 100 – 300 m (Konstantinov et al 1985) **Biology and Ecology** • Feeds on seaweed and algae (Duffy and Hay 1991) • Prey for commercially important species including American plaice and yellowtail flounder (Pitt 1973) **Status and Use** • Ecologically important; important food source for fishes
Basket star (*Gorgonocephalus arcticus*)	**Typical Habitat** Preferred substrate: variable substrate (Gosner 1979) Preferred Depth: Subtidal – more than 1,200m (Gosner 1979) **Biology and Ecology** • Primarily feeds on euphausids (Emson et al 1991) • Associated with deep sea corals (Rosenberg et al 2005) **Status and Use** • No conservation status or fishery in region
Brittlestar (Ophiuroidea)	**Typical Habitat** Preferred Substrate: gravel, cobble, coralline algae, shell Preferred Depth: Intertidal - more than 300 m **Biology and Ecology** • Comprised of several species of brittle star • Distributed from the Arctic to Cape Cod region (Gosner 1979) • Feeds on small crustaceans, polychaetes and detritus • Important prey species for American lobster and American plaice

Species	Details[1]
	Status and Use • No conservation status or fishery in region
Hooded shrimp (Cumacea)	**Typical Habitat** Preferred Substrate: gravel, sand (Houston and Haedrich 1984) Preferred Depth: NDA **Biology and Ecology** • Northwest Atlantic distribution from Newfoundland to Cape Cod (Gosner 1979) • Prey species for American plaice, yellowtail flounder, and cod (Bruno et al 2000, Pitt 1979) **Status and Use** • No conservation status or fishery in region
Icelandic scallop (*Chlamys islandica*)	**Typical Habitat** Preferred Substrate: sand, gravel, shell, boulder Preferred Depth: more than 55 m **Biology and Ecology** • Northwest Atlantic distribution • Inhabits area with strong currents and high salinity • Size portioning in relation to depth with larger individuals at higher depths • Suspension feeders on phytoplankton **Status and Use** • Commercial fishery
Jellyfish (Scyphozoa)	**Typical Habitat** Preferred Temperature: 5 - 20°C Preferred Depth: 20 – 40 m **Biology and Ecology** • Main species observed on Grand Bank are *Cyanea capillata* and *Aurelia aurita* • Commonly captured during Grand Bank plankton tows (LGL 2012) • Distributed inshore and offshore • Feeds on fish eggs and larvae **Status and Use** • No conservation status or fishery in region
Northern shrimp (*Pandalus borealis*)	**Typical Habitat** Preferred Substrate: mud, silt Preferred Depth: 150 – 600 m **Biology and Ecology** • Distributed from west Greenland to Georges Bank • Most commonly observed species in NAFO areas 3NLOPs • Feeds on polychaetes, small crustaceans, detritus, marine plants, copepods, and euphausiids • Northern Shelf Assemblage • Important prey species for halibut, cod, redfish, and harp seals **Status and Use** • Commercial fishery • Ecologically important: forage species
Orange footed sea cucumber (*Cucumaria frondosa*)	**Typical Habitat** Preferred Substrate: gravel, cobble, rubble (So et al 2009) Preferred Depth: 20 – 100 m (Hamel and Mercier 2010) **Biology and Ecology** • Distributed across the North Atlantic • Patchy distribution for inshore and offshore populations (So et al 2009) • Concentration of sea cucumbers on either side of the French corridor off St Pierre

Species	Details[1]
	• Suspension feeder that consumes mainly phytoplankton and detritus • Preyed upon by seastars **Status and Use** • Commercial fishery
Pale sea urchin (*Strongylocentrotus pallidus*)	**Typical Habitat** Preferred Substrate: sand, cobble (Gilkinson et al 1998) Preferred Depth: 60-1,600 m (Bluhm et al 1998; Gilkinson et al 1998) **Biology and Ecology** • High abundance on sandy bottoms of the Grand Bank (Kenchington et al 2001) • Feeds on epibiotics on stones, infauna meiobenthos and detritus (Bluhum et al 1998) • Prey species for commercially important fish species including American plaice (Gilkinson et al 1998) **Status and Use** • No conservation status or fishery in region
Polychaete worms	**Typical Habitat** Preferred Substrate: silt (Houston and Haedrich 1984) Preferred Depth: more than 50 m **Biology and Ecology** • Distributed throughout the North Atlantic • Variety of species found on the Grand Bank • Prey species for groundfish and invertebrates **Status and Use** • Ecologically important: Major component of marine benthic communities
Propellor clam (*Cyrtodaria siliqua*)	**Typical Habitat** Preferred Substrate: sand (Kenchington et al 2001) Preferred Depth: 120 – 150 m (Kenchington et al 2001) **Biology and Ecology** • High abundance on sandy bottoms of the Grand Bank (Kenchington et al 2001) • Population is dominated by clams older than 100 years (Kilada et al 2009) • Prey species for cod, American plaice and wolffish (Kilada et al 2009; Templeman 1985) **Status and Use** • Commercial fishery
Sand dollar (*Echinarachnius parma*)	**Typical Habitat** Preferred Substrate: sand Preferred Depth: more than 800 m **Biology and Ecology** • Northwest Atlantic Distribution from Labrador to North Carolina • Burrows in soft substrates • Reaches densities of 100 individuals / m^2 • High abundance on sandy bottoms of the Grand Bank (Kenchington et al 2001) • Stomach gut contents include diatoms, sand grains, sponge spicules and detritus **Status and Use** • Ecologically important as food source for commercially important groundfish species
Sea anemone (Actiniaria)	**Typical Habitat** Preferred Substrate: cobble, rubble, boulder Preferred Depth: Variable **Biology and Ecology** • Commonly observed during Orphan Basin remote video surveys (LGL 2012) • Variety of species found on the Grand Bank • Feeds on echinoderms and other invertebrates **Status and Use**

Species	Details[1]
	• No conservation status or fishery in region
Sea scallop (*Placopecten magellanicus*)	**Typical Habitat** Preferred Substrate: sand, gravel, pebble Preferred Depth: 20 – 70 m **Biology and Ecology** • Northwest Atlantic distribution from Labrador to North Carolina • Suspension feeders on phytoplankton and detritus • Prey species for crab, lobster, seastars, gastropods, cod, plaice and wolffish **Status and Use** • Commercial fishery
Short-finned squid (*Illex illecebrosus*)	**Typical Habitat** Preferred Temperature: 16.0 – 27.0°C Preferred Depth: NDA **Biology and Ecology** • Northwest Atlantic distribution from Greenland to Florida. Concentrated from Newfoundland to Cape Hatteras • Feed on euphausiids, fish and other squid • Undertakes diurnal vertical migrations • Southern Deepwater Assemblage **Status and Use** • Commercial fishery
Sipunculan worms (*Sipuncula*)	**Typical Habitat** Preferred Substrate: mud, sand, rock, coral (Gosner 1979) Preferred Depth: intertidal to subtidal depths (Gosner 1979) **Biology and Ecology** • Burrowing worms • Many species are deposit feeders (McMahon et al 2006) • Preyed upon by groundfish and other invertebrates **Status and Use** • No conservation status or fishery in region
Snow crab (*Chionoecetes opilio*)	**Typical Habitat** Preferred Substrate: mud, sand Preferred Depth: 60 – 400 m **Biology and Ecology** • Northwest Atlantic distribution from Greenland to the Gulf of Maine • Feeds on polychaetes, bivalves, echinoderms, and fish carcasses • Commonly observed species in NAFO area 3NLOPs • Commonly observed during Orphan Basin remote video surveys (LGL 2012) • Dominated otter trawl sampling of sandy areas of the Grand Bank (Prena et al 1999) • Prey species for various groundfish other snow crabs and seals • Cold Shelf Assemblage **Status and Use** • Commercial fishery
Sponges (*Geodia* sp.)	**Typical Habitat** Preferred Substrate: cobble (Freese 2001) Preferred Depth: 800 – 1,450 m (Murillo et al 2012) **Biology and Ecology** • Commonly observed during Orphan Basin remote video surveys (LGL 2012) • Variety of species found on Grand Bank • *Geodia* sp. most dominant species observed on sponge grounds on the Grand Bank, Flemish Cap and Flemish Pass (Murillo et al 2012)

Species	Details[1]
	Status and Use • No conservation status or fishery in region
Surf clam (*Spisula solidissima*)	**Typical Habitat** Preferred Substrate: silt, sand Preferred Depth: 8 – 66 m **Biology and Ecology** • Northwest Atlantic distribution from the Gulf of St. Lawrence to North Carolina • High abundance along the eastern edge of the Grand Bank (Ollerhead et al 2004) • Prey species for benthic invertebrates (rock crabs, seastars, hermit crabs, moon snails, whelks) and groundfish (cod, flounder, sculpin, ocean pout) **Status and Use** • Commercial fishery
Striped pink shrimp (*Pandalus montagui*)	**Typical Habitat** Preferred Substrate: sand (Warren and Sheldon 1967) Preferred Depth: 140 – 260 m (Hudon et al 1992) **Biology and Ecology** • Undertakes diurnal vertical feeding migrations (Hudon et al 1992) • Feeds mainly on copepods in pelagic waters and on polycheaetes and foraminiferans at benthic depths (Hudon et al 1992) • Northern Shelf Assemblage • Prey species for halibut, cod, redfish and seals **Status and Use** • Commercial fishery • Ecologically important as forage species
Whelk (*Buccinum* sp.)	**Typical Habitat** Preferred Substrate: mud, sand, gravel, rock (Himmelman and Hamel 1993) Preferred Depth: Tidal - 180 m **Biology and Ecology** • Distributed in cold waters from Labrador to New Jersey • Common in otter trawl sampling on sandy areas of the Grand bank (Prena et al 1999) • Feeds on urchins, polychaetes, amphipods, crustaceans and fish eggs • Scavenges on animal carcasses • Prey species for lobster, cod, crab, seastars and dogfish **Status and Use** • Commercial fishery

[1] Information is summarized from:Christian et al (2010) unless otherwise noted.

Figure 4.15 Spawning Periods and Reproductive Biology for Key Invertebrate Species

Family	Common Name	Scientific Name	J	F	M	A	M	J	J	A	S	O	N	D	Egg Location	Larvae Location	Known Spawning Location
Buccinidae	Whelk [1]	*Buccinum* sp.					■	■							Demersal	Demersal	
Cnidaria	Deep sea corals [2,3]	-			■	■	■	■							Variable	Variable	
Geodiidae	Sponges [4]	*Geodia* sp.				■	■								Pelagic	Pelagic	
Illicinae	Short-finned squid [1,5]	*Illex illecebrosus*			■	■	■								Pelagic	Pelagic	North Carolina to Florida
Mactridae	Surf clam [1,6]	*Spisula solidissima*								■	■	■			Pelagic	Pelagic	NAFO area 3N
Nephropidae	American lobster [1]	*Homarus americanus*					■	■	▒	▒					Brooded	Pelagic	
Oregoniidae	Snow crab [1,7]	*Chionoecetes opilio*				■	■								Brooded	Pelagic	
Pectinidae	Icelandic scallop [1,6]	*Chlamys islandica*								■	■				Pelagic	Pelagic	NAFO areas 3LNP
Pandalidae	Northern shrimp [1,6]	*Pandalus borealis*			■	■	■	■		▒	▒				Brooded	Pelagic	NAFO areas 3LNP
Pandalidae	Pink shrimp [8]	*Pandalus montagui*	▒		■	■	■						▒	▒	Brooded	Pelagic	
Pectinidae	Sea scallop [1,6]	*Placopecten magellanicus*								■	■				Pelagic	Pelagic	NAFO area 3P

Light shading represents mating periods and dark shading indicates spawning periods.
[1]Christian et al 2010; [2]Sun et al 2010; [3]Mercier et al 2011; [4]Spetland et al 2007; [5]Dawe et al 2012; [6]Ollerhead et al 2004; [7]Hooper 1986; [8]Allen 1963

Benthic Invertebrate Distributions

Distributions of three commercially important benthic invertebrate species (snow crab and two shrimp species) are described below using data from Canadian RV surveys and information from the avaialble and relevant literature.

Shrimp

Newfoundland waters are home to more than 30 species of shrimp (Templeman 2010). Northern shrimp are the most abundant species captured in DFO RV surveys in the Study Area and constitute the bulk of commercial fish landings (Dawe et al 2012). Along with Northern shimp, pink striped shrimp are also well represented in RV survey catches. At larval stages, survival and recruitment of Northern shrimp is affected by the strength of phytoplankton blooms and sea surface temperatures (Ouellet et al 2011). Young Northern shrimp are males that undertake nocturnal feeding migrations. Later in life they morph to females and engage in a more benthic existence (Fuentes-Yaco et al 2007; Templeman 2010) where growth rates are influenced by latitude (Fuentes-Yaco et al 2007) and the availability of particulate organic carbon (e.g. detritus from decomposing phytoplankton; Ramseier et al 2000). Shrimp stocks are declining in the southern part of their range (Orr et al 2011), after experiencing trends of increased numbers related to cooling water temperatures and the collapse of the groundfish stocks (Lilly et al 2000; Ramseier et al 2000).

RV surveys indicate that Northern shrimp are concentrated in the northeast portions of the Study Area, in the Flemish Pass and northern Grand Banks and to a lesser extent at the mouth of Placentia Bay (Figure 4.16). In contrast, they are at very low abundance in the shoal areas of the Grand Banks. Pink striped shrimp, however, are found at highest densities in parts of the Study Area that are proximal to the coast (e.g. areas off Conception Bay, the Burin Peninsula, St. Mary's Bay and Fogo; Figure 4.17).

Snow Crab

Snow crab have become an increasingly important ecosystem component since cold ocean temperatures in the Study Area caused a rapid increase in their abundance in the early 1990s. Since that time they have become a staple of the commercial fishery, following only shrimp in commercial value (Dawe et al 2012). Snow crab pass through several planktonic larval stages before occupying the benthic habitats where they remain for the remainder of their life (DFO 2008). Commercial harvests are comprised only of larger male crabs (DFO 2008; Mullowney et al 2013) as females undergo their final moult at a size that excludes them from commercial exploitation (DFO 2008). Habitat use of crabs varies according to size. Large males are typically found over mud and mud/sand while smaller crabs are more common over harder substrates (DFO 2008). Crabs have a diverse diet that includes polychaetes, brittle stars, crustaceans, shrimp and fish. They, in turn, serve as prey for groundfish, seals and other snow crabs (DFO 2008).

Snow crab stocks have declined in recent years, a trend that is expected to continue due to unfavourable environmental conditions (Dawe et al 2012; Mullowney et al 2012). In recent years, snow crab have been abundant along the slopes of the Northern Grand Banks, St. Pierre Bank and off Placentia Bay and Cape Freels (Figure 4.18). It is much less abundant along the shallows of the southern Grand Banks, the continental slope and the western extremities of the Study Area (i.e. west of St. Pierre Bank).

Figure 4.16 Distribution of Northern Shrimp in the Study Area (Canadian RV Surveys, 2008-2012)

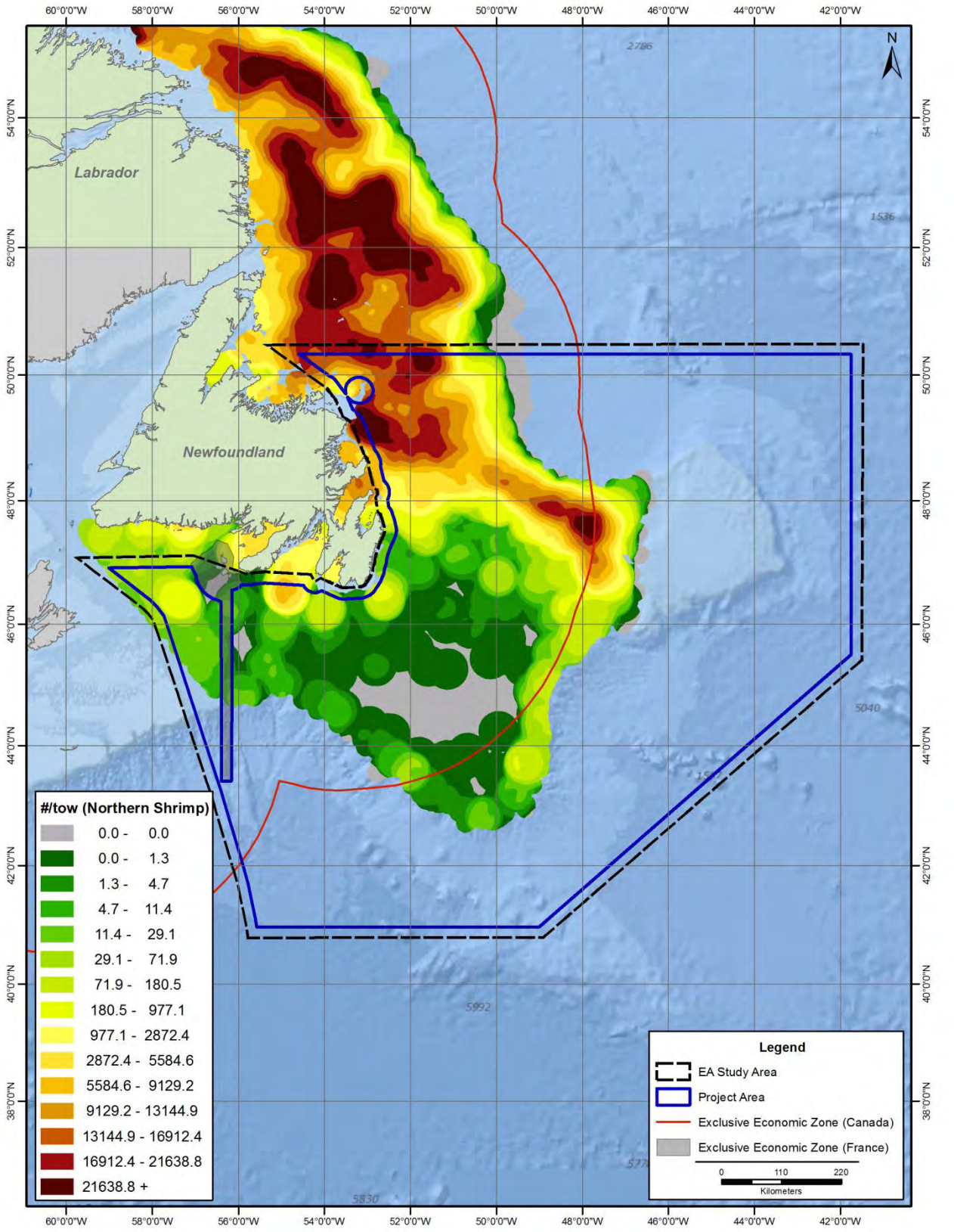


Figure 4.17 Distribution of Pink Striped Shrimp in the Study Area (Canadian RV Surveys, 2008-2012)

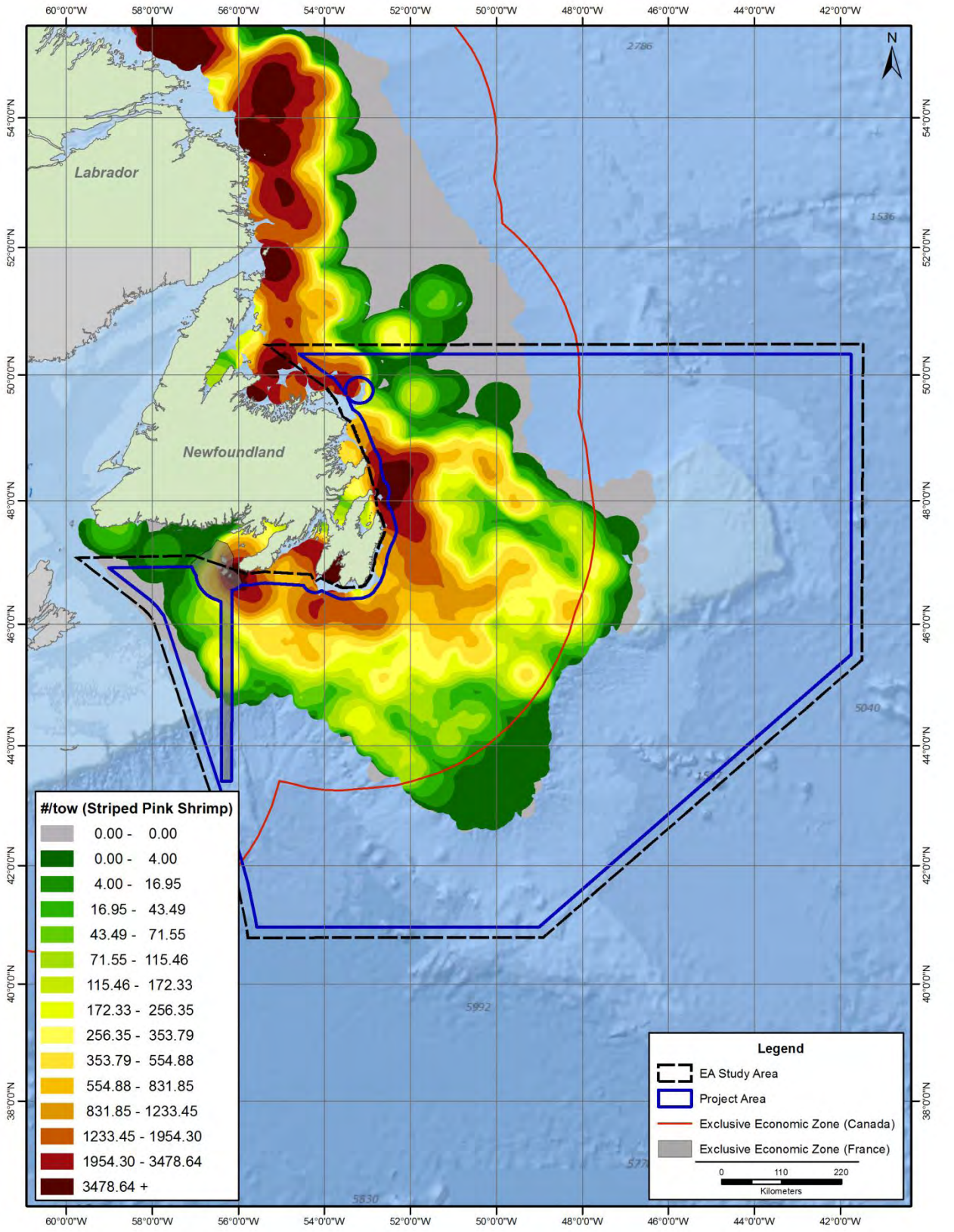
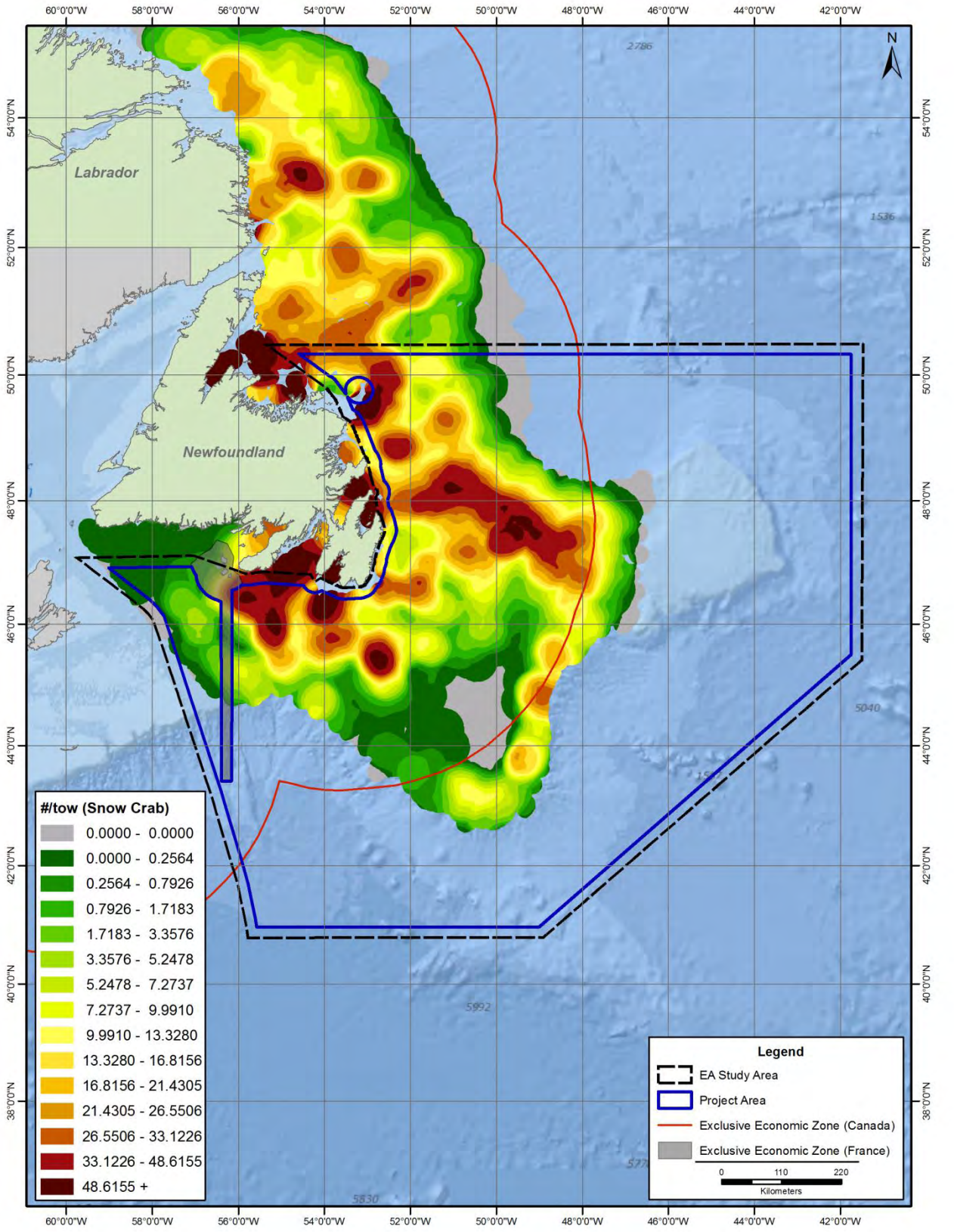


Figure 4.18 Distribution of Snow Crab in the Study Area (Canadian RV Surveys, 2008-2012)



Corals and Sponges

Deep-sea corals and sponges are sessile organisms that are of conservation interest due to their habitat-forming capacity and their sensitivity to anthropogenic disturbance (Murillo et al 2011; Beazley et al 2013). The presence of these taxa create structural complexity on the seafloor, which is used as shelter and a place to find food (Watanabe et al 2009; WGEFAM 2008) for a variety of vertebrate and invertebrate species including those of commercial importance (Gilkinson and Edinger 2009; Baillon et al 2012). Consequently, deep-sea corals and sponges increase biodiversity and habitat heterogeneity in the deep sea system (Buhl-Mortensen et al 2010; WGEFAM 2008; Beazley et al 2013). Unfortunately, the vertical structure associated with many of these organisms, and their fragile nature and slow growth leave these taxa vulnerable to anthropogenic activities that disturb bottom habitats (such as trawling, oil and gas infrastructure placement) (Campbell and Simms 2009, Watanabe et al 2009). Of the coral groups that occur in the Study Area, black corals, large gorgonians and small gorgonian corals are considered to be the most sensitive to disturbance because their carbonate skeletons become permanently detached from substrate once dislodged (Gilkinson and Edinger 2009).

Sea pens, soft corals, stony corals, and sponges are well represented in the Study Area (Gilkinson and Edinger 2009; DFO 2010a; WGEFAM 2008; Murillo et al 2012). Within the Canadian EEZ, gorgonians are found at their highest densities along southwest Grand Banks, the northeast Grand Banks near the Flemish Pass and the edge of the Newfoundland Shelf (DFO 2010; Figure 4.19). Surveys with fishermen indicate that gorgonians also occur along the edges of Rose Blanche and Burgeo Banks (LGL 2010), although density information was not associated with these reports. Sea pens are most abundantly distributed in the Laurentian Channel, whereas sponges predominantly occur in northern parts of the Study Area (along the Newfoundland Shelf and slope) although they are also found relatively common on the banks off Southwest Newfoundland (Rose Blanche, Burgeo and St. Pierre).

In NAFO administered waters, corals are abundant along the slopes (600 m to 1,300 m) of the Flemish Cap (Murillo et al 2011), the northern and southern portions of the Flemish Pass and the southwestern slopes of the Grand Banks (WGEFAM 2008). In these areas, Murillo et al (2001) reported 21 species of soft corals and gorgonian sea fans (alcyonaceans), 11 species of sea pens (pennatulaceans), two species of cup corals (solitary scleractinians), and three species of black coral (antipatharians) in the bycatch associated with fisheries surveys. Habitat associations differed according to taxa, as sea pens and cup corals were found on mud substrates while black corals, soft corals and sea fans were common on bedrock and gravel. Predictive habitat modelling, conducted by Knudby et al (2013) indicate that the slopes around the entire Flemish Cap are important for black corals, the eastern slopes of the Flemish Cap and the northern Flemish Pass as important for large gorgonians and the slopes of the Flemish Cap (except the southern portion) and the tail of the Grand Banks as important for sea pens. Sponges are also abundant along the slopes of the Flemish Cap, in the Flemish Pass and along the tail of the Grand Banks (WGEFAM 2011). Beazley et al (2013) determined that the slopes of the Flemish Cap were dominated by axinellid and polymastid sponges, while deeper areas of the Flemish Pass were characterized by geodiids and *Asconema* sp.

Some important coral and sponge areas are closed to damaging fishing activities (Figure 4.20). Other areas that host considerable diversity (Beazley et al 2013), such as the southern slope of the Flemish Cap, are not currently protected.

Figure 4.19 Coral and Sponge Areas

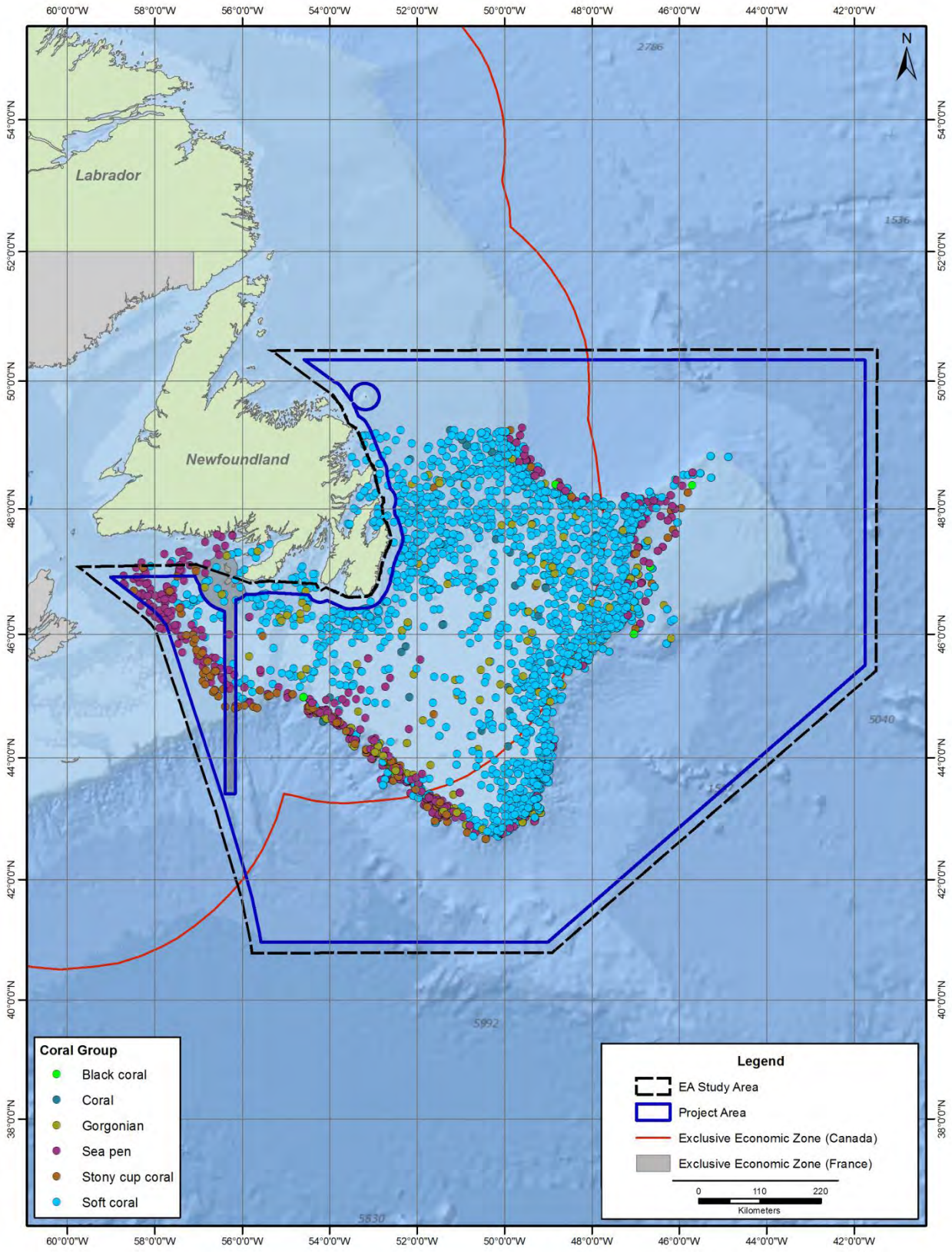
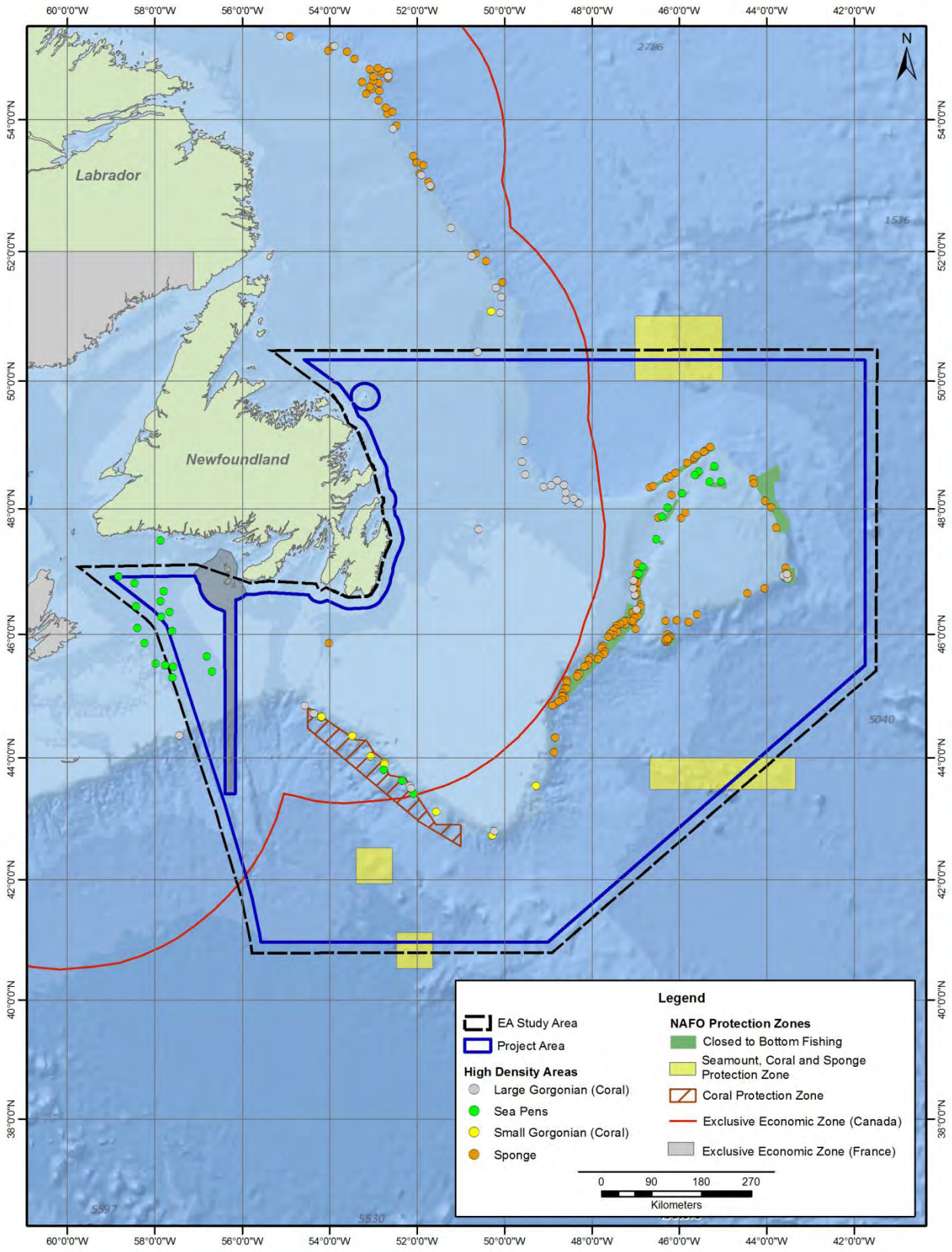


Figure 4.20 High Density Areas and Protection Zones for Corals, Seamounts and Sponges



4.2.1.6 Marine Fish

Marine fish are found throughout the Study Area and, among the 188 species known to occur in Newfoundland waters (Templeman 2010), many are of ecological, commercial, conservation and/or cultural importance. The species collectively reflect a diversity of morphologies, life histories, habitat requirements and their presence within the Study Area varies according to environmental conditions, habitat, and life history stage. This section identifies key demersal and pelagic marine fish species that occur in the Study Area, summarizes their preferred habitats, distribution, spawning behaviour, and identifies their significance. Additional information on marine fish spawning, migration and regional distributions are also provided on a subset of these species.

Ecology and Significance of Marine Fish

The ecology and significance of key marine fish species are summarized in Tables 4.8 and 4.9. These represent the most numerically abundant and/or ecologically or economically important species found in the Study Area.

Table 4.8 Overview of Groundfish Species that are Known or Likely to Occur in the Study Area

Species	Details[1]
Atlantic cod (*Gadus morhua*)	**Typical Habitat** Preferred Temperature: 0.5 - 10°C Preferred Depth: 150 – 200 m **Biology and Ecology** • Occurs on both sides of the North Atlantic • Areas of concentration on the Grand Bank include the Northeast Slope, Virgin Rocks, and upper Southwest Slope (Kulka et al 2003a) • Feeds on fish and benthic invertebrates • Found in cool-temperature to subarctic waters from inshore regions to the edge of the continental shelf • Occurs throughout the Atlantic Canada with regionally unique stocks • Juveniles cod are abundant in inshore areas (Gregory and Anderson 1997) • Commonly observed species in NAFO areas 3NLOPs • Widespread Shelf Assemblage **Status and Use** • COSEWIC (Endangered) and IUCN (Vulnerable) status • Recreational and commercial fishery • Culturally and ecologically important species
American plaice (*Hippoglossoides platessoides*)	**Typical Habitat** Preferred Temperature: 0.0 - 1.5°C Preferred Depth: 90 – 250 m **Biology and Ecology** • Occurs on both sides of the Atlantic • Areas of concentration on the Grand Bank include the north and south areas of the Bank (Kulka et al 2003a) • Feeds on polychaetes, echinoderms, molluscs, crustaceans and fish • Tolerates salinities as low as 20 – 22 ppt • Commonly observed species in NAFO area 3NLOPs • Widely distributed on the shelf • Widespread Shelf Assemblage

Species	Details[1]
	Status and Use • COSEWIC (Threatened) status. • Commercial fishery
Atlantic hagfish (*Myxine glutinosa*)	**Typical Habitat** Preferred Temperature: less than 12°C Preferred Depth: 30 – 958 m **Biology and Ecology** • Inhabits areas with soft, muddy bottoms and high salinity. • Nocturnal species that burrows into soft bottoms. • Feeds on internal organs of dead and injured animals found on the sea floor • Young hagfish preyed upon by cod, hake and halibut. **Status and Use** • Commercial fishery
Atlantic halibut (*Hippoglossus hippoglossus*)	**Typical Habitat** Preferred Temperature: 3 – 9 °C Preferred Depth: up to 1,000 m **Biology and Ecology** • Areas of concentration on the Grand Bank include the Southwest Slope and Laurentian Channel Slope (Kulka et al 2003a) • Feeds on polychaetes, molluscs, crustaceans and fish • The largest of the flat fishes, and typically found along the slopes of the continental shelf • Moves seasonally between deep winter waters and the shallow waters of the Gulf where they feed • Avoids temperatures below 2.5°C • Warm Southern Shelf Assemblage **Status and Use** • Commercial fishery
Atlantic wolffish (*Anarhichas lupus*)	**Typical Habitat** Preferred Temperature: 1.0 – 4.0°C (Kulka et al 2004) Preferred Depth: 25 - 250m (Kulka et al 2004) **Biology and Ecology** • Occurs on both sides of the North Atlantic Ocean • Areas of concentration on the Grand Bank include the Northeast Newfoundland Shelf and the northern edge of the Grand Bank (Kulka et al 2003a) • Associated with a variety of substrates (Kulka et al 2004) • Feeds benthic invertebrates (echinoderms, molluscs, crustaceans) and some fish • Commonly an inhabitant of deep water along the shelf (Dutil et al 2010) • Warm Southern Shelf Assemblage **Status and Use** • SARA (Special Concern) and COSEWIC (Special Concern) status
Barndoor skate (*Dipturus laevis*)	**Typical Habitat** Preferred Temperature: 1.2 – 10.9°C Preferred Depth: 650 – 750 m **Biology and Ecology** • Feeds on bivalves, squid, rock crabs, lobster, shrimp and polychaetes • Migrates offshore to seek cool temperatures • Warm Southern Shelf Assemblage **Status and Use** • IUCN (Endangered) status

Species	Details[1]
Black dogfish (*Centroscyllium fabricii*)	**Typical Habitat** Preferred Temperature: 3.5 – 4.5 °C Preferred Depth: 350 - 500m (Kulka 2006) **Biology and Ecology** • Distributed along the Canadian slope, with concentrations in the Laurentian Channel (Kulka 2006) • Feeds mainly on squid, crustaceans, jellyfish and small redfish • Small, deepwater shark occurring near bottom, at times forming schools • Deep Demersal Assemblage **Status and Use** • No conservation status or fishery in region
Blue hake (*Antimora rostrata*)	**Typical Habitat** Preferred Temperature: 3.0 – 4.5°C (Kulka et al 2003b) Preferred Depth: Greater than 1,400 m (Kulka et al 2003b) **Biology and Ecology** • Benthopelagic species associated with mud bottoms • Feeds on benthic invertebrates including crustaceans and squids • Distributed in slope waters along the eastern Grand Bank (Kulka et al 2003b) • Deep Demersal Assemblage **Status and Use** • No conservation status or fishery in region
Cusk (*Brosme brosme*)	**Typical Habitat** Preferred Temperature: 2.0 – 12.0°C Preferred Depth: 20 – 549 m **Biology and Ecology** • Occurs on both sides of the North Atlantic Ocean on hard, rough or rocky bottoms • Sporadically observed on Grand Bank around the Flemish Cap, around the Nose and Southwest Slope of the Grand Banks (Kulka et al 2003a) • Feed on crustaceans, molluscs and echinoderms • In the Canadian region more common on southwestern Scotian Shelf and Slope and Fundian Channel • Warm Southern Shelf Assemblage **Status and Use** • COSEWIC Status
Lumpfish (*Cyclopterus lupus*)	**Typical Habitat** Preferred Temperature: 8°C Preferred Depth: 50 – 150 m **Biology and Ecology** • Primarily lives on rocky or stony bottoms • Uses a pelvic adhesive disc to adhere to rocks and other solid objects • Observed mainly on the north and south areas of the Grand Bank. High concentration on St. Pierre Bank (Kulka et al 2003a) • Feeds on invertebrates (euphausiid shrimp, amphipods, copepods, comb jellies) and small fish (sand lance, herring) • Preyed upon by seals and sharks **Status and Use** • Commercial fishery
Monkfish (*Lophius americanus*)	**Typical Habitat** Preferred Temperature: 6.0 – 10.0°C Preferred Depth: 0 – 320 m **Biology and Ecology**

Species	Details[1]
	• Areas of concentration on the Grand Bank are the Southwest Slope and within the Laurentian Channel (Kulka et al 2003a) • Feeds on fish (herring, sand lance, smelt, cod, haddock, cunner, sculpin, flounder, skates) and invertebrates (crab, squid, molluscs, echinoderms, polychaetes) • Migrates to shallow waters of the banks in summer and migrate to deeper waters in winter. Associated with deep waters along the western Grand Bank (Gomes et al 1992) • Warm Southern Shelf Assemblage **Status and Use** • Commercial fishery
Greenland halibut (*Reinhardtius hippoglossoides*)	**Typical Habitat** Preferred Temperature: 0.0 - 4.5 °C Preferred Depth: 200 – 800 m **Biology and Ecology** • Areas of concentration on the Grand Bank include the slope of the Northeast Newfoundland shelf and northeast edge of the Grand Bank (Kulka et al 2003a) • Bathypelagic predator that feeds fish (capelin, Atlantic cod, polar cod, roundnose grenadier, redfishes, sand lance), and invertebrates (shrimp, squid, benthic invertebrates) • Spends considerable time in the pelagic zone (Morgan et al 2013) • Distributed across areas of the Grand Bank and Flemish Pass (Morgan et al 2013) • Deep Demersal Assemblage **Status and Use** • Commercial fishery
Haddock (*Melanogrammus aeglefinus*)	**Typical Habitat** Preferred Temperature: 1.0 - 13.0 °C Preferred Depth: 27 – 366 m **Biology and Ecology** • Found off southwest Newfoundland and St. Pierre Bank • Areas of concentration include the Laurentian Channel Slope, and Southwest Slope of the Grand Bank (Kulka et al 2003a). • Bottom feeding fish that consume crustaceans, molluscs, echinoderms, polychaetes and fish • Occurs in a variety of habitats; juveniles have higher survival rates when they settle on sand or gravel bottoms **Status and Use** • Commercial fishery
Hookear sculpin (*Artediellus* sp.)	**Typical Habitat** Preferred Temperature: NDA Preferred Depth: 0 – 384 m **Biology and Ecology** • Distributed off Labrador and around Newfoundland and into the Gulf of St. Lawrence • Includes Atlantic hookear sculpin (*A. atlanticus*) and snowflake hookear sculpin (*A. uncinatus*) • Inhabits soft bottom areas • Feeds on benthic invertebrates • Cold Areas Shelf Assemblage **Status and Use** No conservation status or fishery in region

Species	Details[1]
Longnose eel (*Synahobranchus kaupi*)	**Typical Habitat** Preferred Temperature: Not less than 1.4°C Preferred Depth: 240 – 3,650 m **Biology and Ecology** • Occurs on both sides of the North Atlantic Ocean to South Atlantic Ocean, in the Pacific Ocean and Gulf of Mexico • Feeds on squid, polychaetes, copepods and scavenges on fish remains (Gordon and Mauchline 1996) • Bottom-dwelling fish occurring in deep water between 240 and 3650 m • Commonly observed in the Grand Bank (Baker et al 2012; LGL 2012) • Deep Demersal Assemblage **Status and Use** • No conservation status or fishery in region
Longfin hake (*Physis chesteri*)	**Typical Habitat** Preferred Temperature: 3.5 – 6.5°C (Methven and McKelvie 1986) Preferred Depth: 300 - 450m (Methven and McKelvie 1986) **Biology and Ecology** • Occurs along Labrador to the southern edge of the Grand Bank • Feeds mainly on invertebrates (shrimp, euphausiids and amphipods) and vertically migrating fishes (hatchetfish and lanternfish) • Commonly observed species in NAFO area 3NLOPs • Warm Deep Offshore Shelf Assemblage **Status and Use** • No conservation status or fishery in region
Marlin-spike (*Nezumia bairdi*)	**Typical Habitat** Preferred Temperature: 3.0 – 8.0°C Preferred Depth: 183 – 732 m **Biology and Ecology** • Benthic species that usually lives on mud bottoms • Distributed in the Gulf of St. Lawrence and Bay of Fundy. Distributed from the southwestern Grand Bank, to the banks of the Scotian Shelf and southward along the continental slope of the West Indies • Commonly observed species in NAFO area 3NLOPs • Feeds on benthic euphausiids and amphipods. Preyed upon by swordfish • Deep Demersal Assemblage **Status and Use** • No conservation status or fishery in region
Northern wolffish (*Anarhichas denticulatus*)	**Typical Habitat** Preferred Temperature: less than 5°C Preferred Depth: 150 – 1,000 m **Biology and Ecology** • Occurs in Arctic seas on both sides of the North Atlantic Ocean • Feeds benthic invertebrates (echinoderms, molluscs, crustaceans) and some fish • Widespread Shelf Assemblage **Status and Use** • SARA (Threatened) and COSEWIC (Threatened) status
Northern sand lance (*Ammodytes dubius*)	**Typical Habitat** Preferred Temperature: 3.0 – 6.0°C Preferred Depth: 73 – 90 m **Biology and Ecology** • Adults burrow into sandy or fine gravel bottoms to avoid predation

Species	Details[1]
	• Feeds on plankton with preference towards copepods • High densities observed on the eastern and South East Shoal of the Grand Bank • Grand Bank Shelf Assemblage **Status and Use** • No conservation status or fishery in region • Ecologically important as a forage fish species
Pollock (*Pollachius virens*)	**Typical Habitat** Preferred Temperature: 7.2 – 8.6 °C Preferred Depth: 110 - 181 m **Biology and Ecology** • Areas of concentration on the Grand Bank include the southwest edge of the Bank and the Laurentian Channel slope (Kulka et al 2003a) • Juveniles are common in shallow inshore waters, while adults live in deeper inshore waters or on offshore banks • Feeds mainly on copepods • Distributions mainly restricted to the slope waters of the Burgeo and St. Pierre Banks • Warm Southern Shelf Assemblage **Status and Use** • No conservation status or fishery in region
Redfish (*Sebastes mentella*, *S. fasciatus*)	**Typical Habitat** Preferred Temperature: 3.0 - 8.0°C Preferred Depth: 100 – 700 m **Biology and Ecology** • In the western Atlantic, redfish species range from Baffin Island in the north to the waters off New Jersey in the south • Areas of concentration on the Grand Bank include the Northeast Newfoundland Shelf, the Flemish Cap and the Laurentian Channel slope • Bathypelagic or pelagic feeders that primarily consume amphipods, copepods, euphausiids • The three redfish species that occur in the Northwest Atlantic include *Sebastes mentella*, *S. fasciatus*, and *S. marinus*. The latter species is relatively uncommon except in the area of the Flemish Cap • *S. mentella* is typically distributed deeper than *S. fasciatus* (Gascon 2003) • *S. mentella* a commonly observed species in NAFO area 3NLOPs • Warm Deep Offshore Shelf Assemblage **Status and Use** • *S. mentella* - COSEWIC (Threatened) and IUCN (Least Concern) status • *S. fasciatus* – COSEWIC (Threatened) and IUCN (Endangered) status • Commercial fishery
Roughead grenadier (*Macrourus berglax)*	**Typical Habitat** Preferred Temperature: 2.0 – 3.5°C Preferred Depth: 700 – 800 m (Lorance et al 2008) **Biology and Ecology** • Areas of concentration on the Grand Bank include the Flemish Pass and Nose of the Grand Banks (Kulka et al 2003a) • Feeds on benthic invertebrates (bivalves, shrimp, echinoderms) and some fish (redfish, grenadier, sand lance, skate) • Slow growing species with late maturation • Deep Demersal Assemblage

Species	Details[1]
	Status and Use • COSEWIC (Special Concern) status • Commercial and bycatch fishery
Roundnose grenadier (*Coryphaenoides rupestris*)	**Typical Habitat** Preferred Temperature: 3.5 – 4.5°C Preferred Depth: 400 - 1500m (Lorance et al 2008) **Biology and Ecology** • Inhabits continental slopes and shelves in the North Atlantic • Areas of concentration on the Grand Bank include areas between the Flemish Cap and Nose of the Grand Banks (Kulka et al 2003) • Feeds on small crustaceans, euphausiids, squid and small fishes • Undergoes diurnal vertical feeding migrations • Deep Demersal Assemblage • Adults are preyed upon by Greenland halibut and juveniles are preyed upon by redfishes **Status and Use** • COSEWIC (Endangered) status
Sculpin (*Triglops* sp.)	**Typical Habitat** Preferred Temperature: apx 0.0°C Preferred Depth: 135 – 930 m **Biology and Ecology** • Boreal cool-water benthic marine group of species that occur from shallow to deep depths • Occurs on both sides of the Atlantic Ocean • Commonly observed species in NAFO area 3NLOPs • Grand Bank Shelf Assemblage • Feeds on small crustaceans including mysids and amphipods • Preyed upon by cod and murres **Status and Use** • No conservation status or fishery in region • Ecologically important as a forage fish species
Silver hake (*Merluccius biolinearis*)	**Typical Habitat** Preferred Temperature: 6.0 – 8.0°C Preferred Depth: 55 – 375 m **Biology and Ecology** • Benthic species that prefers warm waters. Migrates to shallow inshore areas in the spring and offshore in the fall • Undergoes vertical feeding migrations • Opportunistic feeders that consume pelagic fishes (other gadids, Atlantic herring, myctophids, smelt, mackerel, sand lance) and squid • Silver hake are cannibalistic **Status and Use** • Commercial fishery
Smooth skate (*Malacoraja senta*)	**Typical Habitat** Preferred Temperature: 2.7 - 10.0°C (Kulka et al 2006) Preferred Depth: 70 – 480 m **Biology and Ecology** • Generally occur on soft mud and clay substrates over a range of depths (COSEWIC 2012a) • Feed mainly on crustaceans, euphausiids, mysids and some fish • Egg capsules are eaten by gastropods, halibut, monkfish and Greenland sharks (COSEWIC 2012a)

Species	Details[1]
	• Widespread Shelf Assemblage **Status and Use** • COSEWIC (Endangered) and IUCN (Endangered) status
Spotted wolffish (*Anarhichas minor)*	**Typical Habitat** Preferred Temperature: less than 5.0°C Preferred Depth: 300 - 500 m **Biology and Ecology** • Occurs on both sides of the North Atlantic • Areas of concentration on the Grand Bank include the Northeast Newfoundland Shelf, the Flemish Cap and the north and east edges of the Grand Banks (Kulka et al 2003a) • Feeds mainly on invertebrates (mollusks, crustaceans, echinoderms, polychaetes) and some fish. • Migrations by spotted wolffish are local and limited • Warm Deep Offshore Shelf Assemblage **Status and Use** • SARA (Threatened) and COSEWIC (Threatened) status
Spiny dogfish (*Squalus acanthias*)	**Typical Habitat** Preferred Temperature: 6.0 – 15.0°C Preferred Depth: 100 – 250 m (Kulka 2006) **Biology and Ecology** • Widely distributed in coastal waters of temperate seas throughout the world • Small, schooling shark that frequents coastal and inshore waters. This species is tolerant of low salinities and may ascend estuaries • Resident population that migrates between inshore and offshore areas in Canadian waters • Opportunistic feeder that consumes mainly small fishes. Juvenile dogfish are prey to various fish and sharks • Warm Southern Shelf Assemblage • Spiny dogfish is slow-growing and long-lived **Status and Use** • COSEWIC (Threatened) and IUCN (Vulnerable) status • Commercial fishery
Spiny eel (*Notacanthus chemnitzii*)	**Typical Habitat** Preferred Temperature: 2.0 – 4.0°C (Tokranov et al 2004) Preferred Depth: 250 – 1,000 m **Biology and Ecology** • Worldwide distribution, except for tropical regions • Bottom feeders that mainly feed on sea anemones • Northward migration of older larger fish **Status and Use** • No conservation status or fishery in region
Spinytail skate (*Bathyraja spinicauda*)	**Typical Habitat** Preferred Temperature: -1.5 – 3.3°C Preferred Depth: 165 – 365 m **Biology and Ecology** • Occurs on both sides of the North Atlantic • Coldwater skate not commonly observed in Canadian Atlantic waters. • Adults feed on benthic and pelagic fishes including capelin, sand lance redfish, other skates, cod and plaice

Species	Details[1]
	Status and Use • IUCN (Near Threatened) status
Thorny skate (*Amblyraja radiata*)	**Typical Habitat** Preferred Temperature: -1.4 - 14°C Preferred Depth: 18 – 966 m **Biology and Ecology** • Occurs on both sides of the North Atlantic • Areas of concentration on the Grand Bank include the Southwest Slope, edges of the Grand Bank, and Tail of the Bank. Concentrations vary seasonally (Kulka et al 2003a) • Boreal to Arctic species that inhabits offshore areas with hard and soft bottoms • Concentrated on the Grand Banks edge from December to June and on the Banks from July to November • Single stock across NAFO area 3LNOPs • Feeds mainly on polychaetes amphipods, decapods and fishes • Egg capsules are consumed by Greenland sharks and halibut • Widespread Shelf Assemblage **Status and Use** • COSEWIC(Special Concern) and IUCN (Vulnerable) status • Commercial fishery
Vahl's eelpout (*Lycodes vahlii*)	**Typical Habitat** Preferred Temperature: 2.0 – 4.5°C Preferred Depth: 200 – 600 m **Biology and Ecology** • Occurs on both sides of the Atlantic Ocean • Captured at average depths of 410m in the Orphan Basin during the spring and fall respectively (LGL 2012) • Feeds on polychaetes, small crustaceans and mollusks • Northern Shelf Assemblage **Status and Use** • No conservation status or fishery in region
White hake (*Urophycis tenuis*)	**Typical Habitat** Preferred Temperature: 4.0 – 8.0°C (Kulka et al 2005) Preferred Depth: 50 – 600 m **Biology and Ecology** • Inhabits areas with mud bottoms • Areas of concentration on the Grand Bank include the Southwest Slope and Laurentian Channel slope (Kulka et al 2003a) • Young hake utilize sand-hiding behavior • Feeds mainly on fish (herring, mackerel, other hake species) • Occurrence on the Grand Banks mainly along the southwest slope (Templeman 2007) • Warm Southern Shelf Assemblage **Status and Use** • No conservation status or fishery in region • COSEWIC (Threatened) status
Winter skate (*Leucoraja ocellata*)	**Typical Habitat** Preferred Temperature: 5.0 – 9.0°C Preferred Depth: 36 – 90 m **Biology and Ecology** • Distribution restricted to the northwest Atlantic • Prefers cool temperatures

Species	Details[1]
	• Benthic species that prefers living over sand and gravel bottoms • Feeds mainly on invertebrates (amphipods and polychaetes) and some fish. Sand lance is an important prey species • Warm Southern Shelf Assemblage **Status and Use** • COSEWIC (Special Concern, Threatened, Endangered) and IUCN (Endangered) status • No conservation status or fishery in region.
Witch flounder (*Glyptocephalus cynoglossus*)	**Typical Habitat** Preferred Temperature: 2.0 – 6.0°C Preferred Depth: 185 – 366 m **Biology and Ecology** • Benthic species that prefers living over mud or mud-sand bottoms • Areas of concentration on the Grand Banks include northeast edge, Southwest Slope and Laurentian Channel (Kulka et al 2003a) • Captured at average depths of 432 and 487m in the Orphan Basin during the spring and fall respectively (LGL 2012) • Feeds mainly on polychaetes, amphipods, molluscs and small fishes • Does not undergo extensive migrations • Deep Demersal Assemblage **Status and Use** • No conservation status or fishery in region
Yellowtail flounder (*Limanda ferruginea*)	**Typical Habitat** Preferred Temperature: 3.1 – 4.8°C Preferred Depth: 57 – 64 m **Biology and Ecology** • Offshore benthic species that prefers living over sand or mud-sand bottoms • Areas of concentration include the Laurentian Channel slope and Tail of the Bank (Kulka et al 2003a) • Feeds mainly on polychaetes and amphipods and some small fish (sand lance and capelin). • Commonly observed species in NAFO area 3NLOPs • Undertakes seasonal migrations to shallow water in spring and deep waters in fall and winter • Grand Bank Shelf Assemblage **Status and Use** • Commercial fishery.

[1] Information is summarized from Scott and Scott (1988) and Kearley (2012) unless otherwise noted

Table 4.9 Overview of Pelagic Fish Species that are Known or Likely to Occur in the Study Area

Species	Details[1]
Albacore tuna (*Thunnus alalunga*)	**Typical Habitat** Preferred Temperature: 15.6 – 19.4°C Preferred Depth: 0 – 600 m (Collette and Nauen 1983) **Biology and Ecology** • Cosmopolitan species captured on the Grand Banks • Epipelagic and mesopelagic oceanic species • Feeds on pelagic fish, crustaceans and squid (Pusineri et al 2005) • Forms mixed schools with skipjack tuna, yellowfin tuna and bluefin tuna (Collette et al 2011) • Pelagic Assemblage **Status and Use** • IUCN (Near Threatened) status • Commercial fishery
Alewife (*Alosa pseudoharengus*)	**Typical Habitat** Preferred Temperature: 3.0 – 17.0°C Preferred Depth: 56 – 110 m **Biology and Ecology** • Distribution restricted to Northwest Atlantic • Anadromous species; spawns in freshwater and lives most of adult life in the ocean • Light-sensitive, found at greater depths during daylight hours • Feeds mainly on zooplankton; amphipods, copepods, mysids, and fish eggs **Status and Use** • Commercial fishery
American eel (*Anguilla rostrata*)	**Typical Habitat** Preferred Temperature: 15.4 - 19.4°C Preferred Depth: 0 – 35 m **Biology and Ecology** • Distributed in freshwater streams along the western North Atlantic • Occurs in estuaries, lakes and rivers (Jessop et al 2002) that have access to the sea • Catadromous species; migrates to freshwater to feed and grow and to saltwater to reproduce. • Larval eels at sea feed on plankton. Juvenile and adult eels in freshwater feed on benthic invertebrates and small fishes **Status and Use** • Provincial (Vulnerable) and COSEWIC (Threatened) status • Recreational and commercial fishery
Atlantic bluefin tuna (*Thunnus thynnus*)	**Typical Habitat** Preferred Temperature: more than 13.0°C Preferred Depth: 27 – 183 m **Biology and Ecology** • Undertakes extensive migrations; moves northward into Canadian waters in summer and southward again in late fall • Feeds on pelagic and benthic fishes (capelin, saury, herring, mackerel and lanternfishes). • Squid and capelin are important food sources in Newfoundland waters • Occurs over the continental shelf, off Newfoundland, and in the Gulf of St. Lawrence • Predators include sharks, orca whales and pilot whales • Pelagic Assemblage **Status and Use** • COSEWIC (Endangered) and IUCN (Endangered) status

Species	Details[1]
	• Commercial fishery
Atlantic herring (*Clupea harengus harengus*)	**Typical Habitat** Preferred Temperature: 5.0 – 9.0°C Preferred Depth: 5 – 200 m **Biology and Ecology** • Occurs on both sides of the North Atlantic Ocean • Feeds on phytoplankton, copepods and euphausiids • Pelagic, schooling species • Undertakes annual migrations to spawning grounds, feeding areas and wintering areas • Multiple stocks / populations occur in Canadian waters • Pelagic Assemblage **Status and Use** • Ecologically important; important food source for fishes, marine birds and marine mammals.
Atlantic mackerel (*Scomber scombrus*)	**Typical Habitat** Preferred Temperature: 9.0 – 12.0°C Preferred Depth: 70 – 200 m **Biology and Ecology** • Occurs on both sides of the North Atlantic Ocean • Pelagic, schooling species common to temperate waters • Distributed in Canadian coastal and inshore waters during summer and fall • Plankton feeder; filters organisms from water with gill rakers • Pelagic Assemblage **Status and Use** • Commercial fishery
Atlantic salmon (*Salmo salar*)	**Typical Habitat** Preferred Temperature: 2.0 – 9.0°C Preferred Depth: 1 – 10 m **Biology and Ecology** • Occurs on both sides of the North Atlantic Ocean • Anadromous species; lives in fresh water and estuaries the first 2 to 7 years of life before migrating to sea • Cool rivers with extensive gravelly bottom headwaters are important habitat • When about 15 cm long, young salmon migrate to sea, where they may live for 1, 2, or more years before returning to freshwater **Status and Use** • COSEWIC (Special Concern, Threatened, Endangered) and IUCN (Least Concern) status • Recreational fishery • Historical commercial fishery
Atlantic saury (*Scomberesox saurus*)	**Typical Habitat** Preferred Temperature: 8.0 - 25.0°C Preferred Depth: 0 – 30 m (Wisner 1990) **Biology and Ecology** • Occurs in warm temperate waters • Schooling species that undertakes diurnal vertical migrations • North to south migrations associated with warm water temperatures • Feeds mainly on zooplankton including copepods, euphausiids, amphipods, and fish eggs and larvae **Status and Use** • No conservation status or fishery in region

Species	Details[1]
Basking shark (*Cetorhinus maximus*)	**Typical Habitat** Preferred Temperature: 8.0 – 12.0°C Preferred Depth: 0 – 750 m **Biology and Ecology** • Species is highly migratory; occurring in coastal warm waters around Newfoundland during the summer and fall • Distributed mainly off southern Newfoundland, on the Scotian Shelf and in the Gulf of Maine (DFO 2008) • Pelagic, filter feeding shark that mainly feeds on plankton. • Pelagic Assemblage **Status and Use** • No conservation status or fishery in region
Bigeye tuna (*Thunnus obesus*)	**Typical Habitat** Preferred Temperature: 13.0 – 29.0°C Preferred Depth: 0 – 250 m **Biology and Ecology** • Worldwide distribution; Atlantic, Indian and Pacific Oceans (FAO 2013) • Young fish school with other tuna species in surface waters (DFO 1998) • Migrates through temperate waters after spawning • Feeds on fish and squid (Logan et al 2012) • Pelagic Assemblage **Status and Use** • IUCN (Vulnerable) status • Commercial fishery
Blue shark (*Prionace glauca*)	**Typical Habitat** Preferred Temperature: 7.0 – 16.0°C Preferred Depth: 10 – 220 m (Carey and Scharold 1990) **Biology and Ecology** • Wide-ranging pelagic species in temperate waters • Worldwide distribution in inshore and offshore waters • Undertakes large vertical migrations at night • Feeds mainly on fish (herring, hake, cod, haddock, pollock, mackerel, butterfish, sea raven, flounders) and squid • Unlike many other sharks, blue sharks are known to leap out of the water • Pelagic Assemblage **Status and Use** • COSEWIC (Special Concern) and IUCN (Near Threatened) status • Commercial fishery
Capelin *(Mallotus villosus*)	**Typical Habitat** Preferred Temperature: -1.0 – 6.0°C (Rose 2005) Preferred Depth: 0 – 280 m **Biology and Ecology** • Inhabits cold, deep waters, in the Atlantic Ocean on the offshore banks and in coastal areas • Seasonal migrations to inshore spawning areas • The largest concentrations in Canadian waters are found off Newfoundland and the Labrador Coast • Feeds on planktonic organisms; mainly euphausiids and copepods • Important food source for other fish, marine birds and marine mammals. Preyed upon heavily by Atlantic cod

Species	Details[1]
	• Commonly observed species in NAFO area 3NLOPs • Pelagic Assemblage **Status and Use** • Commercial fishery • Ecologically important as a forage fish species
Greenland shark (*Somniosus microcephalus*)	**Typical Habitat** Preferred Temperature: 0.6 – 12.0°C Preferred Depth: 10 – 1,200 m **Biology and Ecology** • Distribution restricted to the North Atlantic Ocean • Occupies near surface areas in winter months and deep cool waters during summer months • Feeds on fish (herring, salmon, char, capelin, redfish, sculpin, lumpfish, cod, haddock, halibut and skate), invertebrates (squid, gastropods, crustaceans), seabirds and marine mammals **Status and Use** • No conservation status or fishery in region
Lanternfish (Myctophidae)	**Typical Habitat** Preferred Temperature: 4.0 – 16.0°C Preferred Depth: 30 – 1,200 m **Biology and Ecology** • Commonly observed species in NAFO area 3NLOPs • Opportunistic planktivores feeding on copepods, euphausiids, ostracods, fish eggs and larvae • Characterized by light organs on the head and body • Undertakes diurnal vertical migrations. • Deep Pelagic Assemblage **Status and Use** • No conservation status or fishery in region • Ecologically important as a forage fish species
Porbeagle shark (*Lamna nasus*)	**Typical Habitat** Preferred Temperature: 6.0 – 16.0°C Preferred Depth: 0 – 710 m **Biology and Ecology** • Common on continental shelves with occurrences offshore • Distributed in Atlantic, Pacific and Indian Oceans • Occurs in Canadian waters during spring, summer and fall • Pelagic Assemblage **Status and Use** • COSEWIC (Endangered) and IUCN (Vulnerable) status
Shortfin mako shark (*Isurus oxyrinchus*)	**Typical Habitat** Preferred Temperature: 17.0 – 22.0°C Preferred Depth: 100 – 150 m (Bianchi et al 1999) **Biology and Ecology** • Extremely active species, considered the fastest shark • Feeds on fish (Mackerel, tuna, swordfish, bonito) • Estimate lifespan of 24 years with maximum life expectancy of up to 45 years (DFO 2010b) • Circumglobal distribution in temperate and tropical waters • Individuals in Canadian waters part of the North Atlantic Population • Migrate to Atlantic Canadian Waters in late summer and fall (DFO 2010b)

Species	Details[1]
	• Pelagic Assemblage. **Status and Use** • COSEWIC (Threatened) and IUCN (Vulnerable) status • Commercial fishery
Swordfish (*Xiphias gladius*)	**Typical Habitat** Preferred Temperature: 8.0 – 27.0°C Preferred Depth: 0 – 500 m **Biology and Ecology** • Occurs in Canadian waters between June and November • Opportunistic feeders of fish (mackerel, hake, redfish, herring, lanternfish) and squid • Distributed throughout a variety of depths • Undertakes diurnal vertical migrations • Young swordfish preyed upon by blue sharks, tunas and marlins • Pelagic Assemblage **Status and Use** • Commercial fishery
White shark (*Carcharodon carcharias*)	**Typical Habitat** Preferred Temperature: 6.0 - 22.0°C (Weng et al 2007) Preferred Depth: 0 – 150m (Weng et al 2007) **Biology and Ecology** • Occurs in coastal and offshore waters from surface waters to more than 1,280 m • Feeds on fish (salmon, hake, halibut, mackerel, tunas, other sharks) sea turtles, seabirds and marine mammals • Widespread distribution in temperate seas of all oceans • Pelagic Assemblage **Status and Use** • SARA (Endangered), COSEWIC (Endangered) and IUCN (Vulnerable) status
[1] Information is summarized from Scott and Scott (1988) and Kearley (2012) unless otherwise noted	

Spawning

Marine fish of the Newfoundland region spawn in a variety of habitats that occur within and beyond the Study Area. For example, freshwater rivers are used by anadromous species such as Atlantic salmon, temperate and tropical waters are used by many large pelagics (e.g. tuna) and beaches are used by capelin. Nonetheless, many species remain in the Study Area to spawn where they exhibit varying degrees of habitat specificity and a variety of strategies that include broadcast spawning (e.g. Atlantic cod), demersal spawning (e.g. skates) and oviviparous spawning (e.g. redfish). A summary of spawning seasons and known spawning areas for key fish species are provided in Figure 4.21. Most species are spring and early summer spawners but a few, such as Greenland halibut and roughhead grenadier, spawn in winter.

Figure 4.21 Spawning Periods and Reproductive Biology for Key Fish Species

Family	Common Name	Scientific Name	Spawning Period[1,2]												Egg Location	Larvae Feeding	Known Spawning Location
			J	F	M	A	M	J	J	A	S	O	N	D			
Ammodytidae	Northern sand lance	*Ammodytes dubius*	■	■	■								■	■	Pelagic	Pelagic	Southeast Shoal and Tail of the Grand Banks[3]
Anarhichadidae	Atlantic wolffish	*Anarhichas lupus*									■	■			Demersal	Pelagic	
Anarhichadidae	Northern wolffish	*Anarhichas denticulatus*									■	■	■		NDA	Pelagic	
Anarhichadidae	Spotted wolffish	*Anarhichas minor*						■	■	■					NDA	Pelagic	
Cottidae	Sculpin	*Triglops* sp.	■										■	■	Demersal	Pelagic	
Gadidae	Atlantic cod	*Gadus morhua*				■	■	■							Pelagic	Pelagic	Southeast shoal of Grand Bank and Virgin Rocks[3]
Gadidae	Blue hake	*Antimora rostrata*	*NDA*												NDA	NDA	Spawning location unknown[4]
Gadidae	Cusk	*Brosme brosme*				■	■	■	■						Pelagic	Pelagic	
Lamnidae	Porbeagle shark	*Lamna nasus*			■	■			■	■	■				N/A	N/A	Mating grounds South of Newfoundland[5]
Macrouridae	Roughhead grenadier	*Macrourus berglax*	■	■	■									■	Pelagic	Pelagic	Grand Bank
Macrouridae	Roundnose grenadier	*Coryphenoides rupestris*						■	■	■	■				Pelagic	Pelagic	
Myctophidae	Lanternfish	Myctophida*e*			■	■	■	■							Pelagic	Pelagic	
Osmeridae	Capelin	*Mallotus villosus*				■	■	■	■						Demersal	Pelagic	Southeast shoal of Grand Bank[3]
Pleuronectidae	Yellowtail flounder	*Limanda ferruginea*					■	■	■						Pelagic	Pelagic	Virgin Rocks of the Grand Bank[3]
Pleuronectidae	American plaice	*Hippoglossoides platessoides*		■	■	■	■	■							Pelagic	Pelagic	Flemish Cap of the Grand Bank[3]
Pleuronectidae	Greenland halibut	*Reinhardtius hippoglossoides*	*Variable*												Demersal	Pelagic	Northern Flemish Pass, Davis Strait

Family	Common Name	Scientific Name	Spawning Period[1,2]												Egg Location	Larvae Feeding	Known Spawning Location
			J	F	M	A	M	J	J	A	S	O	N	D			
Rajidae	Smooth skate	*Malacoraja senta*	■	■	■	■	■	■	■	■	■	■	■	■	Demersal	Demersal	Flemish Cap
Rajidae	Thorny skate	*Amblyraja radiata*	■	■	■	■	■	■	■	■	■	■	■	■	Demersal	Demersal	
Rajidae	Winter skate	*Leucoraja ocellata*	■	■	■	■	■	■	■	■	■	■	■	■	Demersal	Demersal	
Salmonidae	Atlantic salmon	*Salmo salar*										■	■		Demersal	N/A	Freshwater streams
Scorpaenidae	Deepwater redfish	*Sebastes mentella*					■	■	■						N/A	Pelagic	Southwest Shelf Edge and Slope of Grand Bank[3]
Scorpaenidae	Acadian redfish	*Sebastes fasciatus*					■	■	■						N/A	Pelagic	

[1]Light shading represents breeding and copulation periods, dark shading indicates spawning periods.
[2]Sources: Scott and Scott (1988) unless otherwise specified. [3]Templeman et al (2007); [4]DFO 2013a; [5]Kulka et al (2003a)
NDA – No data available.

Fish Migration Patterns

Fish found in the Study Area also exhibit a variety of migration strategies that are used to avoid adverse conditions, reach ideal spawning habitats and locate suitable feeding grounds. Strategies employed by fish found on the Grand Banks and the Newfoundland Shelf are described in AMEC (2014) and can be summarized as follows:

- Migrations to shallow coastal areas in summer to offshore wintering habitats (e.g. cod and capelin);
- Summer feeding migrations into the Study Area from southerly latitudes by highly migratory warm water pelagic such as tunas, swordfish and a variety of sharks;
- Anadromous migrations of species like Atlantic salmon, which migrate through the Study Area on their way from and to freshwater spawning habitats;
- Catadromous migrations of American eel, which migrate through the Study Area as they move between freshwater rearing environments and the Sargasso Sea spawning areas; and
- More localized movements exhibited by deep water species (e.g. redfish, wolffish and Greenland halibut) and some stock components of other species (e.g. inshore components of Atlantic cod).

Migratory strategies and pathways can differ between stocks within species. For example, Atlantic cod in the Study Area can exhibit limited migration or extensive inshore-offshore movements. Furthermore, migration routes are dependent on the stocks' location (COSEWIC 2010a; COSEWIC 2010b). Both Atlantic cod and Atlantic salmon stocks associated with the northeast coast of Newfoundland exhibit different migratory patterns than those of the south coast. Cod found on the South Coast can migrate from the northern Gulf of St. Lawrence to overwinter within the Study Area on the slopes of the Laurentian Channel. In contrast, Atlantic cod from the east coast of Newfoundland typically overwinter in offshore areas near the continental shelf edge. Similarly, routes of south coast Atlantic salmon take them to oceanic environments via the Grand Banks, whereas northeast coast salmon are able to bypass that area (COSEWIC 2010b).

Some migrations are conducted across wide areas of the Study Area (e.g. inshore-offshore migrations), whereas in other cases some generalized migration corridors can be identified. These include:

- The Cabot Strait, which is used by species such as large migratory pelagics and other species to migrate to and from the Gulf of St. Lawrence (AMEC 2013);
- Warm deep water channels that are used to access inshore areas (e.g. the Bonavista Corridor); and
- The Southern Grand Banks, which likely experience traffic from pelagics migrating to and from southerly latitudes.

Finfish Species Distributions

The habitats and environmental conditions in the Study Area are heterogeneous and as a result vary in their value to resident species. Areas of elevated fish densities were defined using data collected during the 2008-2012 DFO RV Surveys. While the 20 most abundant species are identified (Table 4.10), only the top 10 species for measures of abundance and biomass (13 species comprising approximatetly 95 percent of the individuals captured) are mapped. Distributions of some species of conservation concern are also presented in this Section.

As noted by AMEC (2014), some portions of the Study Area, such as areas beyond the continental shelf and the 200 mile limit, are very much underrepresented in the existing avaialble datsets, and consequently, some species are artificially diminished in their importance (e.g. lanternfish). Nonetheless, the species on this list represent those that are dominant through much of the Study Area and many of those that are of direct importance to commercial fisheries.

A number of more holistic measures of fish distributions (i.e. zones of heightened species richness, total abundance and total biomass) are presented later in this Section.

Table 4.10 Representation of Finfish Taxa From DFO RV Surveys (2008-2012) in the Study Area

Common Name	Scientific Name	% of Total Abundance	% of Total Biomass
Redfish	*Sebastes mentella*	35.33	52.0
Capelin	*Mallotus villosus*	27.37	3.7
Sand lance	*Ammodytes dubius*	17.89	2.2
American plaice	*Hippoglossoides platessoides*	4.43	7.0
Yellowtail flounder	*Limanda ferruginea*	3.18	9.5
Sculpins (*Triglops*)	*Triglops* sp.	2.03	0.2
Atlantic cod	*Gadus morhua*	0.97	6.3
Silver hake	*Merluccius bilinearis*	0.88	1.2
Lanternfish	*Myctophidae*	0.88	0.1
Longfin hake	*Urophycis chesteri*	0.80	0.7
Common grenadier	*Nezumia bairdi*	0.61	0.4
Greeenland halibut	*Reinhardtius hippoglossoides*	0.50	1.8
Longnose eel	*Synaphobranchus kaupi*	0.45	0.3
Hookear sculpin	*Artediellus* sp.	0.43	0.0
Witch flounder	*Glyptocephalus cynoglossus*	0.39	1.0
Thorny skate	*Amblyraja radiata*	0.31	5.2
Blue hake	*Antimora rostrata*	0.31	0.4
Arctic cod	*Boreogadus saida*	0.30	0.1
Roughead grenadier	*Macrourus berglax*	0.24	1.1
Eelpout sp	*Lycodes* sp.	0.21	0.1

Deepwater Redfish (S. mentella)

The deepwater redfish is a commercially valued groundfish that was the most abundant species captured in the RV Surveys, representing approximately 35 percent of the fish caught and 52 percent of the biomass (Table 4.10). This species is long-lived and can reach 40 years of age (DFO 2011a). Although not considered a migratory species, it undertakes nocturnal vertical migrations to to feed on zooplankton and fish (Scott and Scott 1988; Templeman 2010). It is most abundant along the slopes of the southern Grand Banks, the Flemish Pass, St. Pierre Bank and on the continental slope of the northern part of the Study Area (Figure 4.22). COSEWIC has listed the redfish of the Study Area as being Threatened, due to the stock's poor condition (DFO 2011a). Environmental conditions appear to be most limiting in the southern portions of the Study Area, while both environmental conditions and exploitation affect stock health in the northern portions (Devine and Haedrich 2011).

Capelin

Capelin are an abundant (approximately 27 percent of fish captured in RV Surveys; Table 4.10), pelagic, schooling fish of the smelt family. They feed primarily on euphausiids, copepods and amphipods and many undertake seasonal shoreward migrations to spawn in coastal habitats (Scott and Scott 1988). The ecological importance of capelin to the marine ecosystem in the Study Area is well documented (e.g. Scott and Scott 1988; Gomes et al 1992; Davoren and Montevecchi 2003; Rose 2005; Templeman 2010; Dawe et al 2012) as they serve as an important lipid-rich prey source to a variety of marine organisms (fish, birds and marine mammals). Capelin are typically associated with cold water and can quickly alter their distributions to changing temperature conditions (Rose 2005). In the Study Area, they are found at their highest concentrations along the northern edge of the Grand Banks, the Flemish Pass, St. Pierre Bank and in the northwest portions of the Study Area (Figure 4.23). Capelin are also a commercially harvested species.

Sand Lance

Sand lance are small, planktivorous schooling fish (Scott and Scott 1988) that are a critical part of the food web in parts of the Study Area. Although not commercially fished themselves, they serve as prey for other valued species such as Atlantic cod, American plaice and Yellowtail flounder (Gomes et al 1992). Of the species captured in DFO RV Surveys, they were third most abundant, representing approximately 18 percent of fish species captured and two percent of fish biomass (Table 4.10). Within the surveyed portion of the Study Area, sand lance was found primarily over the Grand and St. Pierre Banks (Figure 4.24). This species was noticeably absent from areas north of the Grand Banks and the western extremity of the Study Area (e.g. Rose Blanche Bank).

American Plaice

American plaice are widespread demersal flatfish of the Study Area that were the third most prevalent species in RV surveys in terms of biomass (Table 4.10). This species is an ambush predator that preys upon a variety of invertebrates and fish (Scott and Scott 1988). They in turn also serve as food for large fish such as cod and sharks. In contrast to yellowtail flounder, American plaice are much more tolerant of colder water temperatures (Scott and Scott 1988; Morgan and Brodie 1991) but are found in highest abundance along the slopes of the Grand Bank and St. Pierre Banks (Figure 4.25). This species does not undertake significant

migrations, but its eggs float to the surface and are dispersed by the currents (Scott and Scott 1988; Frank et al 1992).

The population in the Study Area is currently listed as Threatened by COSEWIC. Once the largest flatfish fishery in the world, the Newfoundland and Labrador population has declined 96 percent due to overfishing and increased natural mortality (COSEWIC 2009a).

Yellowtail Flounder

Yellowtail flounder are a flatfish that are common to the warm, offshore banks, typically less than 100 m in depth (Scott and Scott 1988; Gomes et al 1992). It feeds primarily on invertebrates but also includes small fish in its diet (Scott and Scott 1988) and is a dominant species of the fish community where it occurs (Gomes et al 1992). In RV Surveys of the Study Area, it comprised three percent of the individuals captured but 10 percent of biomass (following only redfish) (Table 4.10). The distribution of this commercially valuable species is centred on the southern shallow and warm portion of the Grand Banks and they are largely absent from the Flemish Pass and the Newfoundland Shelf north of Bonavista (Figure 4.26). Since showing relatively low levels in the 1990s, yellowtail flounder abundance has increased (Templeman 2010).

Sculpins (Triglops sp.)

These species of small sculpins are found through much of the Study Area on the continental shelf and shallow slope (Figure 4.27). The highest concentrations occur on the eastern edge of the Grand Banks, along the Bonavista Corridor, St. Pierre Bank and near Fogo. They are the sixth most numerous species encountered by RV surveys but their small size means they contribute only 0.2 percent of the fish biomass taken (Table 4.10). Their abundance suggests they are ecologically important as predators of invertebrate prey but their ecology is somewhat poorly understood (Scott and Scott 1988).

Atlantic Cod

Atlantic cod were the dominant groundfish of the Study Area and this species previously formed the foundation of the fishery in the region (COSEWIC 2010a). The stocks collapsed in the 1990s, however, due to poor environmental conditions and excessive fishing, which had broad socioeconomic consequences as well as ecological ones. For example, the absence of this key marine predator contributed to the regime shift that occurred in the Study Area's ecosystem (Worm and Myers 2003; Dawe et al 2012). Currently the stocks in the Study Area are listed as Endangered by COSEWIC (COWEWIC 2010a) as they remain a small percentage of what they once were (less than three percent), although they are showing signs of recovery after two decades of restricted fishing (Koen-Alonso et al 2010). Despite its current abundance relative to historical levels, cod remain widespread in the Study Area (ranked seventh in RV Survey fish abundance and fourth in biomass, see Table 4.10) and are most prevalent along Burgeo and St. Pierre banks, the Tail of the Grand Banks, the Bonavista Corridor and the Flemish Pass. They are least abundant on the shallows of the northern Grand Banks (Figure 4.28).

Silver Hake

Silver hake are a warm water gadid that are known as voracious feeders (Scott and Scott 1988). They feed on a variety of demersal and pelagic fish and opportunistically on invertebrate species such as squid (Scott and Scott 1988). Where abundant, they are an important prey item for other gadids, dogfish and swordfish (Scott and Scott 1988). They are largely confined to the southern extremities of the Study Area, particularly on the southwest slope of the Grand Banks and St. Pierre Bank (Figure 4.29). Although relatively abundant in more southerly areas, they make up approximately one percent of the RV Survey abundance and biomass (Table 4.10).

Lanternfish

The lanternfish family are comprised of small, pelagic, planktivorous fishes with light producing organs on their bodies (Scott and Scott 1988). They occupy deep ocean waters around the globe and are an important prey item for commercially valued species such as cod, hake, tunas, salmon and marine mammals (Scott and Scott 1988). According to recent RV Surveys, these fish are absent in shallow coastal areas and offshore banks and instead are found in the deep slope portions of the surveyed area, particularly in the Flemish Pass and the deep slope near the northern limits of the Study Area (Figure 4.30). As these fish occupy habitats at and beyond the limits sampled in with the RV Surveys, it is very likely that their representation in the Study Area (less than one percent of fish caught and 0.1 percent of biomass; Table 4.10) is underestimated.

Longfin Hake

The longfin hake is a deepwater species that has pelagic egg and larval stages but demersal adult phases. Most individuals feed on invertebrates but larger individuals will feed on small vertically migrating fish (Scott and Scott 1988). In the Study Area these fish were virtually absent on the banks and across the shelf areas and only detected near the deep water limits of the RV Surveys. Within these areas they were in highest densities off the Burgeo and St. Pierre Banks and the southwest Grand Banks (Figure 4.31). They contribute less than one percent to abundance and biomass of the fish captured in the RV Surveys (Table 4.10).

Roughhead Grenadier

Roughhead grenadier are a component of the of the deepwater demersal community, where they feed on a variety of benthic invertebrates and small fish and they themselves are prey to piscivorous fish (Scott and Scott 1988), and are also a commercially valuable species. Of the species of grenadier known to occupy the area, roughhead grenadiers were the most abundant in RV surveys from 2008-2012, although they represented less than one percent of the catch in terms of abundance and biomass (Table 4.10). Like other deepwater species, the abundance of roughhead grenadier is likely underestimated as their preferred habitat is underrepresented in the Study Area by the RV Surveys. The largest densities of this species is found in the Flemish Pass and on the deep slopes of the eastern margins of the Grand Banks and the Newfoundland Shelf (Figure 4.32).

Greenland Halibut

Greenland halibut are typically a deepwater flatfish species that is commercially valuable. Unlike most flatfish, they spend considerable time off the bottom, feeding pelagically on a variety of fish and invertebrates (Scott

and Scott 1988). As individuals age they are usually found in progressively deeper water (Bowering and Chumakov 1989). In the warmer southern waters of the Study Area, this species is found primarly along the slope of the banks. However, the highest densities in RV Surveys were found along the Newfoundland Shelf in the northern portions of the Study Area and to a lesser degree in the Flemish Pass (Figure 4.33). This species contributed approximately two percent of the fish biomass captured in RV Surveys (Table 4.10).

Thorny Skate

The Thorny skate is a long-lived and late maturing species with low fecundity (i.e. typical hatching success of approximately 15 young per year; COSEWIC 2012b). It is commercially harvested and is the most common of five species of skate that occur in the Study Area, where it contributes the fifth highest biomass among fish species captured in the DFO RV Surveys (Table 4.10). The individuals along the east coast of North America are considered to be one population, and have been listed as being of Special Concern by COSEWIC (2012b) due to its declining abundance in the southern parts of its range. In the parts of its range that coincide with the Study Area, however, the abundance of this species has been increasing (COSEWIC 2012b). Thorny Skate are widespread in the Study Area but are found in high densities along the slope edge of the southern Grand Banks and St. Pierre Bank (Figure 4.34).

Atlantic Salmon

Atlantic salmon are typically anadromous, spawning in freshwater after oceanic feeding migrations (COSEWIC 2010b). Juvenile salmon spend 2-7 years in freshwater as parr before they transform to smolt and begin life in the marine environment. The pelagic nature of oceanic salmon do not make them amenable for study using RV surveys, but they are known to migrate through the Study Area on their way to (Figure 4.35) and from (Figure 4.36 oceanic feeding grounds. Migrants originate from several areas of Atlantic Canada and Maine, with several of these populations listed by COSEWIC (2010b).

Figure 4.22 Distribution of Redfish in the Study Area (Canadian RV Surveys, 2008-2012)

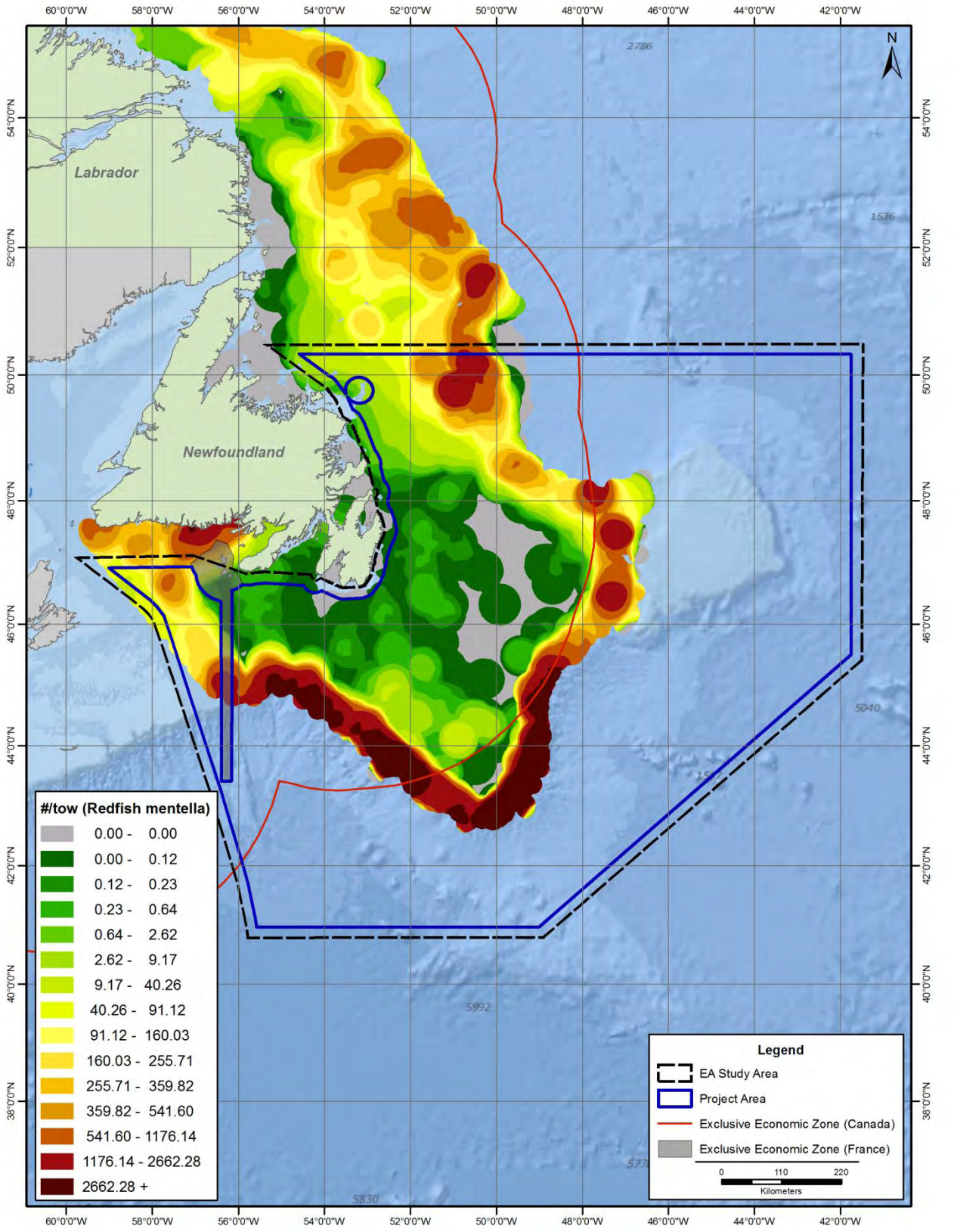


Figure 4.23 Distribution of Capelin in the Study Area (Canadian RV Surveys, 2008-2012)

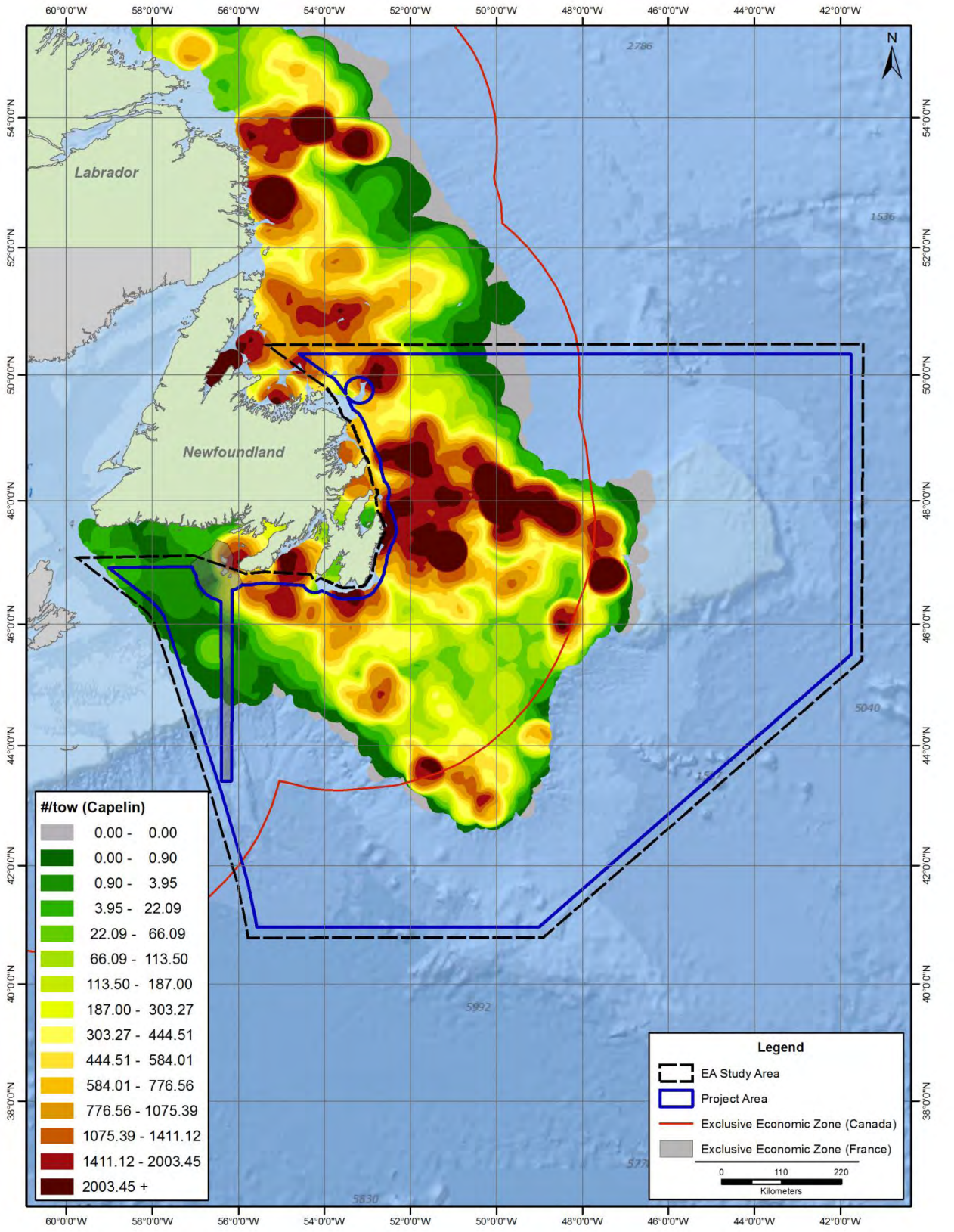


Figure 4.24 Distribution of Sand Lance in the Study Area (Canadian RV Surveys, 2008-2012)

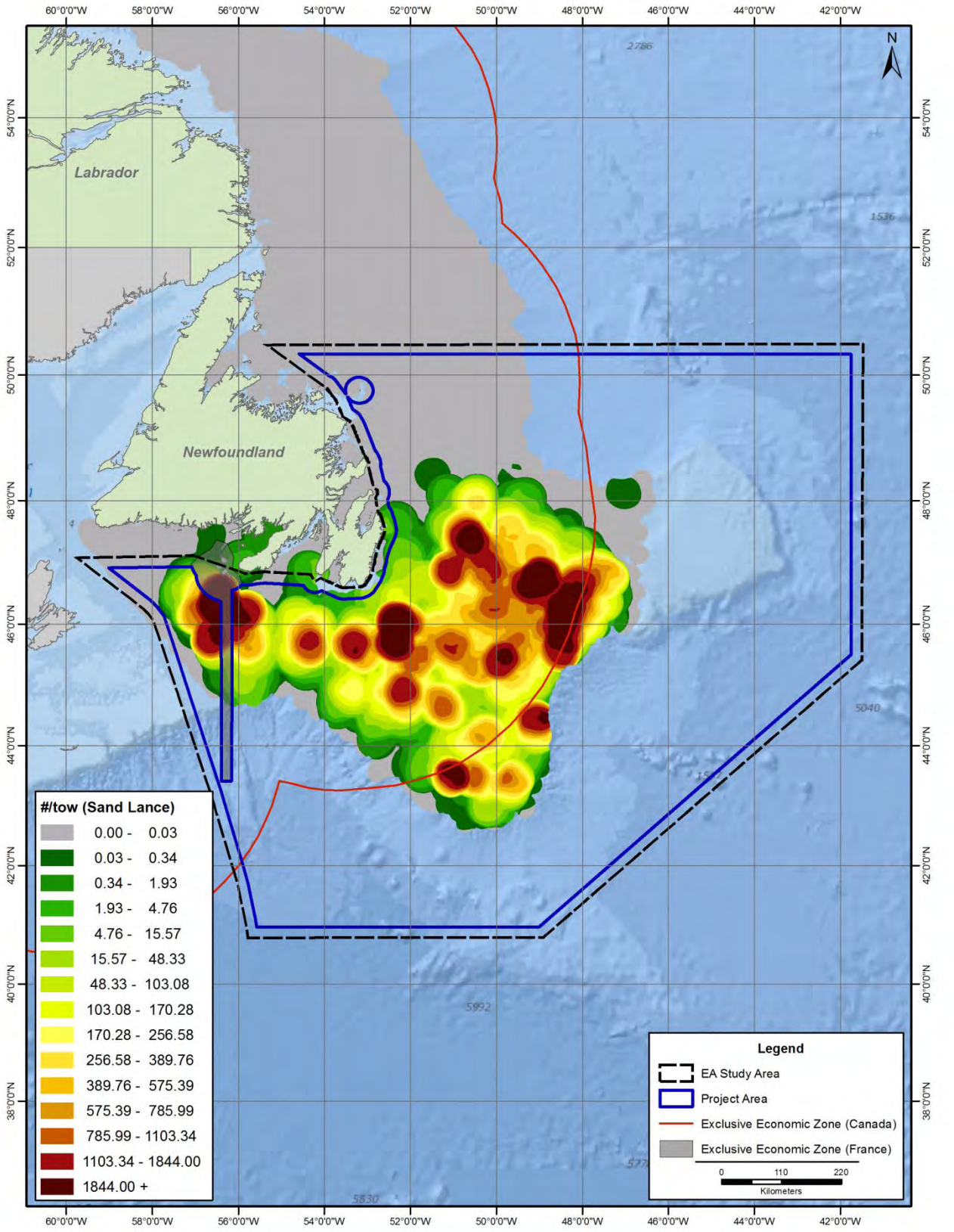


Figure 4.25 Distribution of American Plaice in the Study Area (Canadian RV Surveys, 2008-2012)

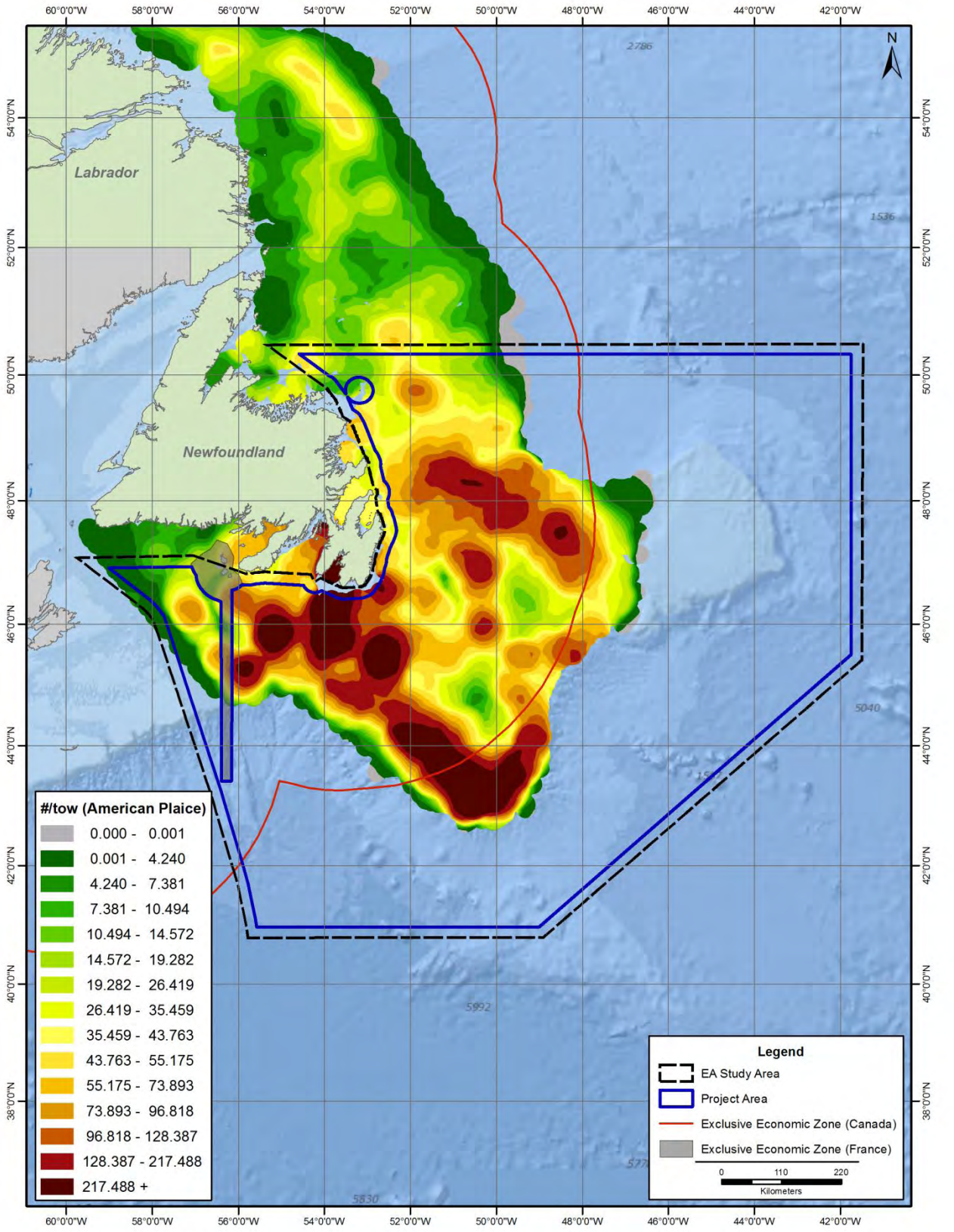


Figure 4.26 Distribution of Yellowtail Flounder in the Study Area (Canadian RV Surveys, 2008-2012)

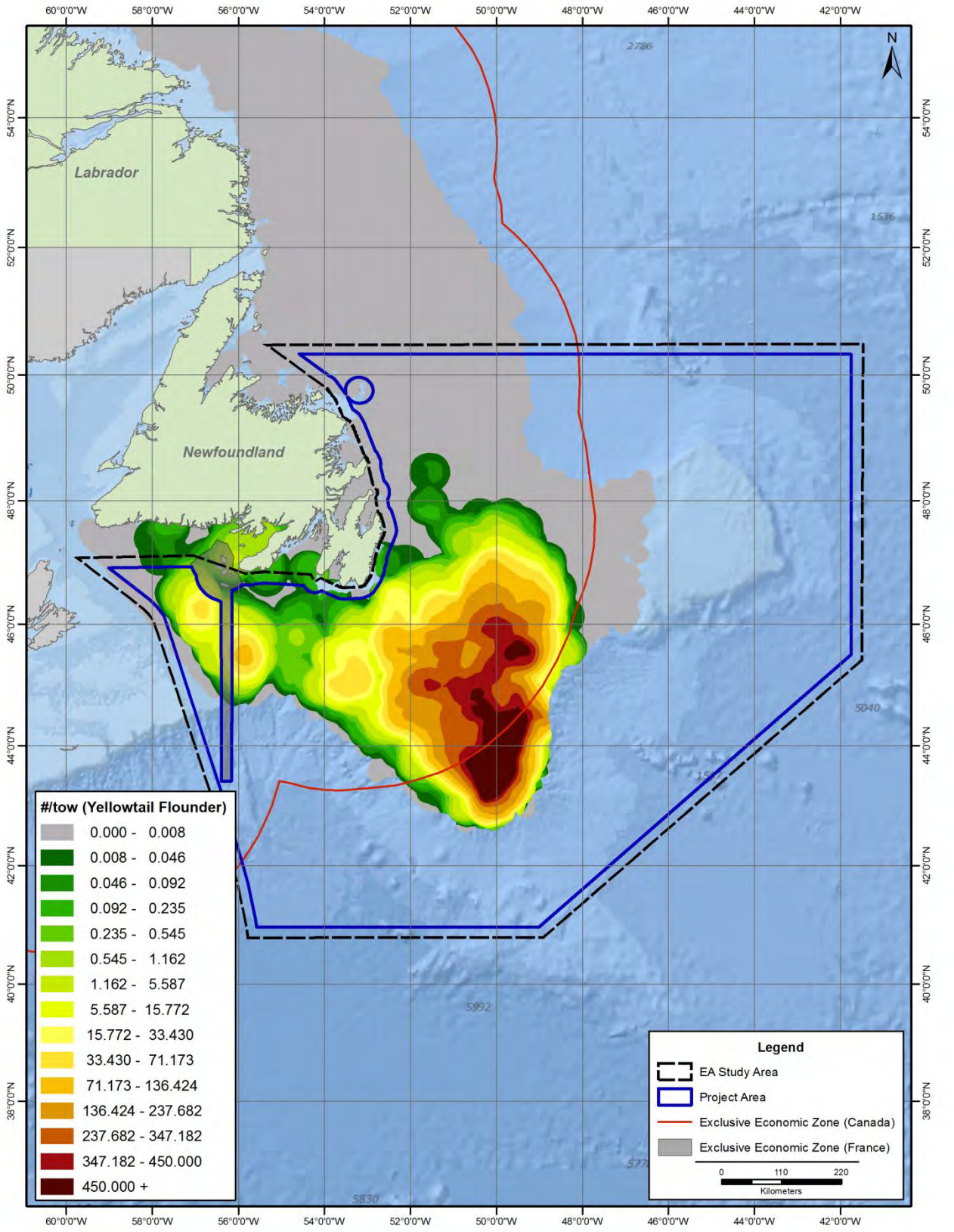


Figure 4.27 Distribution of Sculpins in the Study Area (Canadian RV Surveys, 2008-2012)

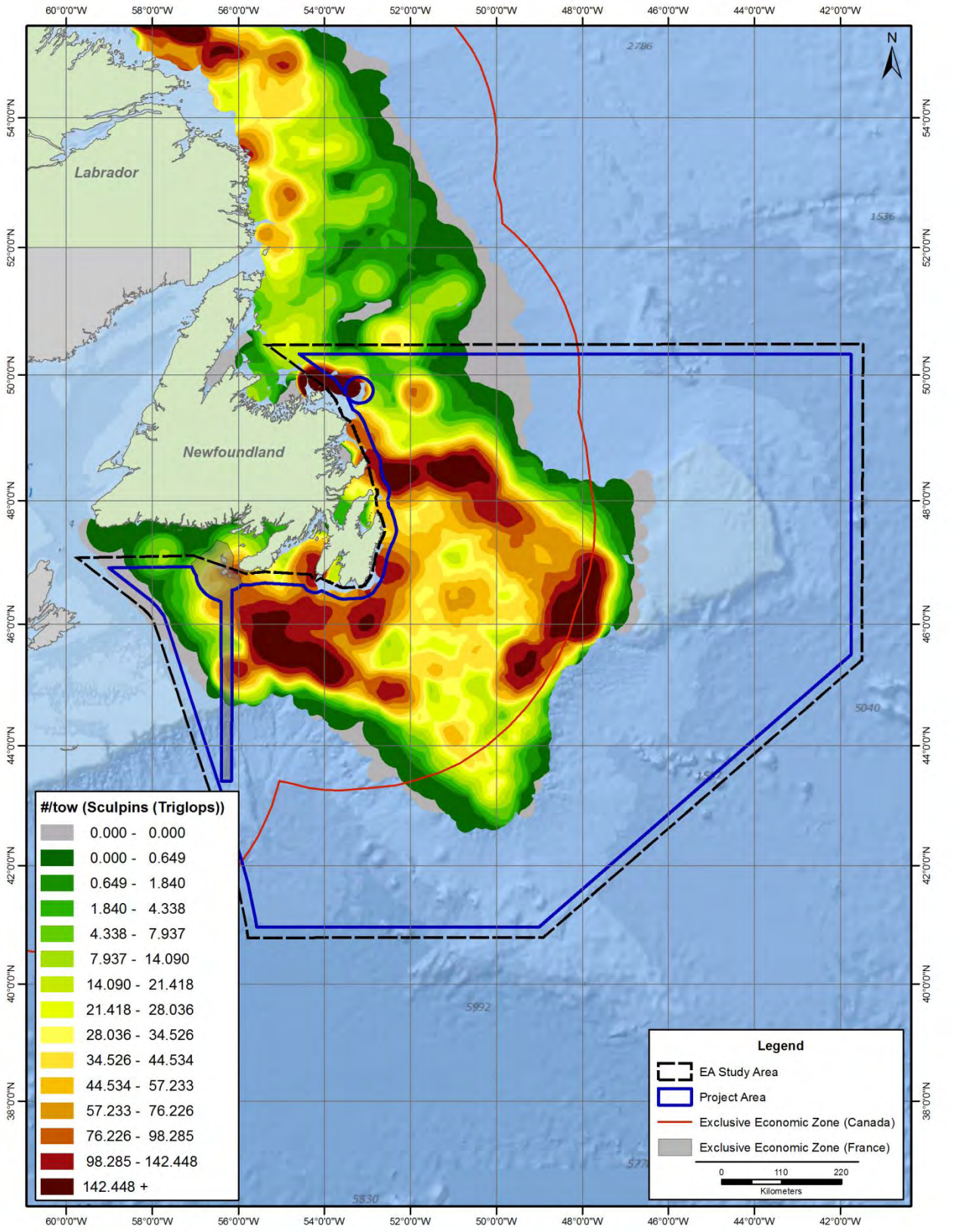


Figure 4.28 Distribution of Atlantic Cod in the Study Area (Canadian RV Surveys, 2008-2012)

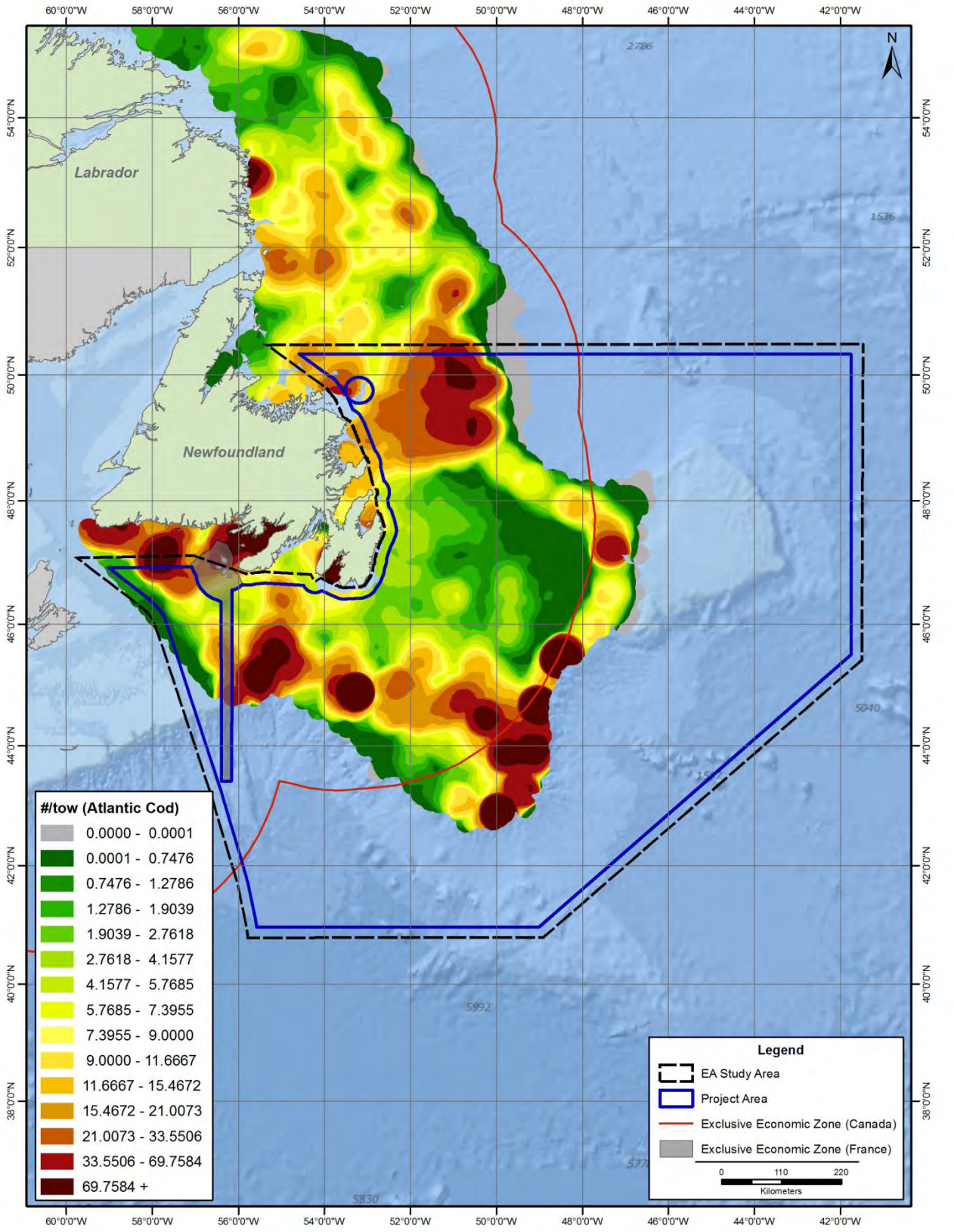


Figure 4.29 Distribution of Silver Hake in the Study Area (Canadian RV Surveys, 2008-2012)

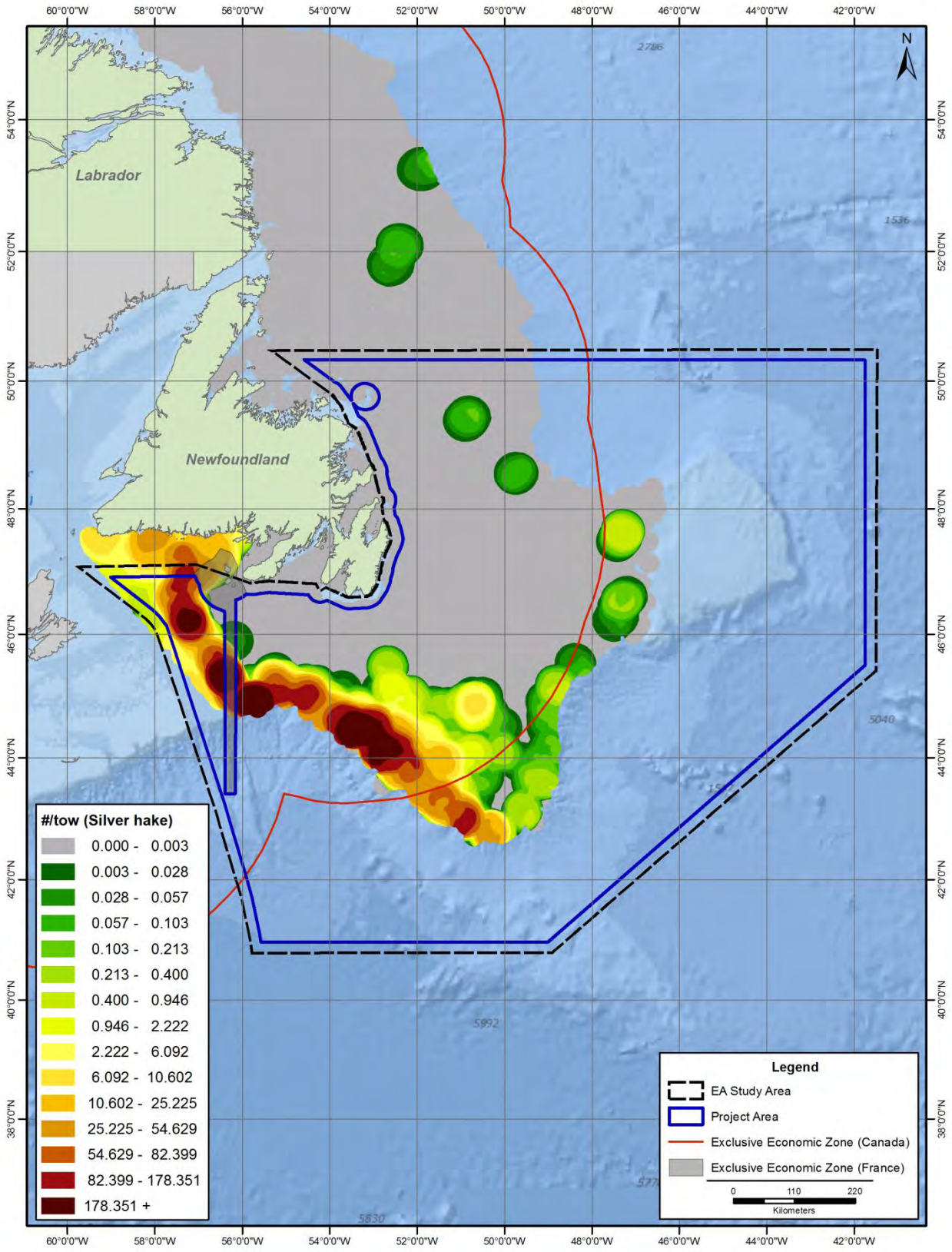


Figure 4.30 Distribution of Lanternfish in the Study Area (Canadian RV Surveys, 2008-2012)

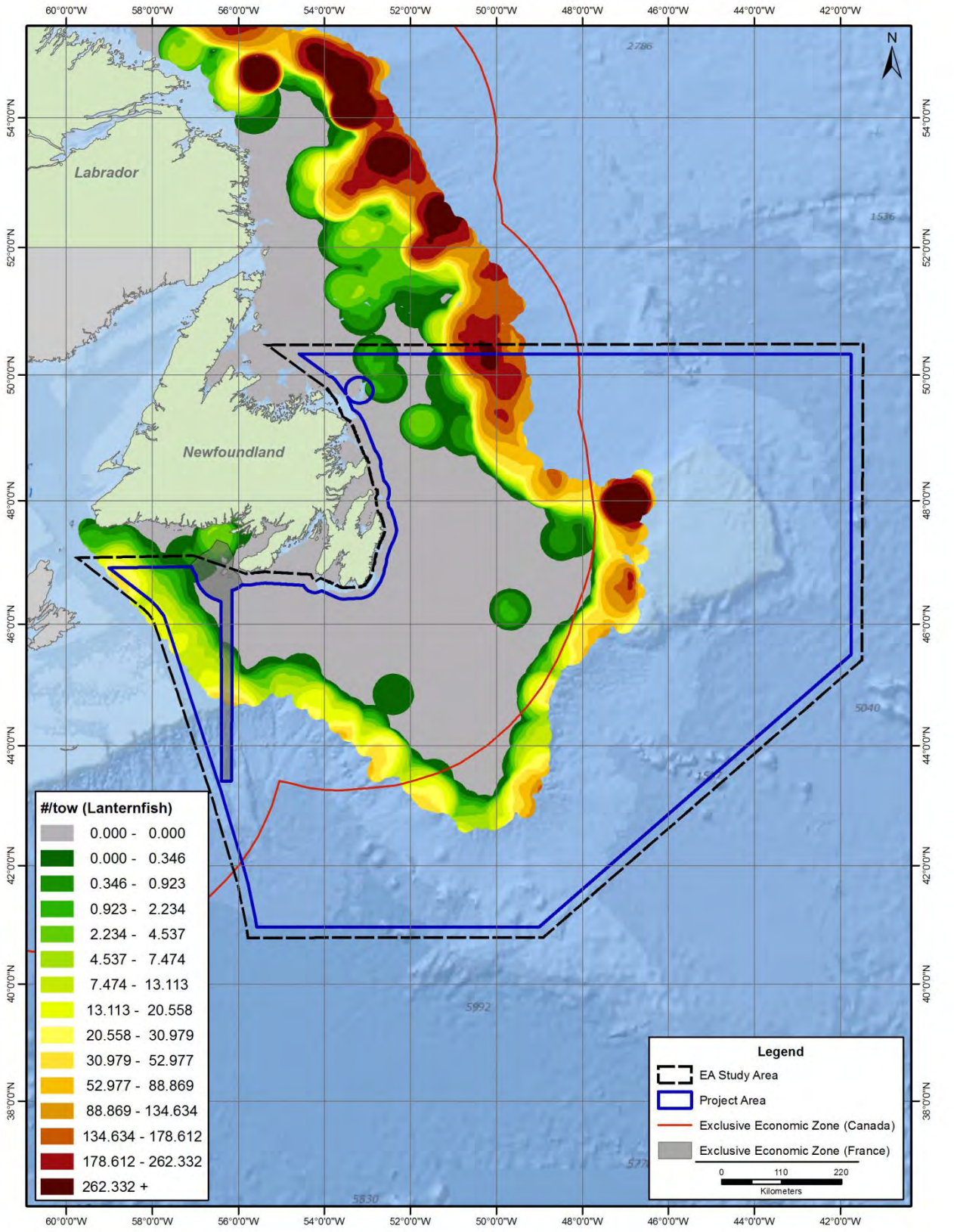


Figure 4.31 Distribution of Longfin Hake in the Study Area (Canadian RV Surveys, 2008-2012)

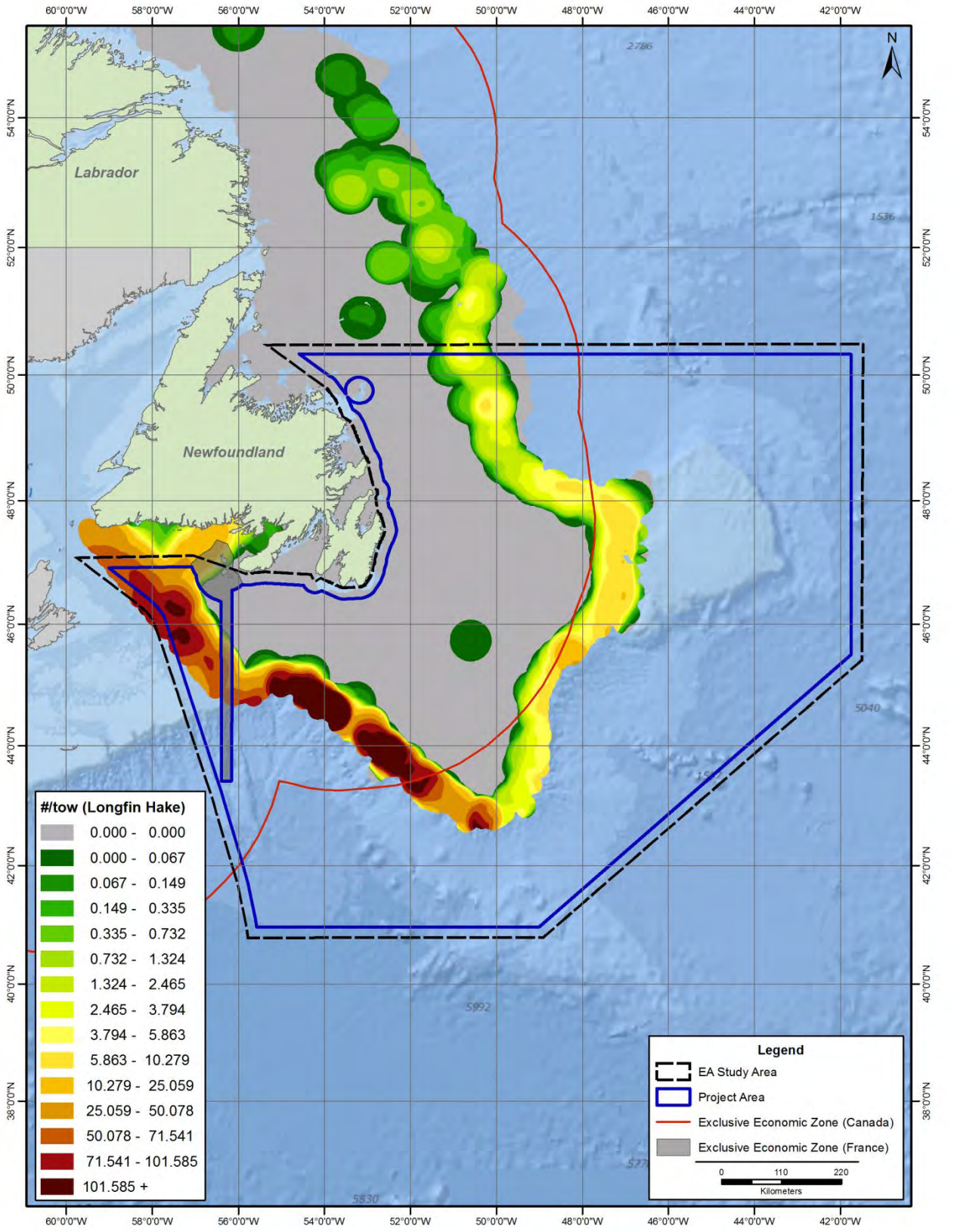


Figure 4.32 Distribution of Roughead Grenadier in the Study Area (Canadian RV Surveys, 2008-2012)

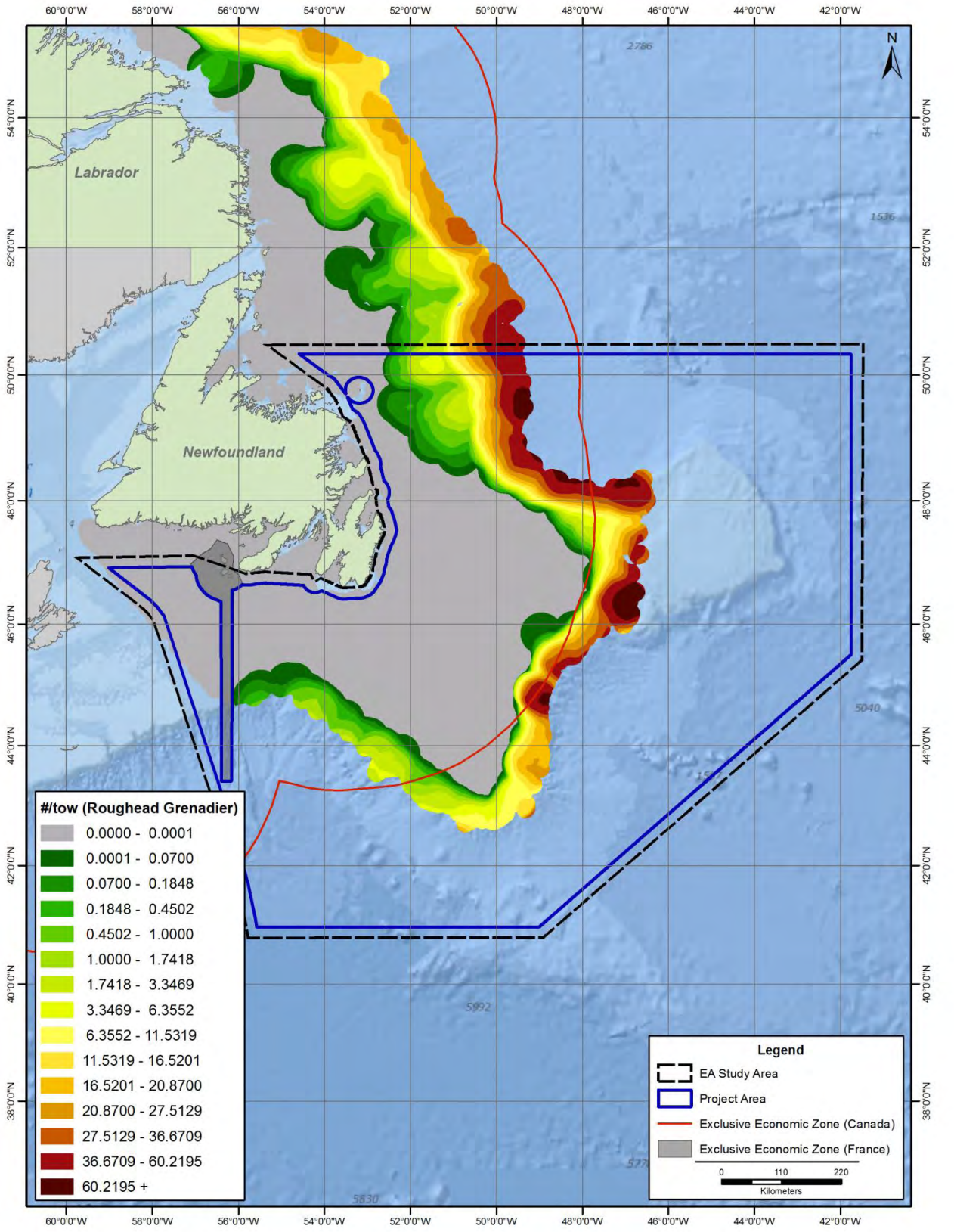


Figure 4.33 Distribution of Greenland Halibut in the Study Area (Canadian RV Surveys, 2008-2012)

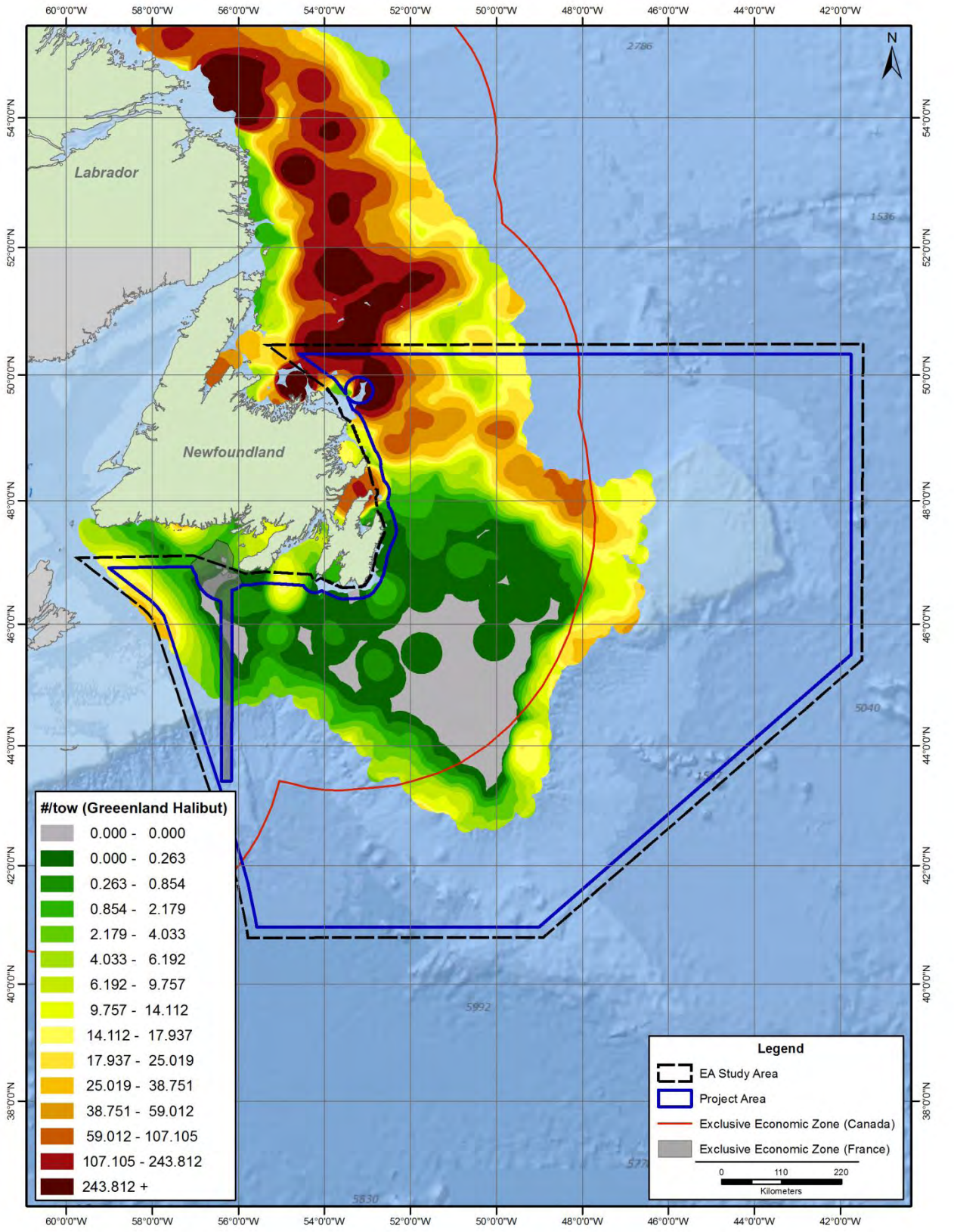


Figure 4.34 Distribution of Thorny Skate in the Study Area (Canadian RV Surveys, 2008-2012)

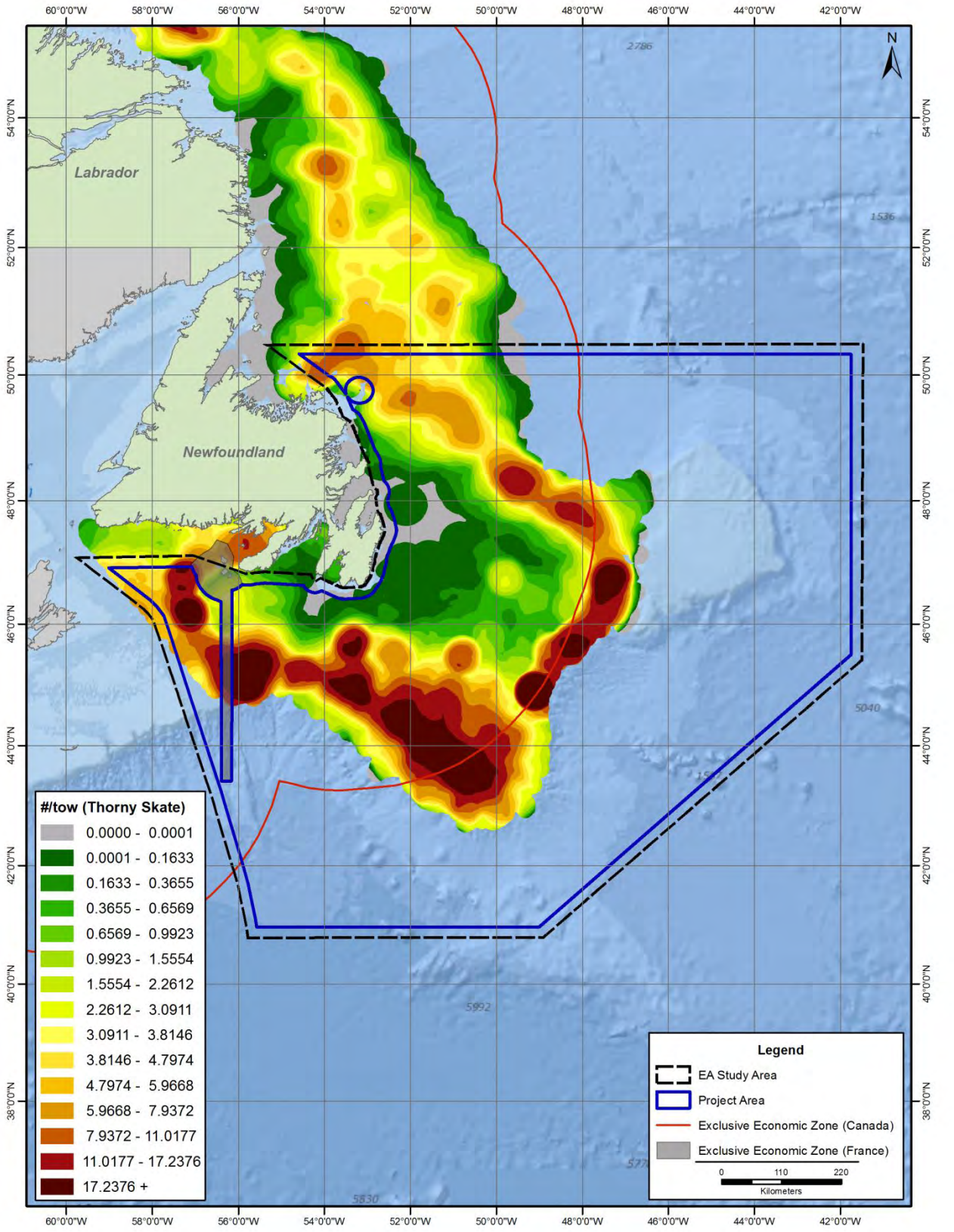


Figure 4.35 Migration Routes of Atlantic Salmon to Oceanic Feeding Grounds

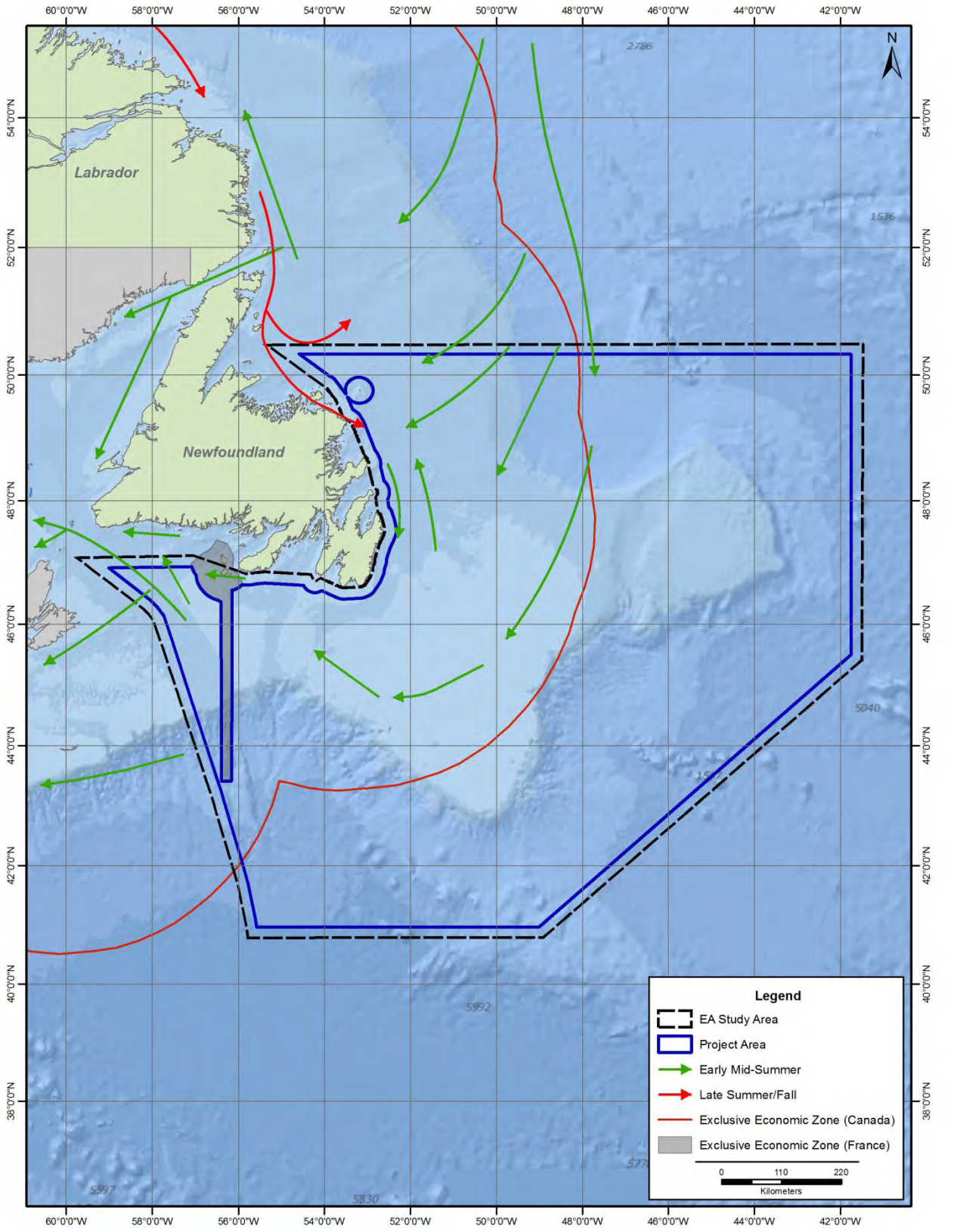
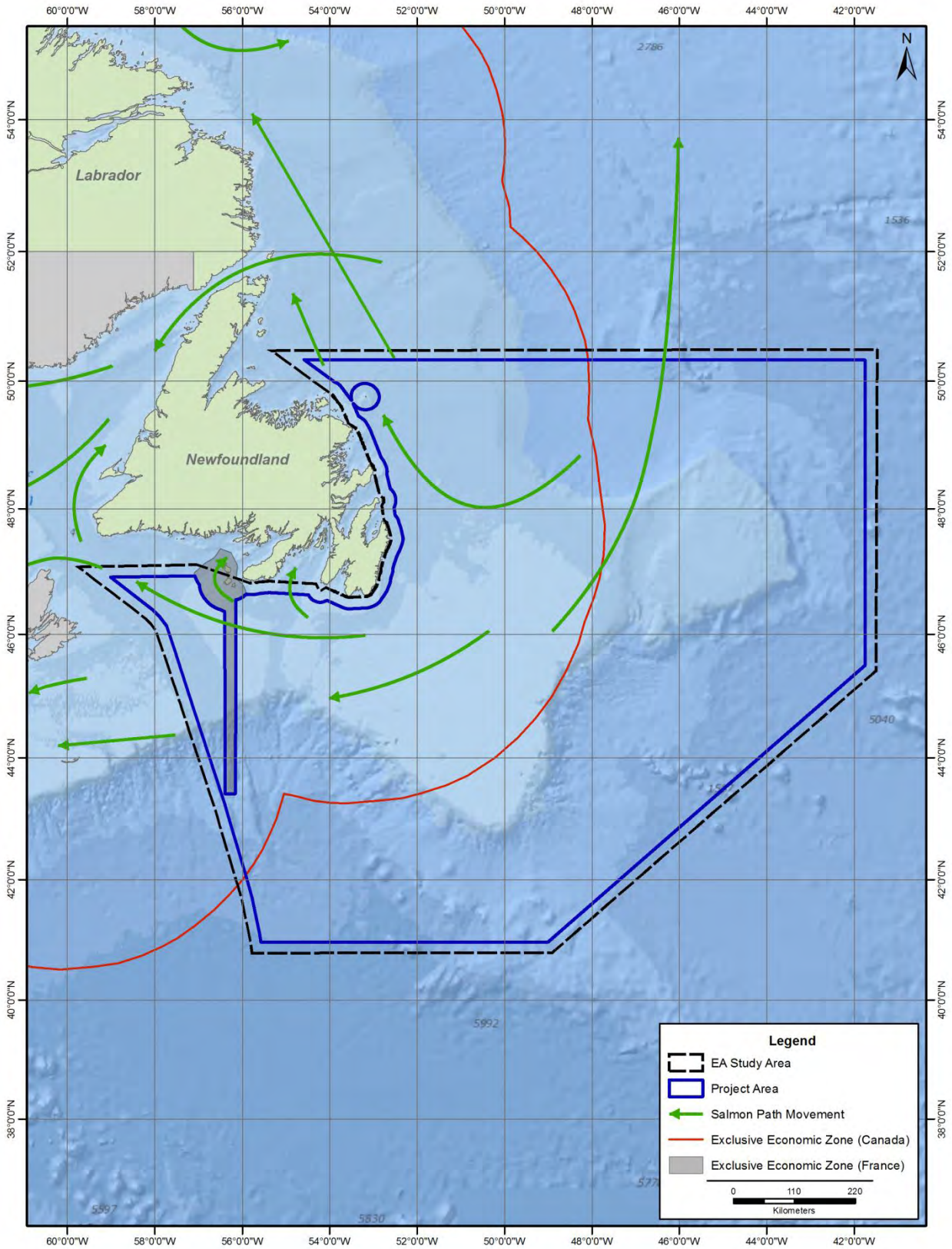


Figure 4.36 Migration Routes of Atlantic Salmon from Oceanic Feeding Grounds



Fish Species at Risk and Otherwise of Special Conservation Concern

Species of conservation concern in the Study Area are identified by 'arms length' conservation organizations such as COSEWIC (Committee on the Status of Endangered Wildlife in Canada) and the IUCN (International Union for the Conservation of Nature). Formal protection against extinction and extirpation is given to a subset of these species at a national level under the federal *Species at Risk Act* (*SARA*) and at a provincial level under the Newfoundland and Labrador Endangered Species Act (*NL ESA*).

There are 26 fish species that are known to or potentially occur in the Study Area and are currently listed under *SARA* (four species) or *NL ESA* (one species) or which have otherwise been assessed by COSEWIC (23 species), or are found on the IUCN Redlist (18 species) (Table 4.11). Some species remain common but exist at a small fraction of their former abundance since the groundfish collapse of the early 1990s (e.g. American plaice, Atlantic cod, redfish), while some others probably never occurred in great densities (e.g. tunas and sharks) in the Study Area.

The four marine fish species that have formal designation and protection under *SARA* include three species of wolffish (family *Anarhichadidae*) and the white shark (Table 4.11). These are outlined in further detail below.

The white shark was assessed in 2006 as being endangered under Schedule 1 of *SARA* as its numbers have declined by about 80 percent over 14 years in areas of the northwest Atlantic Ocean outside of Canadian waters. The poor understanding of the species' biology (DFO 2006a), particularly in Canadian waters where it is less common (only 32 records over 132 years for Atlantic Canada; COSEWIC 2006a), has resulted in an inability to define critical habitat for this species. Southern areas of the Study Area are most likely used by this species as demonstrated by an individual tagged in Florida, which was recently detected on the southern Grand Banks and Placentia Bay areas in the fall of 2013 (Ocearch 2013 *http://www.ocearch.org/profile/lydia/;* Figure 4.37). The greatest source of human induced mortality (by-catch in the American long line fishery) also does not occur in Canadian waters (DFO 2006a).

Figure 4.37 Recent Migration of a Great White Shark as it Moved to and through the Study Area

Wolffish are large, slow-growing and long-lived fish that are experiencing population declines in the Study Area that are thought to be associated with bycatch mortality and habitat alteration by trawling gear. Northern wolffish (95 percent decline) and spotted wolffish (90 percent declines) have both been listed as Threatened by *SARA*, while the striped wolffish has been listed as being of Special Concern. A recovery strategy and management plan have been developed for the wolffish species (DFO 2013a) to increase population levels and distributions. Proposed measures include mitigating human impacts, identifying and protecting critical habitats, improving knowledge of the species' biology and life history, and implementing education programs (DFO 2013a).

Studies indicate that Northern wolffish (300 – 1,200 m) are found in the deepest water, followed by spotted wolffish (100 – 800 m) and Striped wolffish (50 – 450 m). Northern wolffish are found most often on sand / shell / pebble habitats (reviewed in DFO 2013a), while striped (Kulka et al 2004) and spotted (Baker et al 2012) wolffish are thought to occur over rocky substrates. Other studies however, have indicated no substrate preference for either striped or spotted wolffish (DFO 2013a).

DFO RV survey data for wolffish are shown in Figures 4.38 to 4.40. Deep slope areas and the Flemish Pass were used by all species but the more abundant striped wolffish was also found in southern parts of the Study Area and many areas of the continental shelf at lower abundance. The northeast quadrant of the Study Area, including the Bonavista Corridor, also appeared to be an area of high concentration for the spotted wolffish. Of the three species, the Northern wolffish was typically distributed in deeper waters.

Figure 4.38 Distribution of Northern (Broadhead) Wolffish in the Study Area (Canadian RV Surveys, 2008-2012)

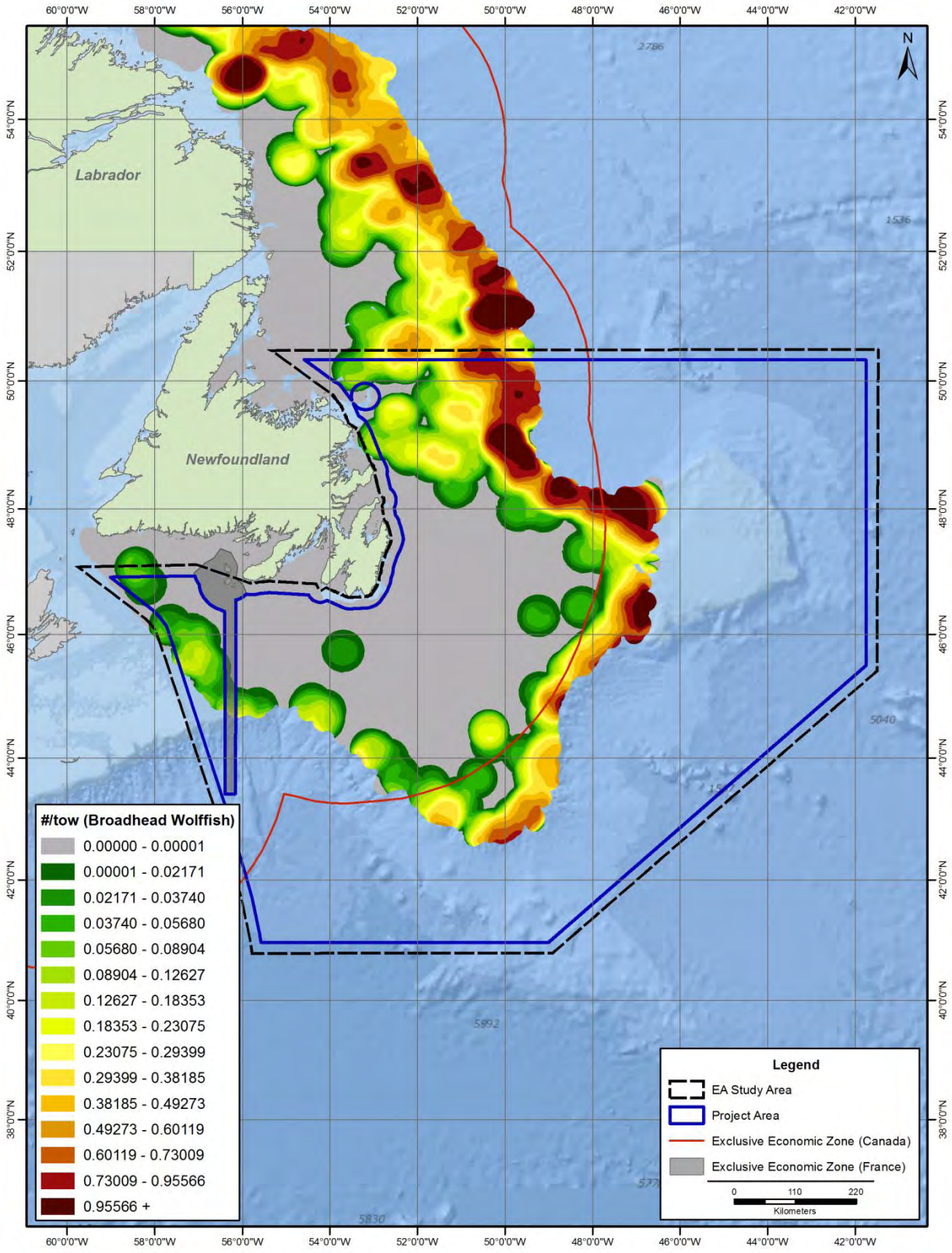


Figure 4.39 Distribution of Striped Wolffish in the Study Area (Canadian RV Surveys, 2008-2012)

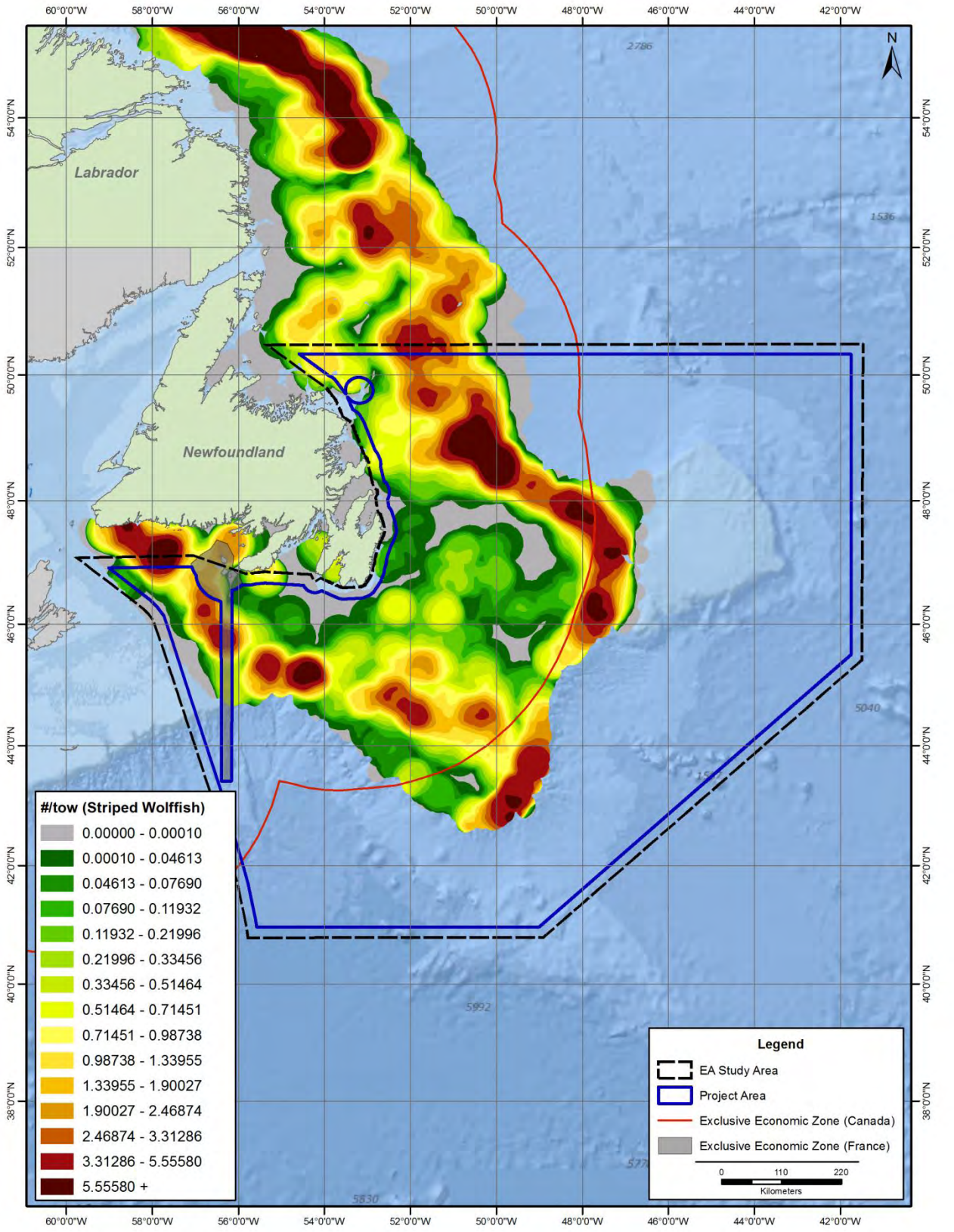


Figure 4.40 Distribution of Spotted Wolffish in the Study Area (Canadian RV Surveys, 2008-2012)

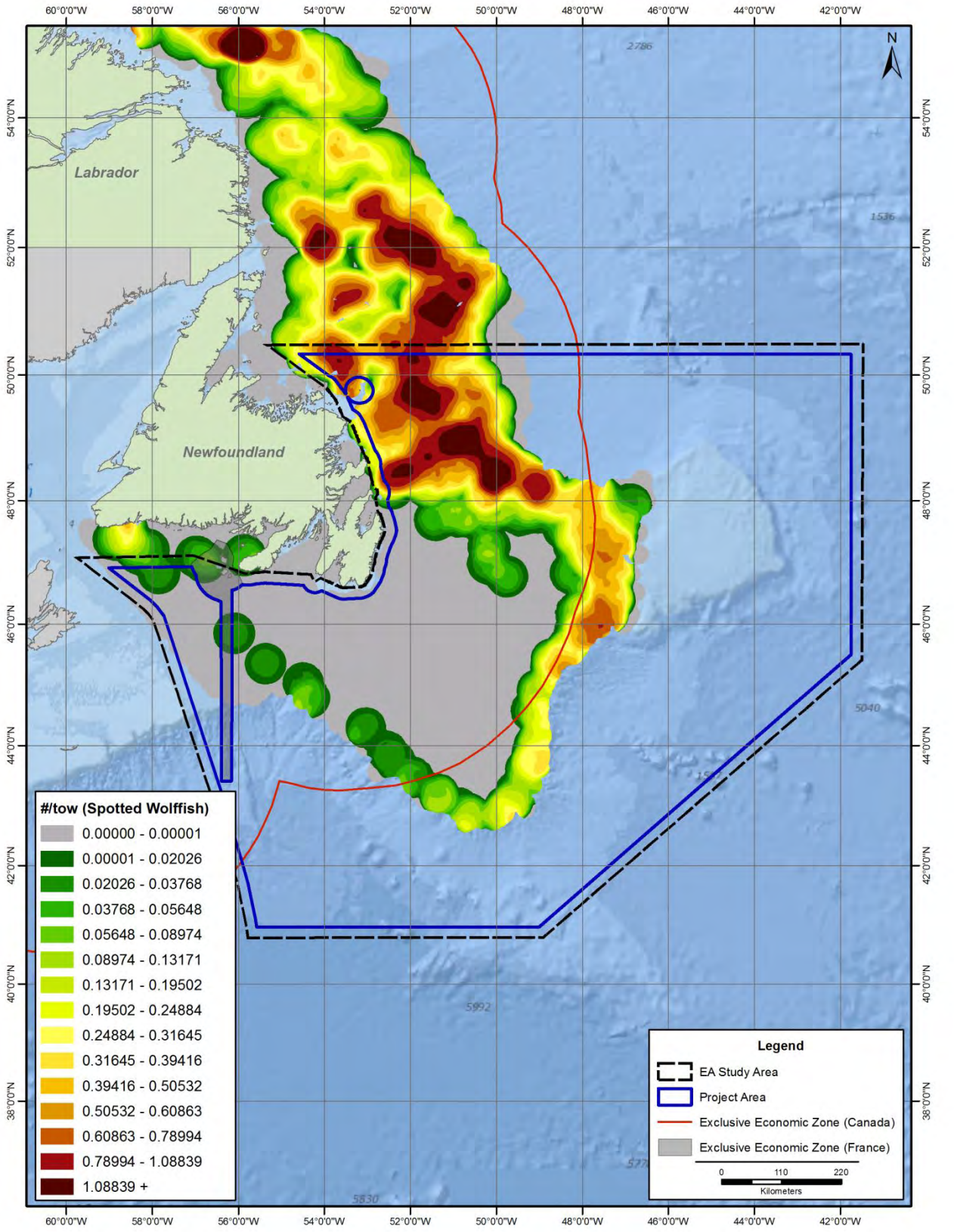


Table 4.11 Fish Species at Risk or Otherwise of Special Conservation Concern

Family	Species		Status / Designation[1,2]				Population
	Common Name	Scientific Name	NL Provincial Designation	SARA Status	COSEWIC Designation	IUCN	
Anarhichadidae	Atlantic wolffish	*Anarhichas lupus*		SC	SC		AO
Anarhichadidae	Northern wolffish	*Anarhichas denticulatus*		T	T		AO
Anarhichadidae	Spotted wolffish	*Anarhichas minor*		T	T		AO
Anguillidae	American eel	*Anguilla rostrata*	V		T		NL, AO
Carcharhinidae	Blue shark	*Prionace glauca*			SC	NT	AO
Cetorhinidae	Basking shark	*Cetorhinus maximus*			SC	V	AO
Gadidae	Atlantic cod	*Gadus morhua*			E	V	NL, AO
Gadidae	Cusk	*Brosme brosme*			E		AO
Lamnidae	Porbeagle	*Lamna nasus*			E	V	AO
Lamnidae	Shortfin mako	*Isurus oxyrinchus*			T	V	AO
Lamnidae	White shark	*Carcharodon carcharias*		E	E	V	AO
Macrouridae	Roughhead grenadier	*Macrourus berglax*			SC		AO
Macrouridae	Roundnose grenadier	*Coryphaenoides rupestris*			E		AO
Pleuronectidae	American plaice	*Hippoglossoides platessoides*			T		NL, AO
Rajidae	Barndoor skate	*Dipturus laevis*				E	AO
Rajidae	Smooth skate	*Malacoraja senta*			E	E	NL, AO
Rajidae	Spinytail skate	*Bathyraja spinicauda*				NT	AO
Rajidae	Thorny skate	*Amblyraja radiata*			SC	V	NL, AO
Rajidae	Winter skate	*Leucoraja ocellata*			E, T, SC	E	AO
Salmonidae	Atlantic salmon	*Salmo salar*			E, T, SC	LC	NL, AO
Scombridae	Albacore tuna	*Thunnus alalunga*				NT	AO
Scombridae	Bigeye tuna	*Thunnus obesus*				V	AO
Scombridae	Bluefin tuna	*Thunnus thynnus*			E	E	AO
Scorpaenidae	Acadian redfish	*Sebastes fasciatus*			T	E	AO
Scorpaenidae	Deepwater redfish	*Sebastes mentella*			T	LC	AO
Squalidae	Spiny dogfish	*Squalus acanthias*			T	V	AO

[1] Least Concern (LC), Vulnerable (V), Near Threatened (NT), Special Concern (SC), Threatened (T), Endangered (E)
[2] Multiple designations refer to multiple populations or sub-populations
[3] Newfoundland and Labrador (NL), Atlantic Ocean (AO)

4.2.1.7 Aquatic Invasive Species

The world's ecosystems are under increasing pressure from invasive species, which upon introduction to a new environment can exhibit rapid population growth and threaten native species through predation, competition or habitat alteration. Within the Study Area, invasive species are a concern to local fishermen (AMEC 2014), where increased industrial traffic serves as potential vectors for invasive species (McKenzie et al 2011; Benoit et al 2012).

To date, seven aquatic invasive species have been identified in the Newfoundland and Labrador Shelf: the European green crab, the Japanese skeleton shrimp, the golden star tunicate, the violet tunicate, the vase tunicate, the coffin box bryozoans and oyster thief algae (Table 4.12). These species are generally thought to have greater effects on benthic coastal communities compared to the open ocean environments that are predominant in the Study Area (Templeman 2010).

Table 4.12 Some Invasive Marine Species Known to be Present on the Newfoundland Continental Shelf

Taxa	Species	Taxonomic Name	Dispersal routes	Potential Effects
Crustacean	European green crab[1]	*Carcinas maenas*	• Spread through movement of fishing gear, and transport via ballast water.	• Prey on invertebrates. • Extremely efficient predators and colonizers.
	Japanese skeleton shrimp	*Caprella mutica*	• Spread through movement of fishing gear, offshore buoys, and boats (Cook et al 2007)	• Interferes with aquaculture operations.
Tunicate	Golden star tunicate	*Botryllus schlosseri*	• Spread through movement of fishing gear, shellfish and boats	• Interferes with bivalve larvae settlement. • Interferes with aquaculture operations.
	Violet tunicate	*Botrylloides violaceus*		
	Vase tunicate	*Ciona intestinalis*		
Bryozoan	Coffin box bryozoan	*Membranipora membranacea*	• Spread through movement of boats and planktonic larvae	• Devastates kelp beds.
Algae	Oyster thief	*Codium fragile* spp. *fragile*	• Spread through movement of fishing gear, shellfish and boats	• Replaces native species including eel grass and kelp.

Source: Modified from DFO (2014a); Matheson (2013); Templeman (2010)
[1] This is a coastal species but has been included here for completeness

4.2.1.8 Identified Important and Sensitive Ecological Environments

There are a variety of identified important and sensitive ecological environments in the Study Area, which include those that are protected through legislation or other formal means (e.g. DFO and NAFO closure areas), those identified as sensitive habitats but not protected (e.g. Ecologically and Biologically Significant Areas and Vulnerable Marine Ecosystems) and those that lack formal recognition but have been identified through recent analyses.

Protected Areas (Existing and Potential)

Protected areas in the marine environment can include National Marine Conservation Areas (managed by Parks Canada), Marine Protected Areas (MPAs managed by DFO) and areas protected through regulatory closures. Within the Study Area there are no National Marine Conservation Areas or MPAs, although the Eastport MPA occurs within approximately 60 km of the Study Area's boundary (Figure 4.41; DFO 2013b). This area was established to assist in the rejuvenation of lobster stocks and also provides habitat to a variety of fish, invertebrates, aquatic plants, seabirds and marine mammals (DFO 2013b).

The first step in MPA establishment is the identification of Areas of Interest (AOI), which then undergo detailed evaluation and public consultation before a decision is made concerning whether to formally designate them as MPAs (Parks Canada 2006). The Laurentian Channel and Slope, located in the southwestrn part of the Study Area (and which overlaps the Project Area) was identified as such an AOI in June 2010. The area comprises a deep submarine valley over 1,200 km long and over 35,000 km^2 in size that extends from the intersection of the St. Lawrence and Saguenay Rivers to the edge of the continental shelf off southwest Newfoundland. This area contains the highest concentration of black dogfish in Canadian waters and is the only place where pupping occurs. It is also an important spawning, nursery and feeding area for a variety of species including porbeagle shark and smooth skate, as well as being an important migration route for marine mammals moving in and out of the Gulf of St. Lawrence. Several species at risk are also found here, including the Northern wolffish, blue whales and leatherback sea turtles (DFO 2012b). The nearby St. Ann's Bank AOI is located further to the west, and is not overlapped by the proposed Project Area (Figure 4.41).

DFO, through the *Fisheries Act,* and NAFO have also established and implemented various fisheries closures to help conserve ocean bottom (benthic) species, habitats and biodiversity (Figure 4.42). These fisheries closure areas restrict one or more types of bottom contact fishing gear (DFO 2011b). DFO and NAFO closures within the Study Area are targeted towards Vulnerable Marine Ecosystems (VMEs) that have been identified in response to a UN directive (FAO 2009) to protect marine habitats that are vulnerable to alteration and will be slow to recover from disturbance. Such areas in the Study Area are represented by coral areas, seamount and sponge protection zones (Table 4.13; Figure 4.42: DFO 2011; FAO 2009) and are formally protected against some damaging activities (e.g. trawling).

Table 4.13 Fisheries Closure Areas

Name	Size (km^2)
Orphan Knoll Seamount	15,737
Corner Seamounts	45,894
NAFO Coral Closures	8,844
Source: DFO (2011b); FAO (2009); AMEC (2014)	

Figure 4.41 Marine Protected Areas and Areas of Interest

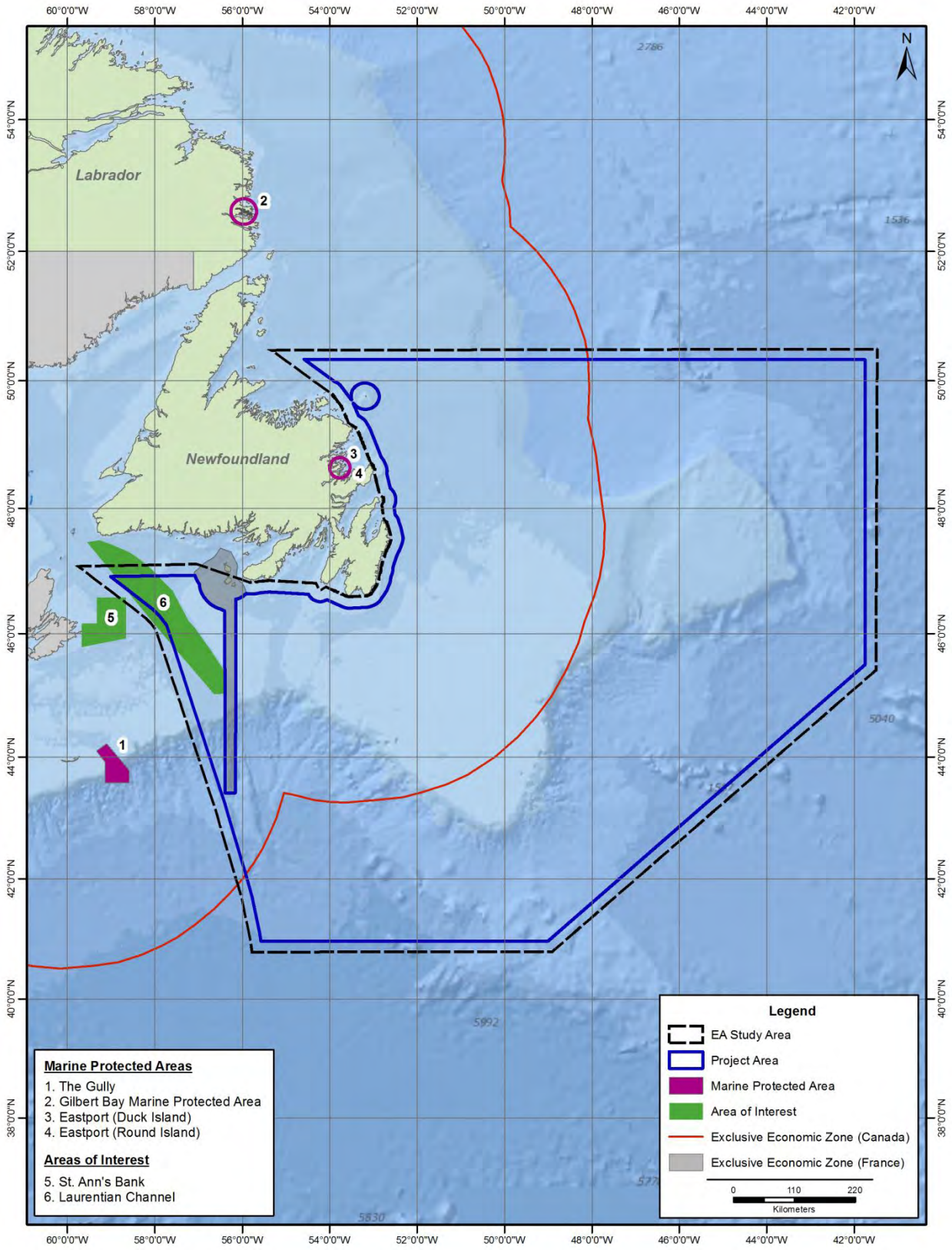
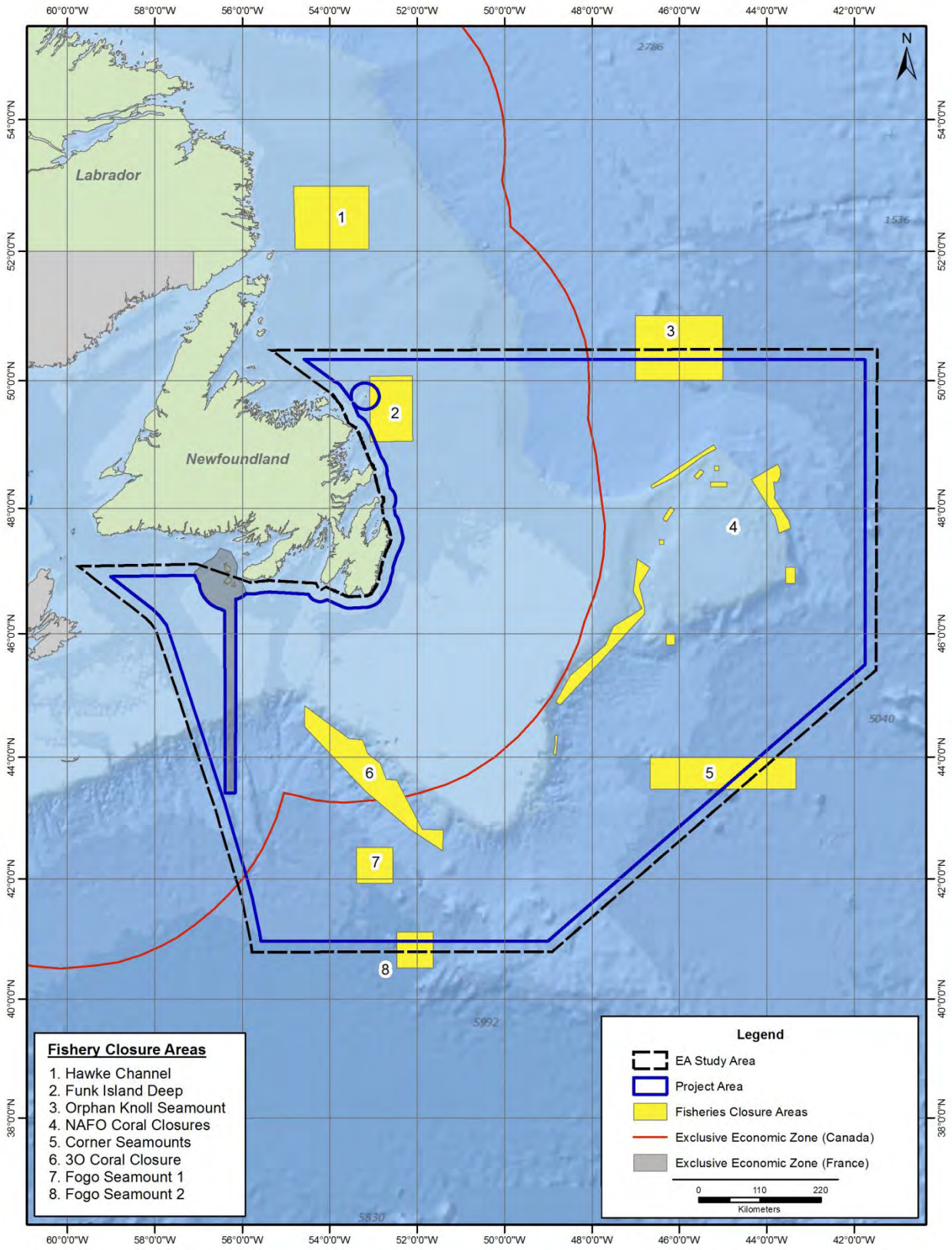


Figure 4.42 Fishery Closure Areas



Large Ocean Management Areas

The *Placentia Bay / Grand Banks Large Ocean Management Area* has been identified by DFO under Canada's *Oceans Act* because it possesses important living and non-living marine resources, areas of high biological diversity and productivity and increasing development pressures and competition for ocean space and resources (PB / GBLOMA 2013).

Ecologically and Biologically Significant Areas

In addition to areas that are formally protected through legislation, DFO has also defined Ecologically and Biologically Significant Areas (EBSAs) for the Placentia Bay-Grand Banks Large Ocean Management Area (Templeman 2007), the Newfoundland and Labrador Shelf (DFO 2013b) and the Scotian Shelf (Doherty and Horsman 2007). This was achieved through a ranking system of candidate areas using criteria of fitness consequence, aggregations, uniqueness, naturalness and resilience. Several EBSAs (Table 4.14; Figure 4.43) have been selected based on their importance to marine fish, invertebrates and planktonic components. The identified EBSAs within the Study Area are summarized below using information from Templeman (2007), DFO (2013b) and Doherty and Horsman (2007). Several of these areas encompass habitats that are also formally protected through the processes described above.

Table 4.14 Study Area EBSA Characteristics Relevant to Fish, Invertebrates and Macroalgae

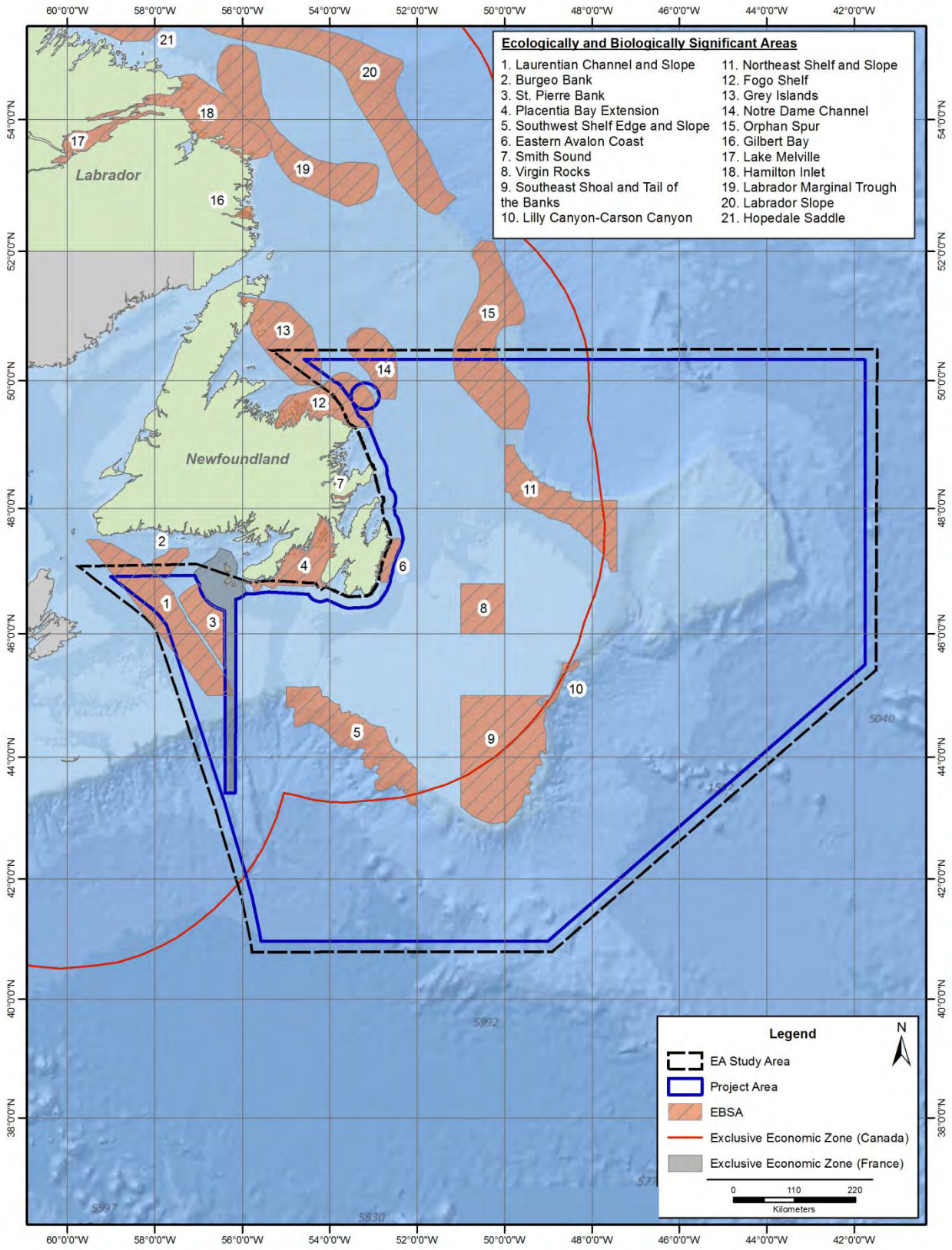
EBSA Name (Province)	Description as it Relates to Benthic Invertebrates and Finfish	#
Laurentian Channel and Slope (Newfoundland)[1]	*Primary production:* The Laurentian Channel and Slope is an area of heightened primary productivity *Finfish:* The EBSA serves as an important area for many finfish species. Features include: • Only pupping ground for black dogfish • A nursery area for smooth skate • A migratory corridor for individuals that migrate out of the Gulf seasonally • An area of elevated densities of monkfish, pollock and white hake	1
Laurentian Channel and Slope (Nova Scotia)[2]	*Benthic invertebrates:* The EBSA serves as an overwintering area for *Calanus* and an aggregation site for krill *Finfish:* The area was identified as having several aspects important to finfish including: • High diversity of demersal, pelagic and mesopelagic fishes • A migration corridor for white hake, cod, redfish, flatfish and Greenland shark • An overwintering area for white hake, cod, sole, redfish and Greenland shark • An important mating area for Porbeagle sharks • A primary overwintering area for 4T cod and white hake	Not shown
Laurentian Channel cold seep[2]	*Benthic invertebrates:* This area is unique to Atlantic Canada and is found on crests of gravel waves. It hosts: • Dense chemosynthetic communities of vesicomyid and thyasind clams, gastropods and galatheid crabs	Not shown

EBSA Name (Province)	Description as it Relates to Benthic Invertebrates and Finfish	#
	• A new family of polychaetes Species in this area have specialized tissue containing carbon fixing, sulphide oxidizing bacteria	
Burgeo Bank[1]	*Finfish:* This EBSA is an important spawning and overwintering area for Atlantic cod. It's also a place where cod stocks (3Pn4RA and 3PS) mix	2
St. Pierre Bank[1]	*Benthic Invertebrates:* The area is characterized by the highest concentrations of sea scallops and is an important area for sea scallop spawning *Finfish:* The area has the highest concentrations of spiny dogfish in the northern part of their range	3
Placentia Bay Extension[1]	*Primary productivity:* Placentia Bay is characterized by high primary productivity *Finfish:* This EBSA is important to finfish for the following reasons: • High densities of ichthyoplankton (e.g. cod and capelin and others) occur there • The largest remaining cod spawning stock occupies this EBSA	4
Southwest Shelf and Edge and Slope[1]	*Benthic Invertebrates:* The area has structure-forming gorgonian corals in high concentrations and high concentrations of other cold-water corals *Finfish:* This area is important to finfish due to the following attributes: • Host to northernmost population of haddock in NW Atlantic Ocean with highest concentrations along the SW slope • Almost exclusive area for Atlantic halibut along SW slope during spring • Haddock spawning (along edge of SW slope in spring) • Important spawning area for redfish • Migration route for cod • A large portion of groundfish species biomass occurs along the SW slope • Monkfish, pollock, and white hake in region occur exclusively along the SW slope and within the Laurentian Channel, with higher concentrations in the spring	5
Eastern Avalon Coast[1]	This EBSA was identified only in relation to marine mammals and seabirds (see subsequent sections for details)	6
Virgin Rocks[1]	*Finfish:* This EBSA was put in place to reflect the aggregations of capelin and other spawning groundfish that include Atlantic cod, American plaice and yellowtail flounder *Macroalgae*: This area is also a rare offshore location for macroalgae, though this feature was not listed as a reason for designation	8
Southeast Shoal and Tail of the Grand Banks[1]	*Benthic invertebrates:* Wedge clams and blue mussels in this area are found at the highest densities observed across the Grand Bank *Finfish:* The importance of this region to finfish includes: • An important spawning area for capelin, American plaice, yellowtail flounder, Atlantic cod and sand lance • The capelin spawning area is a rare offshore site, while the yellowtail flounder stock is only known to spawn in this location	9

EBSA Name (Province)	Description as it Relates to Benthic Invertebrates and Finfish	#
	• Yellowtail flounder and American plaice occur in high densities in this area • Striped wolffish occur at high densities at this location	
Lilly and Carson Canyon[1]	*Benthic invertebrates:* This area is recognized for its importance as a feeding and high production area for Iceland scallops	10
Northeast Shelf and Slope[1]	*Finfish:* This EBSA has the highest concentrations of Greenland halibut and spotted wolffish in the region. These species aggregate in the area in the spring	11
Fogo Shelf[1]	*Finfish:* The area is important for beach and subtidal spawning capelin and is an important migratory path and feeding area for Atlantic salmon	12
Grey Islands[1]	*Benthic invertebrates:* High concentrations of soft corals and small gorgonians are found in this region *Finfish:* High aggregations of capelin occur in the area as well as "small distinct areas" where groundfish and pelagic fish are found	13
Notre Dame Channel[1]	*Benthic invertebrates*: This region is known for high densities of snow crab and shrimp *Finfish*: The area is also important to finfish as it has a high diversity of species, high densities of smooth and thorny skates as well as high densities of capelin, American plaice and Greenland halibut	14
Orphan Spur[1]	*Benthic invertebrates*: This area has been identified as an area where corals occur *Finfish*: This area was defined in part by several attributes that relate to finfish including: • High species diversity • Elevated densities of witch flounder, American plaice and redfish • Elevated densities of species at risk, including northern, spotted and striped wolffish, the skates and roundnose grenadier • An important area for several species of shark	15
Southern Pack Ice[1]	Southern Pack Ice is an EBSA that occurs in the Study Area seasonally. While important to marine mammals and seabirds, there is no direct reason for sensitivity from a benthic invertebrate or marine fish perspective	Not shown

[1]Modified from Templeman (2007), DFO (2013b) and AMEC (2014)
[2]Doherty and Horsman (2007)

Figure 4.43 Ecologically and Biologically Significant Areas Within and Adjacent to the Study Area



Other Ecologically Important Habitats in the Study Area

Other important areas are not covered under any formal framework. Two such areas include the "Bonavista Cod Box" – an important spawning and migration area for Atlantic cod, American plaice and redfish – and the high productivity Frontal Extrusion Zone, located on the continental slope in the northern portions of the Study Area (LGL 2003).

For the current EA, empirical examinations of ecologically important zones were also conducted to determine areas of high faunal abundance, biomass and/or species richness. According to DFO RV surveys, important areas vary for each metric (Figures 4.44 to 4.46, taxa include finfish and invertebrates such as shrimp and snow crab). For example, abundance of individuals captured was elevated on the northern Newfoundland Shelf and the Flemish Pass of the Grand Banks (Figure 4.44). High biomass predominantly occurred on the southern slope and tail of the Grand Banks, and to a lesser extent, the Bonavista Corridor and the Flemish Pass (Figure 4.45). The differences can be explained by the relatively low densities of small bodied organisms (e.g. shrimp) in southern parts of the Study Area and lower densities of large bodied organisms in the northern portions. Species richness was particularly high along northern sections of the continental slope but also was elevated levels in the Bonavista Corridor, the slope of the Flemish Cap and in the western extremities of the Study Area near Rose Blanche Bank (Figure 4.46). In areas where both spring and fall surveys were conducted, spatial patterns in measures of abundance, biomass and richness were also examined. However, there were few detectable differences.

Areas of high abundance, biomass and species richness often coincide with previously identified areas, including the Bonavista Corridor / Bonavista Cod Box (abundance, biomass and richness), some coral areas and NAFO coral protection zones (species richness), the Southeast Shoal and Tail of the Grand Banks EBSA (biomass) and the Laurentian Channel and Slope (species richness).

Figure 4.44 Areas of Relatively High Faunal Abundance (Canadian RV Surveys, 2008-2012)

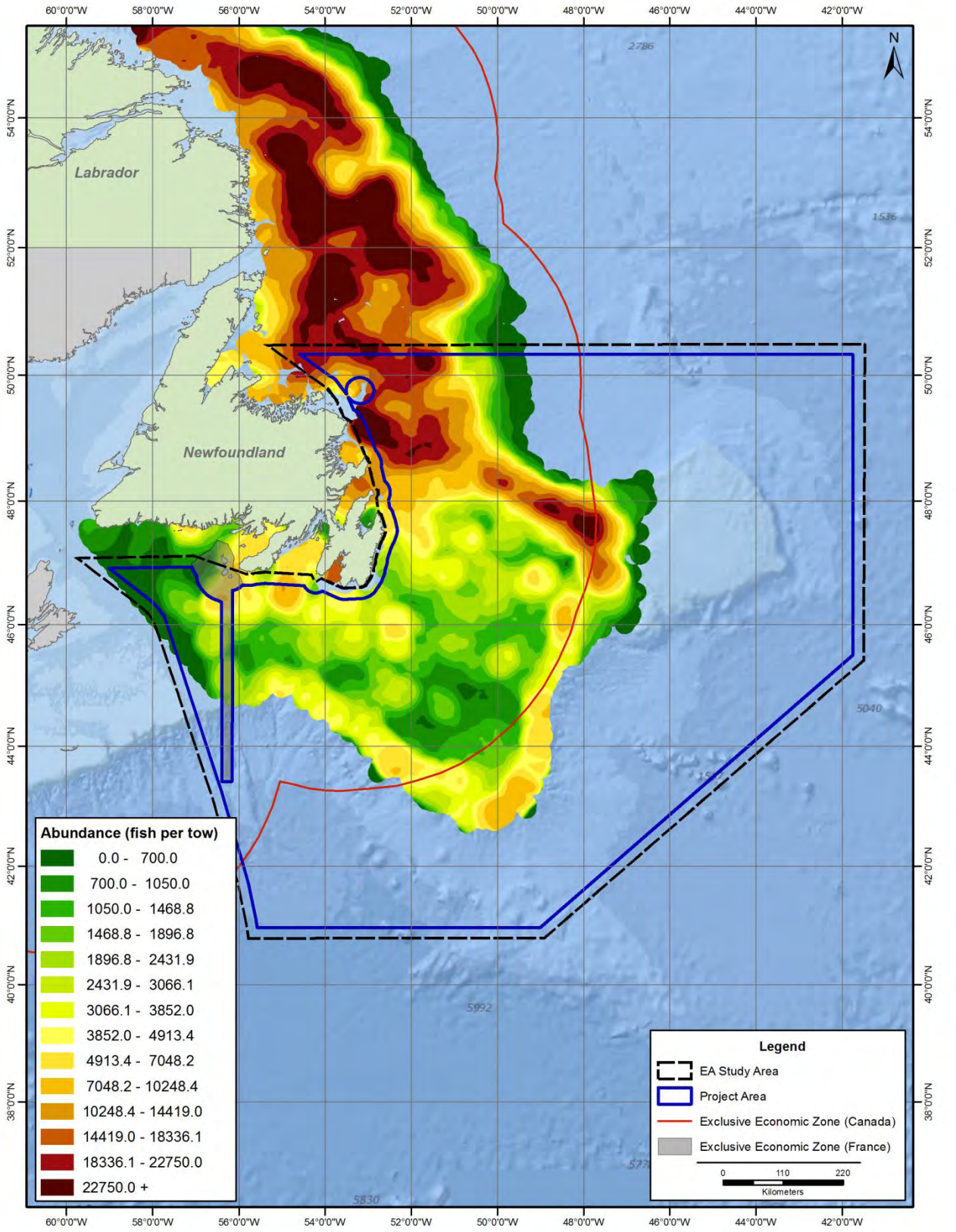


Figure 4.45 Areas of Reatively High Faunal Biomass (Canadian RV Surveys, 2008-2012)

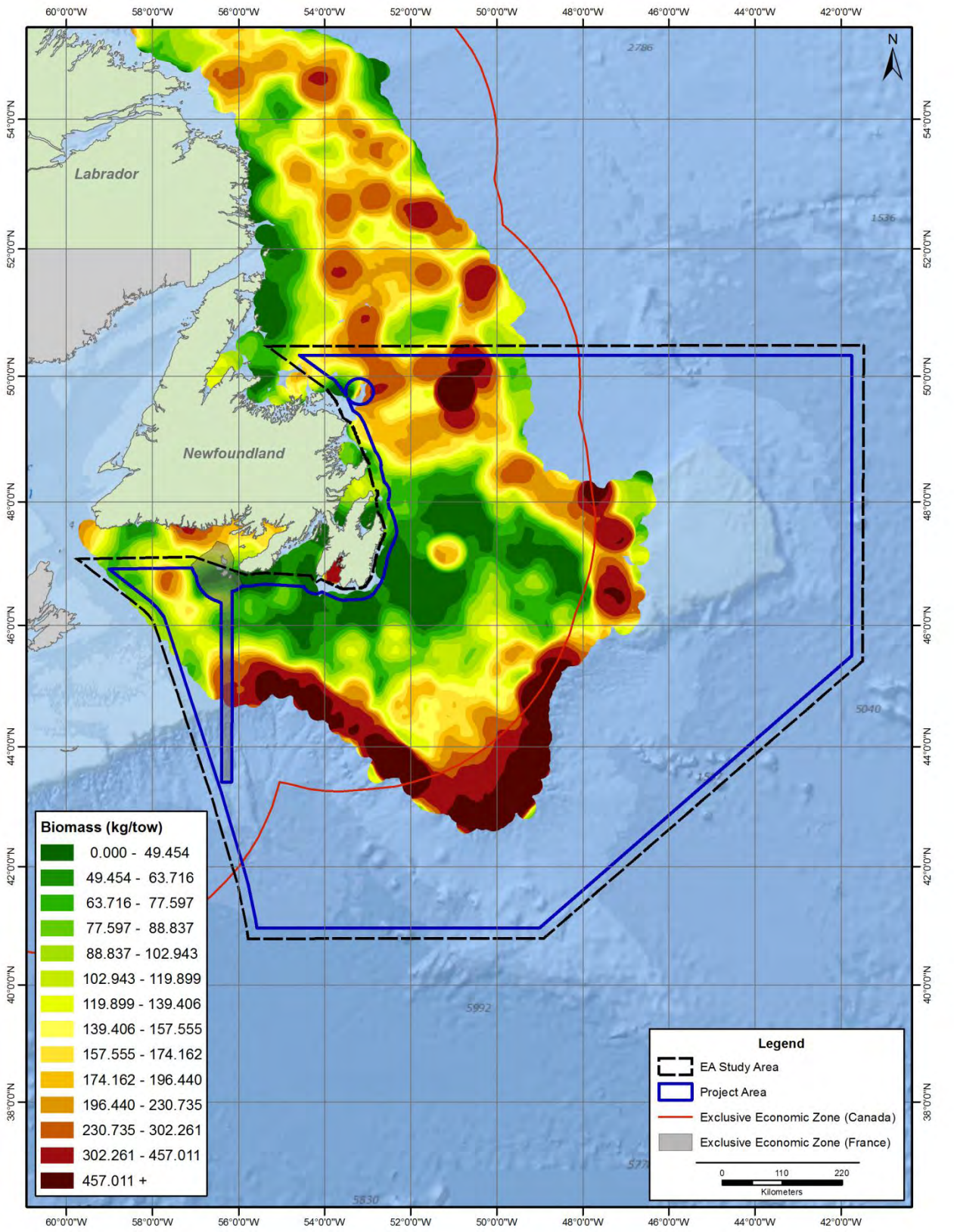


Figure 4.46 Areas of Relatively High Taxonomic Richness (Canadian RV Surveys, 2008-2012)