4.0 BIOLOGICAL ENVIRONMENT

The following sections provide an overview of the existing biological (and socio-economic) environment of the SEA Area. This description is based upon existing, readily available information gathered through a review of the published literature, unpublished reports and other relevant information sources.

SARA-listed species are considered to be a separate VEC and will be discussed in Section 4.7.

4.1 Coastal Algal Communities

4.1.1 Non-estuarine Algal Communities

Shorelines along the south coast of Newfoundland are the most exposed algal habitats in Newfoundland, as the shore faces the prevailing southwest wind. Due to high exposure and the rare occurrence of scouring by sea ice, algal habitats along the south coast are similar to those found in Nova Scotia and New England and have the greatest abundance and diversity of species on the Island of Newfoundland. In extreme cases, algae may be found up to 20 m above the high tide mark, as the exposure and prevalence of fog assist in prevention of desiccation in the spray zone. Fucoids dominate the intertidal zone throughout the south coast regardless of exposure level. The most exposed sites exhibit compressed zonation and fewer species occur, dominated by fucoids, *Palmaria*/*Alaria* and kelps (*Laminaria* spp.). Moderately exposed areas are dominated by fucoids and *Palmaria*/*Alaria* and sheltered areas are dominated by fucoids and *Ascophyllum* (South 1983). A generalized algal zonation is provided in Table 4.1, from the intertidal to the shallow subtidal, compared by degree of exposure.

4.1.2 Estuarine Algal Communities

Estuaries are characterized by having abundant populations of animals and plants/algae, although the features of an estuary (daily changes in water temperature, salinity level, nutrient level) serves to limit the diversity of species (McLusky and Elliot 2004).

There is little variation in algal communities in Newfoundland estuaries. Substrate type is the major feature affecting species distribution. On hard, rocky substrates, estuarine algal habitats are dominated by fucoids and *Chorda* sp. On sand or mud substrates, eelgrass (*Zostera marina*) dominates, with several species of algae present as epiphytes. The deeper parts of estuaries are typically muddy or otherwise unstable, with a high abundance of diatoms and other microscopic forms of algae. Kelp (*Laminaria longicruris*) is often found unattached in the deeper subtidal estuarine environment. Generalized algal communities within estuaries in Newfoundland, compared by substrate type are provided in Table 4.2.

4.1.3 Planning Implications for Marine Algae

Marine algae and plants are host to migratory birds and are associated with some of the more sensitive coastal areas (eelgrass beds, saltmarshes). Common algae (e.g., fucoids) are also important primary producers. Operators in the SEA Area would have to ensure safety measures are in place to minimize the probability of accidental events.

Table 4.1 General Algal and Associated Invertebrate Zonation in Intertidal and Subtidal Areas in Southwestern Newfoundland

Water Depth (m)	Typical Algal/Invertebrate Species by Degree of Exposure		
	Sheltered	**Moderate**	**High**
HW to 5	Marine Lichens Cyanophyta *Fucus spiralis* *Fucus vesiculosis* *Phymatolithon laevigatum* *Hildenbrandia rubra* *Pilayella littoralis* *Ascophyllum nodosum* *Chondrus crispus* *Chorda filum* *Lithothamnium glaciale* *Chaetomorpha* sp.	Marine Lichens Cyanophyta *Fucus spiralis* *Fucus vesiculosis* *Bangia atropurpurea* *Fucus distichus edentatus* *Chondrus crispsus* *Alaria esculenta* *Palmaria palmata* *Mytilus edulis* (Blue Mussels) *Strongylocentrotus droebachiensis* (Green Sea Urchin)	Marine Lichens Cyanophyta *Porphyra* sp. *Bangia atropurpurea* *Pilayella littoralis* *Coliolum pusillum* f. *longpipes* *Fucus filiformis* *Balanus balanoides* (Barnacles) *Mytilus edulis* *Chondrus crispus* *Fucus distichus edentatus* *Melanosiphon intestinalis* *Palmaria palmata* *Alaria esculenta* *Laminaria digitata*
5 to 20	*Phymatolithon laevigatum* *Chaetomorpha* sp. *Lithothamnium glaciale* *Laminaria longicruris* *Agarum cribrosum*	*Strongylocentrotus droebachiensis* *Desmarestia* sp. *Lithothamnium glaciale* *Hildenbrandia rubra* *Agarum cribrosum* *Ptilota serrata*	*Alaria esculenta* *Desmarestia* sp. *Laminaria digitata* *Lithothamnium glaciale* *Clathromorphum compactum* *Hildenbrandia rubra* *Agarum cribosum* *Ptilota serrata*
20 to 30	*Agarum esculenta* *Turnerella pennyi* *Lithothamnium glaciale*	*Agarum esculenta* *Peyssonnelia* sp. *Lithothamnium glaciale* *Turnerella pennyi* *Ptilota serrata*	*Agarum esculenta* *Hildenbrandia rubra* *Ptilota serrata* *Lithothamnium glaciale* *Peyssonnelia* sp.
Source: South 1983.			

Table 4.2 General Estuarine Algal Communities on the Island of Newfoundland

Water Depth (m)	Typical Algal Species by Substrate Type	
	Hard (including pebbles and boulders)	**Sand/Mud**
HW to 5 m	Maritime Lichens Cyanophyta with *Rivularia* (diatom) *Fucus vesiculosis* *Pilayella littoralis* *Enteromorpha* sp. *Ascophyllum nodosum* (attached) *Ahnfeltia plicata* *Chorda filum*	*Spartina* sp. (terrestrial plant) Cyanophyta with *Rivularia* *Enteromorpha* sp. *Zostera marina* *Ascophyllum nodosum* (free-floating) *Ahnfeltia plicata*
5 to 10 m	*Clathromorphum circumscriptum* *Chondrus crispus* *Laminaria longicruris*	*Zostera marina* *Chondrus crispus* *Laminaria longicruris*
Source: South 1983.		

4.2 Plankton

Plankton refers to all free-floating organisms that drift in the water column and are typically not able to swim against currents. Members of this group include bacteria, fungi, phytoplankton (microscopic marine algae), zooplankton (invertebrates), macroinvertebrate eggs and larvae and ichthyoplankton (eggs and larvae of fish).

Plankton is of relevance to this SEA because areas of enhanced plankton production and biomass are also areas where fish, seabirds and marine mammals congregate to feed.

4.2.1 Phytoplankton

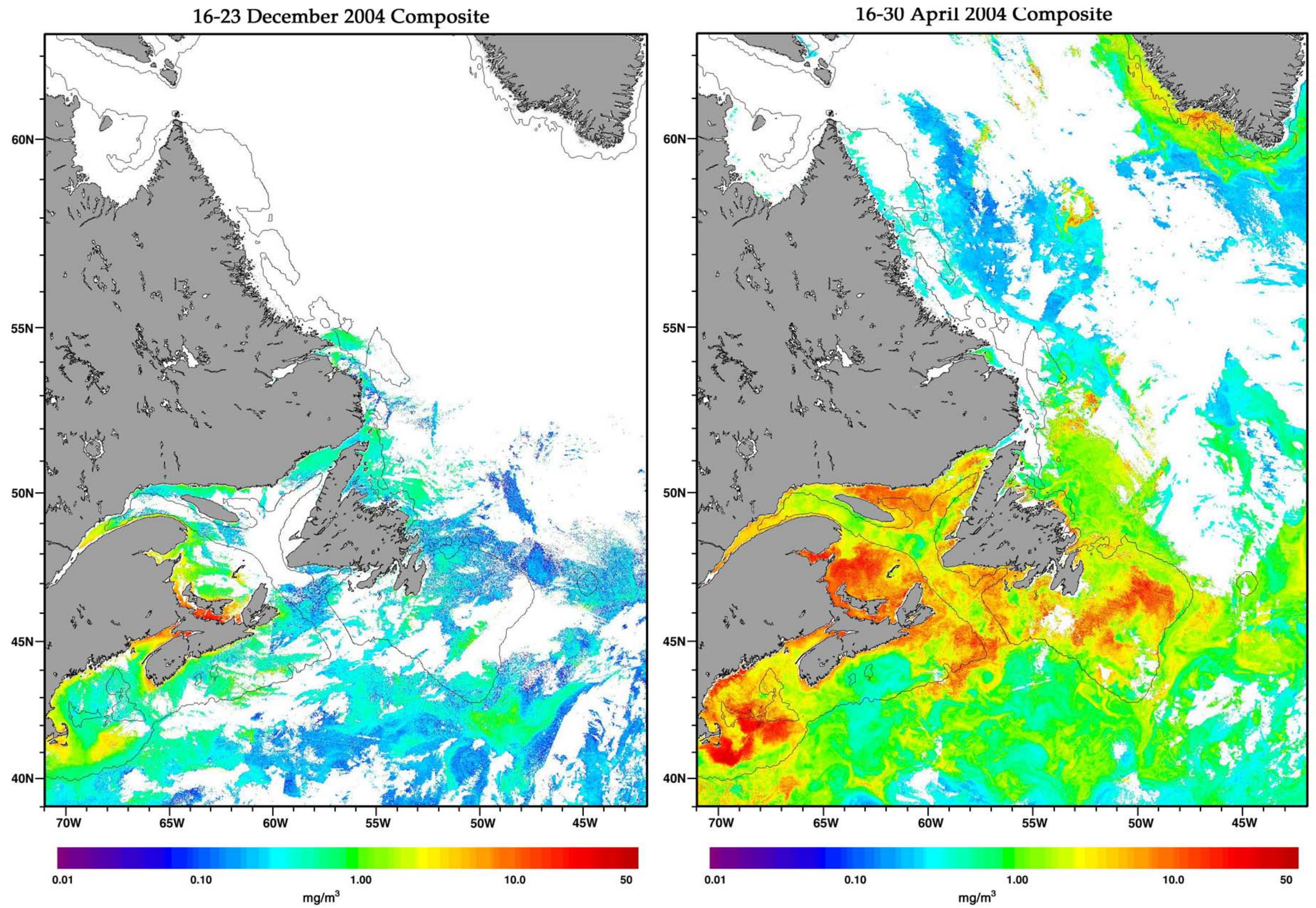
Phytoplankton is the foundation of the marine food chain, using sunlight and nutrients (nitrogen, phosphorus, silicon) to photosynthesize and grow. This process is primary production. Due to upwelling along the slopes of the offshore banks and channels, causing high levels of nutrients, the SEA Area is productive year round (Breeze et al. 2002). In the North Atlantic, there is a strong seasonal variability in primary production, generally peaking in the spring when light levels increase. This is known as the spring bloom. Production peaks to a lesser extent in the fall. The spring bloom can vary from year to year with regard to duration and intensity, but usually occurs between March and June. The increased light during the spring warms the surface waters to depths of 10 to 20 m. The thermocline, combined with intense grazing by zooplankton and depletion of nutrient supply, results in a mid-summer low in primary production. As the thermocline weakens in the fall and upwelling increases, a second bloom occurs (Pinet 1992).

Physical oceanographic conditions and dynamics have effects on the distribution, abundance and growth rates of phytoplankton. Studies have shown clear evidence of spatial variation in phytoplankton biomass and productivity based on oceanographic conditions (Mobil 1985). Waters along the edge of an offshore bank are often highly productive due to upwelling, which brings nutrient-rich deep water to the surface through a combination of factors including bottom topography, wind and currents. This facilitates phytoplankton blooms. Surveys conducted by in the early 1980s show that the western edge of the St. Pierre Bank, in the SEA Area, is an area of high biomass and enhanced primary productivity (Mobil 1985; Petro-Canada 1995). Areas and seasons of high primary production are congregation areas for fish, seabirds and marine mammals.

Since 1959, plankton has been sampled by a Continuous Plankton Recorder, which is towed behind ships (commercial and government) along standard shipping routes. Data collected between 1959 and 1992 were analyzed by Myers et al. (1994). Diatom species typically dominate the spring bloom, while the fall bloom is dominated by dinoflagellates (Myers et al. 1994). Both of these are types of single-cell, photosynthetic algae.

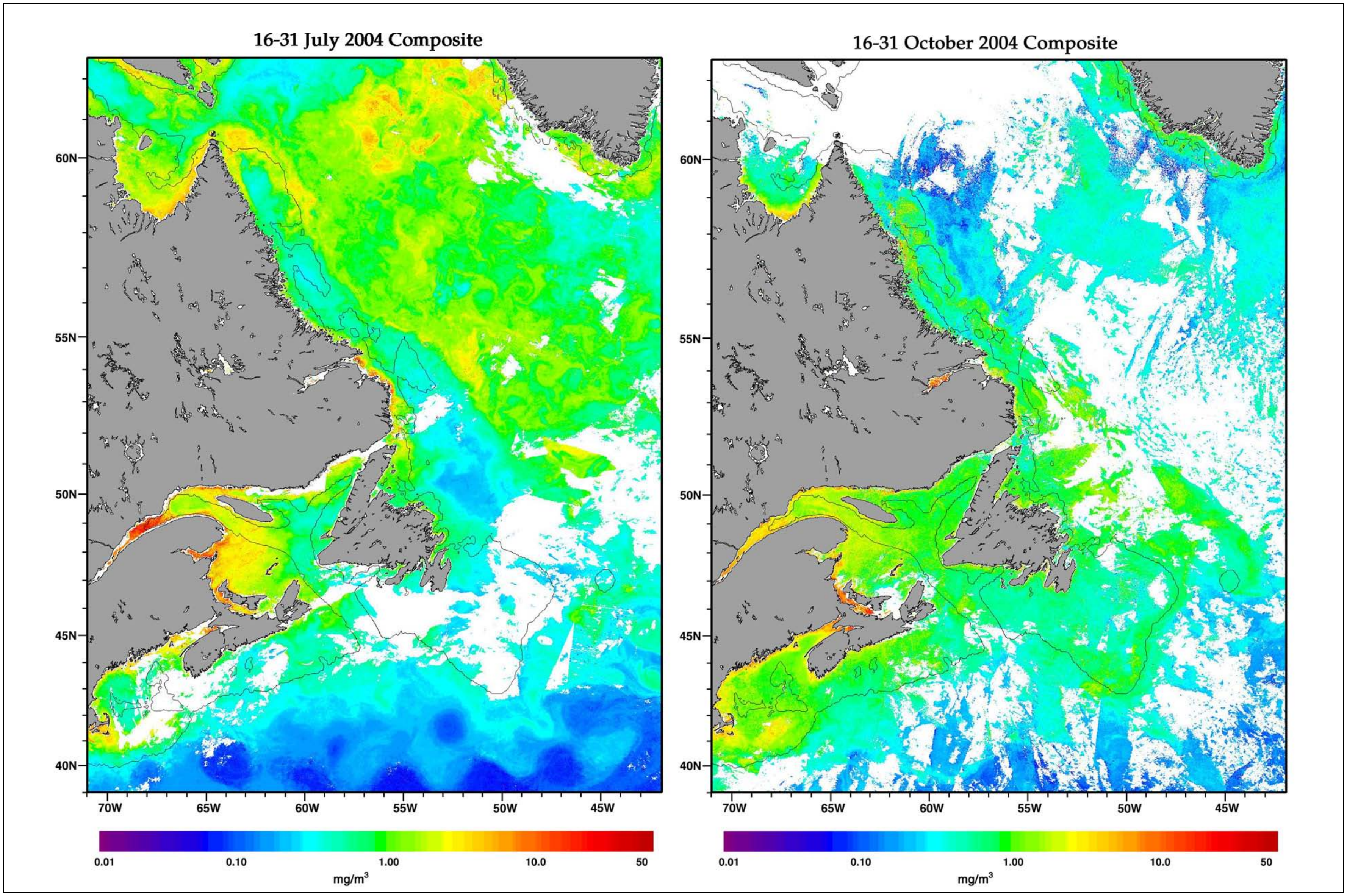
In the SEA Area, the productivity peaks in April, while the lowest productivity usually occurs in December. Primary production in the Northwest Atlantic is indicated in Figures 4.1 and 4.2. These maps were created using chlorophyll *a* (a measure of primary production) data from 2004. These and other semi-monthly images of primary production in the Northwest Atlantic (from 1997 to present) are available through BIO (2006).

Figure 4.1 Representative Maps from Data Collected in 2004 Illustrating Temporal and Spatial Variability in Primary Production in the Northwest Atlantic, December and April



Source: BIO 2006.

Figure 4.2 Representative Maps from Data Collected in 2004 Illustrating Temporal and Spatial Variability in Primary Production in the Northwest Atlantic, July and October



Source: BIO 2006.

4.2.2 Zooplankton

Zooplankton are the link between the energy production by phytoplankton and fish in the marine food web. In the Northwest Atlantic, zooplankton are dominated by copepods (Myers et al. 1994). Their populations increase in the spring as they feed on the phytoplankton bloom. Zooplankton populations decline in the summer as they are grazed by carnivorous zooplankton, fish, seabirds and marine mammals. They are expected to peak in areas of upwelling along channel slopes and the western edge of the St. Pierre Bank.

Euphausiid krill within the Laurentian Channel are dominated by *Meganyctiphanes norvegica, Thysanoessa* spp. and *Calanus* copepod species (White and Johns 1997). Calanoid copepods and krill are especially important in this area as they are an important food source for whales (Section 4.6) that congregate in the Laurentian Channel. The Northwest Atlantic exhibits a *Calanus*-*Sebastes*-dominated plankton system. As calanoid copepods dominate the plankton composition in early summer (late June), larval redfish (*Sebastes* spp.) dominate the ichthyoplankton at the same time, particularly over deeper waters such as the Laurentian Channel (Runge and de Lafontaine 1996).

Calanus glacialis, *C. finmarchicus* and other calanoid copepod species are the most abundant zooplankton species group on St. Pierre Bank and are the principle food source for resident fish larvae (Runge and de Lafontaine 1996). Anderson (1994) determined that variability in the production cycle of *C. finmarchicus* was an important factor in the inter-annual differences of feeding, growth and survival of redfish larvae near the Flemish Cap. Hyperiid amphipods, chaetognaths and euphausiid krill also make up a large part of the zooplankton biomass in the SEA Area (Anderson and Dalley 1997; Sameoto 2001). Zooplankton biomass can vary as much as 2.5 times in consecutive years (Anderson and Dalley 1997). Biomass can also vary diurnally, with more zooplankton present in surface waters during the day, especially over deeper waters (Hays 1996).

4.3 Benthic Invertebrates

Benthic invertebrate food supply in the nearshore environment comes primarily from detritus from rivers and re-suspension of organic particulate in areas of upwelling or shallow water. In offshore environments, benthic invertebrates are reliant on pelagic sources of detritus. The rate of sedimentation of organic detritus in shelf and deeper waters has a direct affect on the structure and metabolism of benthic communities (Desrosiers et al. 2000). The seasonality of phytoplankton can therefore influence production in benthic communities, adding temporal variability to a highly heterogeneous community. The spatial variability of benthic communities can be attributed to physical habitat characteristics such as water depth, substrate type (see Figure 3.1), currents and sedimentation. The wide range of these characteristics within the SEA Area ensures a variety of benthic communities.

Given the limited available data for this SEA Area, this section describes what is known and what can be inferred of the benthic invertebrate community. Benthic fish and shellfish are described in Section 4.4 and the coastal alga communities are described in Section 4.1.

4.3.1 Intertidal Communities

The infrequency of sea ice along the southwest coast allows proliferation and growth of many intertidal species, so the biomass of rockweeds, kelp, mussels and periwinkles are likely higher here, than on more northern shorelines around Newfoundland. Zonation of intertidal species would be quite pronounced in areas where sea ice is not common. However, sea ice may be expected within sheltered bays and fjords.

The fjords within the SEA Area offer some shelter to the intertidal community from the wind and wave exposure. The intertidal community within fjords will not necessarily be more productive than within comparable habitats along the coast, but the fjords likely add diversity to the coastal kelp and mollusc community. Besides exposure to wind and wave, the composition of the intertidal community is also dictated by substrate type. Shorelines with a range of substrate size classes will have a more diverse invertebrate community than a sandy beach, for example.

The intertidal habitats along the southwest coast range from the steep rock slopes of Bay de Vieux to low slope sand beaches, at Sandy Banks Provincial Park near Burgeo. Other unique intertidal features include an alluvial fan habitat at Grey River, gravel beaches on Northwest Island near Ramea, barachois ponds of Barasway Bay, and the steep bedrock cliff east of Burgeo (Meltzer 1996).

Moderately exposed rocky shoreline faunal communities usually consist of dogwhelk (*Thais lapillus*), periwinkles (*Littorina saxatilis* and *L. littorea*), barnacles (*Balanus* spp.), blue mussels (*Mytilus edulis*) and rockweeds (*Fucus* spp.) (Steele 1983). Tubed weeds (*Polysiphonia* spp.) and Irish moss (*Chondrus crispus*) may also be found locally along the southwest coast (Meltzer 1996) (a summary of coastal algal communities is presented separately in Section 4.1).

Sedimentary beach habitats often appear void of sea life. The continuous movement of an unconsolidated sand or gravel substrate limits attachment and growth of flora and fauna on the surface. However, beneath the surface, an infaunal community of amphipods, copepods, cumaceans, nematodes and decapods infauna is often present (Meltzer 1996).

The barachois habitats of Newfoundland typically have fine-grained soft substrates, where clams (*Macoma spp.* and *Mya arenaria*), worms (*Nereis* spp., *Arenicola marina* and *Polycirrus phosphorea*) and amphipods (*Orchestia gryllus* and *Gammarus mucronatus*) are common (Steele 1983).

4.3.2 Subtidal Communities

The subtidal habitats with the SEA Area are as varied as the intertidal habitats. The area includes nearshore, shallow water rocky substrates to the silty seafloor in the middle of the Laurentian Channel (at depths of 450 m) (see Figure 3.1).

Water depths increase quickly moving offshore from the southwest coast. Along the shoreline, east of Burgeo, water depths increase to 200 m within 1.6 km of the mainland. Within La Poile Bay, water depths reach 150 m. Further offshore on Rose Blanche, Burgeo and St. Pierre banks, minimum contoured depths become 150, 100 and 50 m, respectively. Along the slope of the Laurentian Channel, the typical depth range is between 300 and 400 m.

In shallow nearshore waters with rocky substrates, a canopy of perennial kelp and rockweed would be common along the southwest coast (see Section 4.1). Besides the blue mussel, the horse mussel (*Modiolus modiolus*) may also be present in these areas. The gastropod *Lacuna vincta* and gammarid amphipods are likely the dominant macro-herbivores (Meltzer 1996). Sea urchins are likely not abundant near kelp forests. These kelp beds provide prime feeding and nursery habitat for a variety of fish and shellfish species.

At depths of 45 to 100 m, substrates of the Rose Blanche, Burgeo and St. Pierre banks are typically a mixture of sand-gravel (Hutcheson et al. 1981). The seabed of the shallow St. Pierre Bank (45 to 55 m) is composed of stones, shells which are well encrusted with a coralline alga called *Lithothamnium* (Nesis 1965). Sea urchins (*Strongylocentrotus droebachiensis)* and brittlestars (*Ophiopholis aculeate)* would also be common in this habitat. The biomass on the St. Pierre Bank averaged 432 g/m^2, including sand dollar (*Echinarachnius parma*) (334 g/m^2), sand lance (*Ammodytes* spp.) (76 g/m^2) and sea urchin (12 g/m^2) (Hutcheson et al. 1981). Of the top 10 species, polychaetes (eight species) were the dominant taxonomic group, in particular *Exogone hebes* (syllid worm), with an average density of 220 individuals/m^2. The echinoid *Ophiura robusta* (dwarf brittle star) was also found. *Hyas araneus* (toad crabs), snow crab (*Chionoecetes opilio*) and *Mesodesma deauratum* (wedge clam) were also present. Other crustaceans were shrimp, amphipods, isopods and cumaceans. Suspension feeders or surface deposit-feeders and detritivores were the predominant species. The total number of species found at that site is unknown, as a species inventory list is not available.

Nesis (1965) reported similar abundance of species from the banks, but density estimates were based on different groups of species than Hutcheson et al. (1981). Benthic animals including the orange-footed sea cucumber, brittlestar, sea urchin, bryozoans, hydroids, terebellid worm *(Thelepus cincinnatus)*, tube worms (*Spirorbis* spp.) and crenate barnacle (*Balanus crenatus)*. The standing crop was dominated by molluscs (51.6 g/m^2) and echinoderms (190.8 g/m^2), followed by barnacles (21.6 g/m^2), polychaetes (7.7 g/m^2), others (2.9 g/m^2), crustaceans (2.6 g/m^2) and nematodes (0.1 g/m^2). Polychaetes were numerically dominant followed by crustaceans. Benthic colonial organisms, including bryozoans, hydrozoans, sponges and corals, greatly contribute to the complexity of marine habitats. These types of habitats are typical nursery grounds for juvenile fish and invertebrates, due to protection from predators. These types of sessile colonial organisms serve to increase the biodiversity of the benthos (Henry et al. 2002).

Communities of sand dollars, sea urchins and brittle stars occur as a bordering ring around all banks at depths of 95 to 220 m (Nesis 1965). The sediments tend to be sandy or silty sand. The mean biomass of benthic community in this habitat was 149 g/m^2, comprised of 89 g/m^2 of sand dollars, 10 g/m^2 of sea urchins, 9 g/m^2 of brittle stars and sea star. Brittle stars, polychaetes (*Onuphis conchylega*), bryozoans (*Thelepus cincinnatus*) and chalky macoma (*Macoma calcarea)* contributed 2 to 4 g/m^2 of biomass.

In the deeper waters of the Laurentian Channel and slope, benthic community composition changes into a community called the spatangoid heart urchin (*Brisaster fragilis*) community. These urchins burrow in sand and mud substrates and are often associated with the mud sea star (*Ctenodiscus crispatus*), a deposit feeding echinoderm, a deep sea brittle star (*Amphiodia otteri*), and an octocoral sea pen (Renillidae). The community biomass has been estimated as approximately 35 g/m^2. *Brisaster fragilis*, *Ctenodiscus crispatus* and *Amphiodia otteri* each have a mean biomass of approximately 6 g/m^2. A bivalve (*Astarte crenata whiteavesi*), thread worms, (*Lumbriconereis fragilis*) and a sea pen (*Kophobelemnon stelliferum*) make up approximately 1.5 to 3 g/m^2 each.

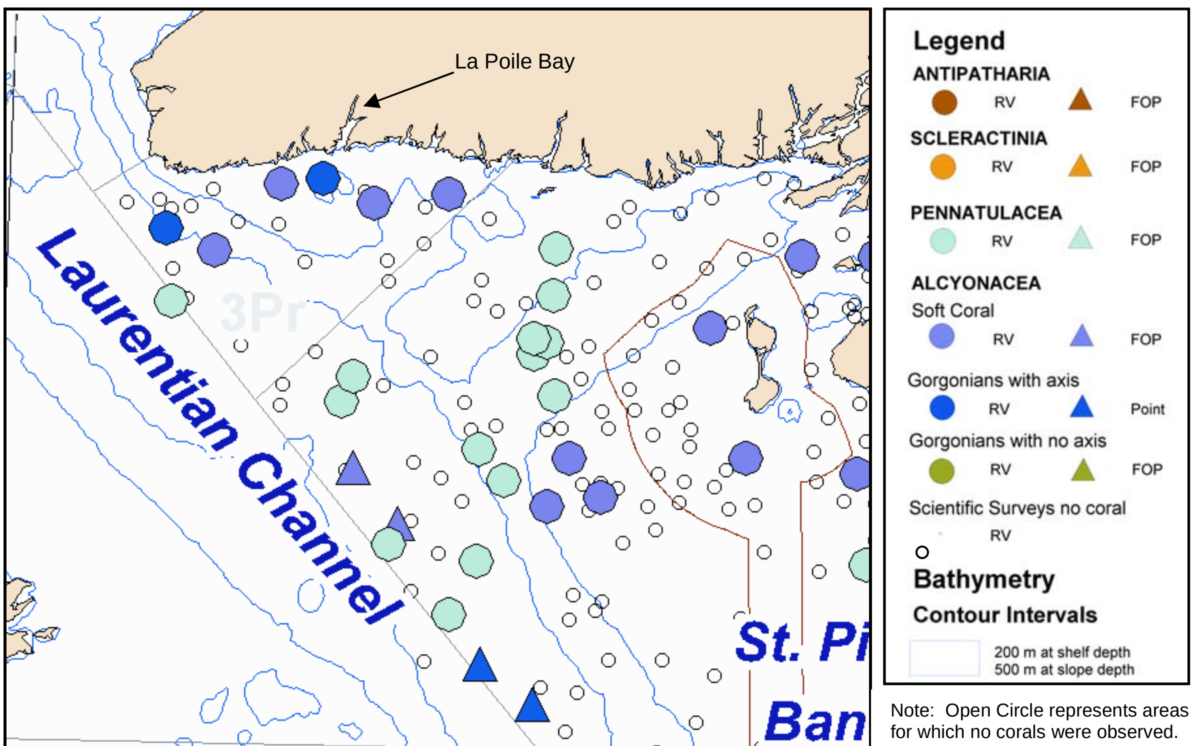
The Laurentian Channel habitat is characterized by warm water species and an absence of cold water forms. The low diversity in the fauna is attributed to the soft bottom, unfavourable habitat for epilithic species.

4.3.3 Deep-sea Corals

Deep-sea corals usually occur in submarine canyons and along the edges of channels, but have also been found on the slope of the Scotian Shelf (Breeze et al. 1997). They provide unique habitat in deep waters, acting as a reef in an often barren seafloor. They are long-lived and slow growing, so do not rebound quickly from disturbance. The generic term coral refers to stony corals (scleractinians), sea anemones (actinarians), soft/leather corals (alcyonaceans), horny corals (gorgonaceans) and sea pens (pennatulaceans).

Twenty-seven coral species have been identified within the Newfoundland and Labrador region (Gilkinson et al. 2006). There are three families of corals found within the SEA Area, at depths greater than 200 m. They are soft/leather corals (Alcyonacea), horny corals (Gorgonacea) and sea pens (Pennatulacea) (Wareham and Edinger in press). The most common are the sea pens, followed by the soft corals and the horny corals. There are four known occurrences of the horny coral within the SEA Area (Figure 4.3). The open circles in Figure 4.3 indicate areas that were surveyed by RV but for which no coral were observed. These data (Figure 4.3) are a combination of DFO RV data and fisheries observer data. Scleratinia have also been reported to occur within the Laurentian channel (Mortensen et al. 2006). Except for the Stone Fence area, the Laurentian Channel outside the SEA Area has relatively few corals (mean density of 0.78 colonies/100 m^2) when compared to other deep water areas of Atlantic Canada (Mortensen et al. 2006). The Alcyonacean *Gersemia rubiformis*, was reported 17 times in La Poile Bay, which an average of 0.5 colonies/100 m^2.

Figure 4.3 Deep-sea Coral Occurrences within the Strategic Environmental Assessment Area



Adapted from: Wareham and Edinger (in press).

Note: Open Circle represents areas surveyed for which no corals were observed.
RV – Remote Video
FOP – Fisheries Observer Program

Generally, the soft corals can be widely distributed in relatively shallow and deep waters, whereas the horny and stony corals have a more localized distribution in deeper water. Most corals need a hard substrate on which to settle, except for the gorgonian *Acanella arbuscula* and scleractinians of the genus *Flabellum*, which occur on soft or muddy substrates. Depending upon species, corals form colonies (reefs) or are solitary; some can be metres tall while others are only a few centimetres. Gorgonian corals, the most abundant corals in other areas of Atlantic Canada, settle out and grow only on large boulders (Breeze et al. 1997).

Based on traditional ecological knowledge gained from interviews with Newfoundland and Labrador fishers, it would appear that *A. arbuscula* is more common off Newfoundland and Labrador than other species (Gass and Willison 2005). However, as *A. arbuscula* has a root like structure supporting growth in soft sediment, it in actuality may be more susceptible to being caught in gillnets as compared to other deep-sea corals (Gass and Willison 2005).

Polychaetes, amphipods, sponges, barnacles, bryozoans, ophuroids and larval and adult fish are found in association with corals. Corals create heterogeneous habitats and are important locations for protecting juvenile fish from predators. The corals also provide habitat to invertebrates, an important food source for bottom-dwelling fishes. As a result, coral areas are often targeted by fishers for the redfish, pollock, halibut and shrimp that aggregate there (Breeze et al. 1997).

4.3.4 Planning Implications for Benthic Invertebrates

It is important to note that DFO used information and knowledge gained from Environmental Studies Research Fund-funded research to create three consideration areas off the coast of Nova Scotia to protect deep sea corals from further damage and allow recovery (Mortensen et al. 2006). Currently, there are no conservation measures in place to protect deep sea corals within the Newfoundland and Labrador region (Gilkinson et al. 2006). Operators should be aware that there is a possibility that conservation measures to protect deep sea corals could be adopted in the future for the Newfoundland and Labrador region.

Pre-spud remotely-operated vehicle or other similar baseline surveys may be required to determine the existence and species of coral communities at the drilling location.

4.3.5 Data Gaps for Benthic Invertebrates

There has been little scientific investigation of the intertidal communities along the coastline within the SEA Area. General habitat descriptions as found in Meltzer (1996) and South (1983) can be used to infer species. However, the coastline has many features that are not found in comparable climates that may result in unexpected species diversity and abundance. There is an evident void of scientific literature on the biology of the intertidal community along this shoreline.

There is little site-specific information on intertidal or subtidal benthic invertebrates from within the SEA Area. Information is lacking on benthic species distribution, abundance and diversity. There have been previous assessments of commercial benthic species such as Iceland scallop (*Chlamys islandica*) and snow crab from the SEA Area, but these assessments are dated.

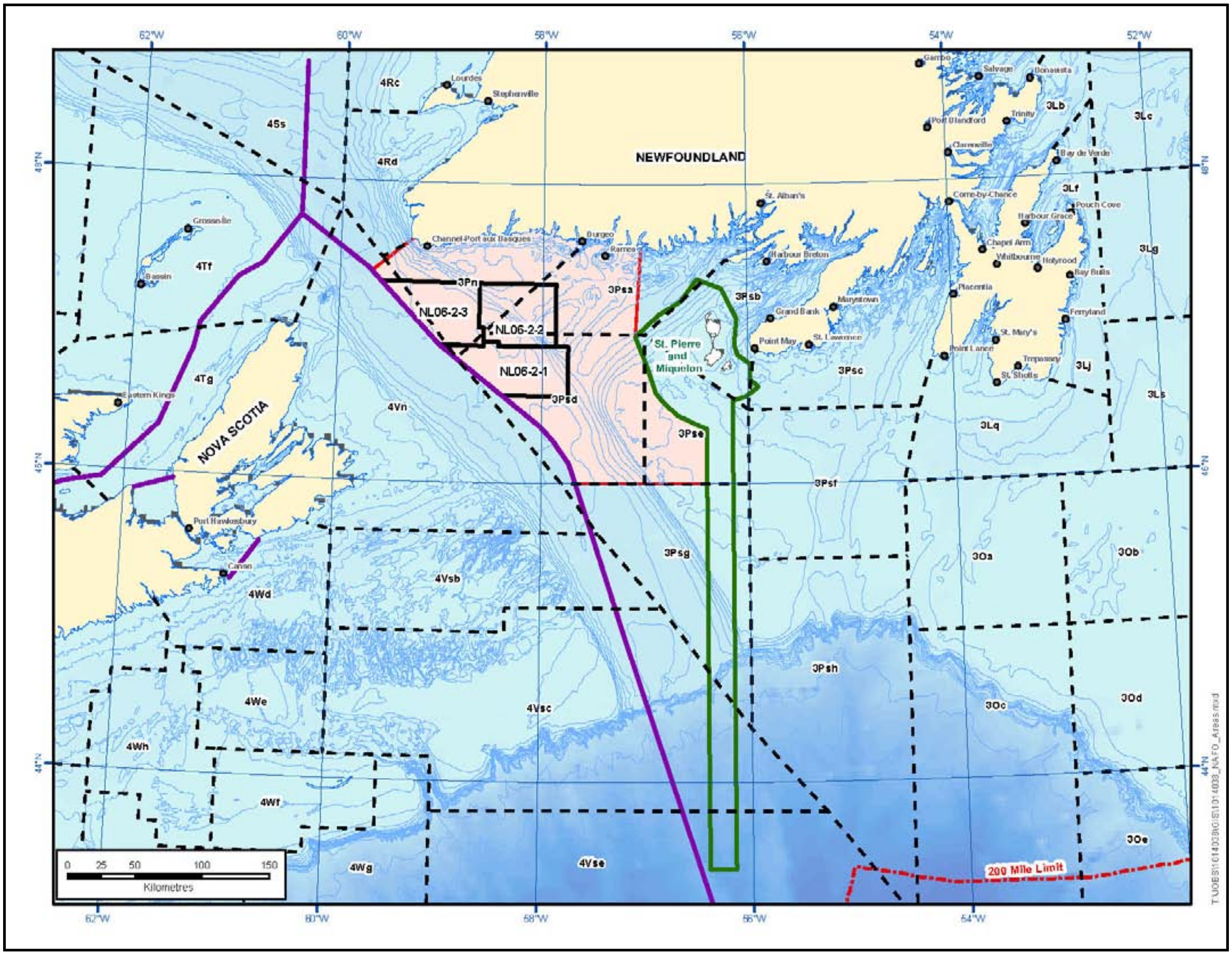
The literature covering the effects of seismic and noise on invertebrates is limited and incomplete. The lack of information from within the SEA Area, on the potential sensitivities within the benthic community promotes the need for site-specific baseline data for environmental assessment purposes.

The study of deep-sea corals in Newfoundland and Labrador is a new area of focus and research. Research to date has focussed on mapping of coral distributions and diversity (Gilkinson et al. 2006). Up to 2005, the Newfoundland and Labrador deep-sea coral research program was an opportunistic program taking advantage of coral bycatch from multispecies surveys, Fisheries Observer Programs and traditional ecological knowledge from commercial fishers (Gilkinson et al. 2006). Since 2005, the deep sea coral program has been expanded to include studies on deep-sea coral trophic relationships, reproductive ecology and the role of deep sea corals as fish habitat. Nevertheless, the deep sea coral program is new and there are data gaps associated with the mapping of deep sea coral distributions and diversity, the understanding of their ecology and their role in the ecosystem.

4.4 Fish and Fish Habitat

Fish species distributions are described in terms of Northwest Atlantic Fisheries Organization (NAFO) divisions and areas (Figure 4.4).

Figure 4.4 Northwest Atlantic Fisheries Organization Divisions



4.4.1 Shellfish Species

4.4.1.1 Lobster

Lobsters (*Homarus americanus*) are distributed in the nearshore around the Island of Newfoundland, including the southwest coast of the island. Populations tend to be localized. The major life-history events (moulting, spawning, larval hatching) occur from mid-summer to early fall following the spring fishing season (DFO 2003a). Their depth range is from 1 to 700 m, but are typically found in depths of less than 50 m. Lobsters live on the seabed and prefer habitats with rocky substrates covered with algae that offer shelter for hiding and foraging. Adult lobsters are found close to the coast in the summer because of warmer water, but migrate to open water in the winter to avoid turbulence. Young lobsters generally stay close to the coast in depths of 10 m or less, on gravel and cobble bottoms. They do not migrate to the open ocean during the winter; they hide in shelters amongst the rocky substrate (St. Lawrence Observatory 2006).

Mating occurs immediately following the female's moulting (or ecdysis) of her old shell during the summer months. The female carries the embryos under her tail for almost a year (9 to 12 months) until the pre-larvae hatch. Therefore, female lobsters mate only once every two years and is said to have a biennial molt-reproductive cycle (St. Lawrence Observatory 2006; DFO 2006a).

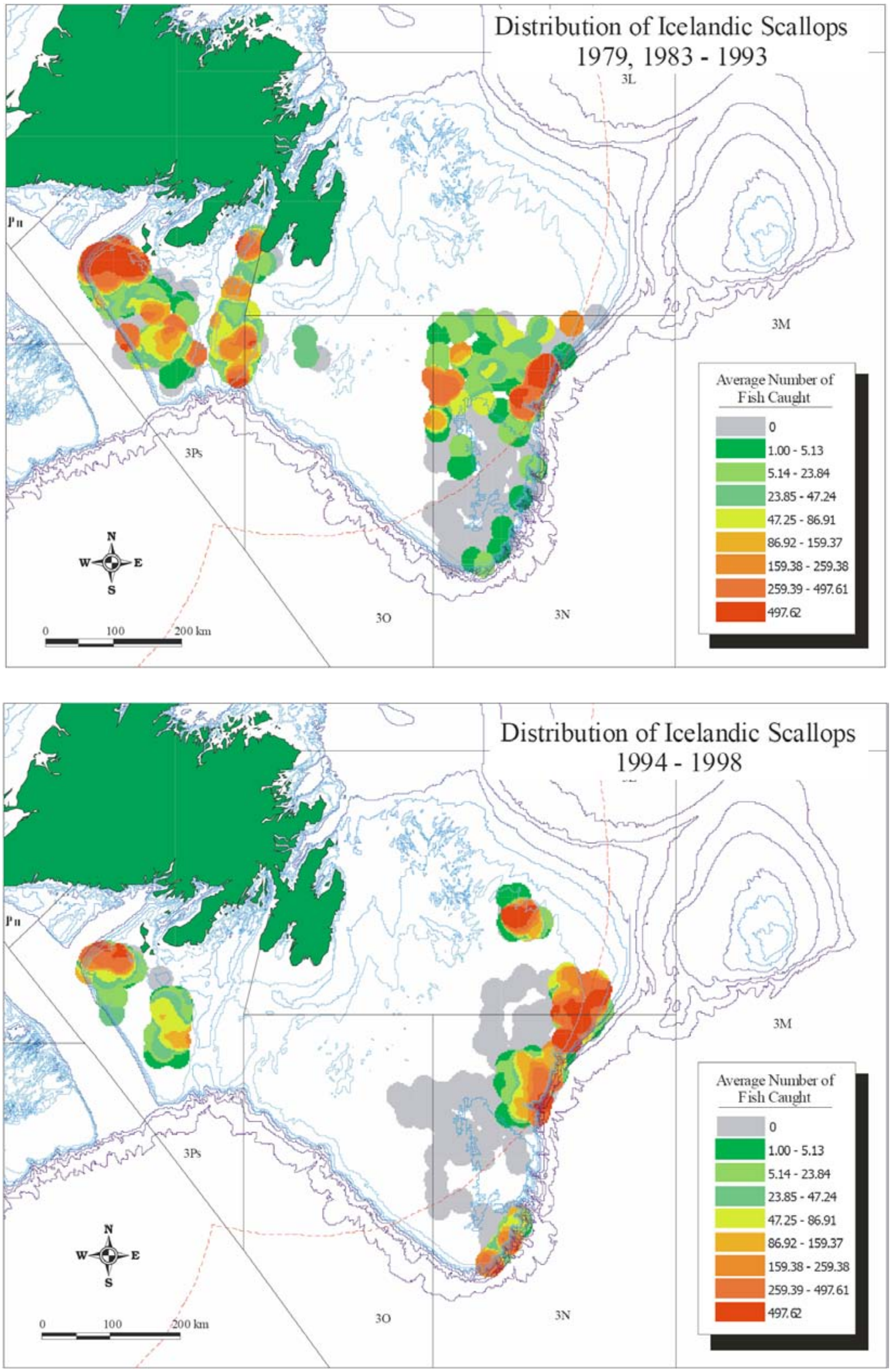
Lobster diet consists mainly of benthic invertebrates including rock crab, polychaetes, molluscs, echinoderms and fish. Adult lobsters have few natural predators. Commercial fishing accounts for most mortality (DFO 2006a).

4.4.1.2 Iceland Scallops

Iceland scallops are widely distributed throughout the sub-Arctic and occur in commercial-sized beds on the St. Pierre Bank (JWEL 2003) at depths of 50 to 180 m on hard substrates consisting of sand, gravel, shells and stones (DFO 2006b). They are suspension feeders and as such, tend to be most abundant in areas with substantial water movements (Naidu 1997).

The spawning season for Iceland scallop is short and varies geographically from April to August (Wallace 1981; Crawford 1992). Iceland scallops spawn on the St. Pierre Bank in late summer (Figure 4.5), but are now present in lower numbers than in the 1980s and early 1990s (Ollerhead et al. 2004). Juveniles settle to the seabed in the fall and approximately five weeks after spawning (DFO 2002a).

Figure 4.5 Distribution of Spawning Iceland Scallop, 1979 to 1998



Source: Ollerhead et al. 2004.
Note: The 0 class represents survey sets where no scallops were caught.

4.4.1.3 Sea Scallops

Sea scallops (*Plactopecten magellanicus*) are benthic, bivalve molluscs found only in the Northwest Atlantic, from the Strait of Belle Isle to Cape Hatteras. They occur on sand or gravel substrates at depths of 35 to 120 m in large aggregations (beds). Sea scallops do not migrate, but are capable of limited 'swimming' by contracting their muscle and clapping their shells together (Harvey-Clarke 1997). Commercial-sized scallop beds are found on Newfoundland's large offshore banks, including on St. Pierre Bank in the southern part of the SEA Area.

Spawning occurs from August to October (DFO 2002b). Ollerhead et al. (2004) showed spawning occurring on St. Pierre Bank, although the average number of spawning scallops has decreased since the early 1990s (Figure 4.6). The first two larval stages of the scallop, the trocophore and veliger, are pelagic, remaining planktonic for over a month after hatching and usually settle to the seabed by December (Hart and Chute 2004). Settlement is dependant on the larvae detecting a suitable substrate (Pearce et al. 2004). Larvae preferentially settle on hard surfaces, preferring substrates with shell fragments and small pebbles including existing scallop beds (Hart and Chute 2004).

4.4.1.4 Snow Crab

Snow crab is a decapod crustacean that occurs over a broad depth in the Northwest Atlantic from Greenland south to the Gulf of Maine. Distribution is widespread on the Newfoundland and Labrador shelves, but the stock structure is not defined (DFO 2005a). Commercial-sized crab commonly occurs on mud or sand substrates (DFO 2005a) at depths of 70 to 280 m (Elner 1985). Smaller crab is also found on harder substrates (DFO 2002c).

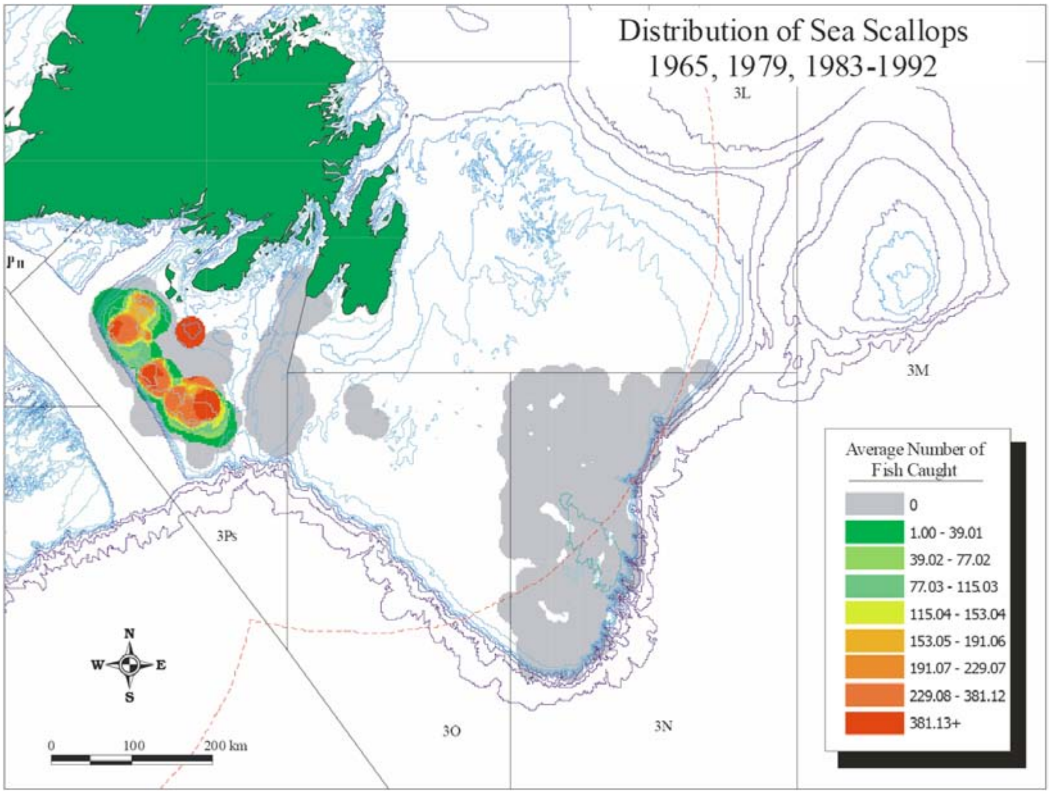
Offshore snow crab migrations have not been described; however, nearshore populations in Bonne Bay, on the west coast of Newfoundland, have been observed migrating to shallow water in the spring; an event which coincides with moulting and mating (Hooper 1986; Ennis et al. 1990). Offshore mating also occurs during the spring and females carry the fertilized eggs for approximately two years. The eggs hatch in the late spring or early summer and larvae spend 12 to 15 weeks living pelagically in the water column before settling to the seabed (DFO 2002c).

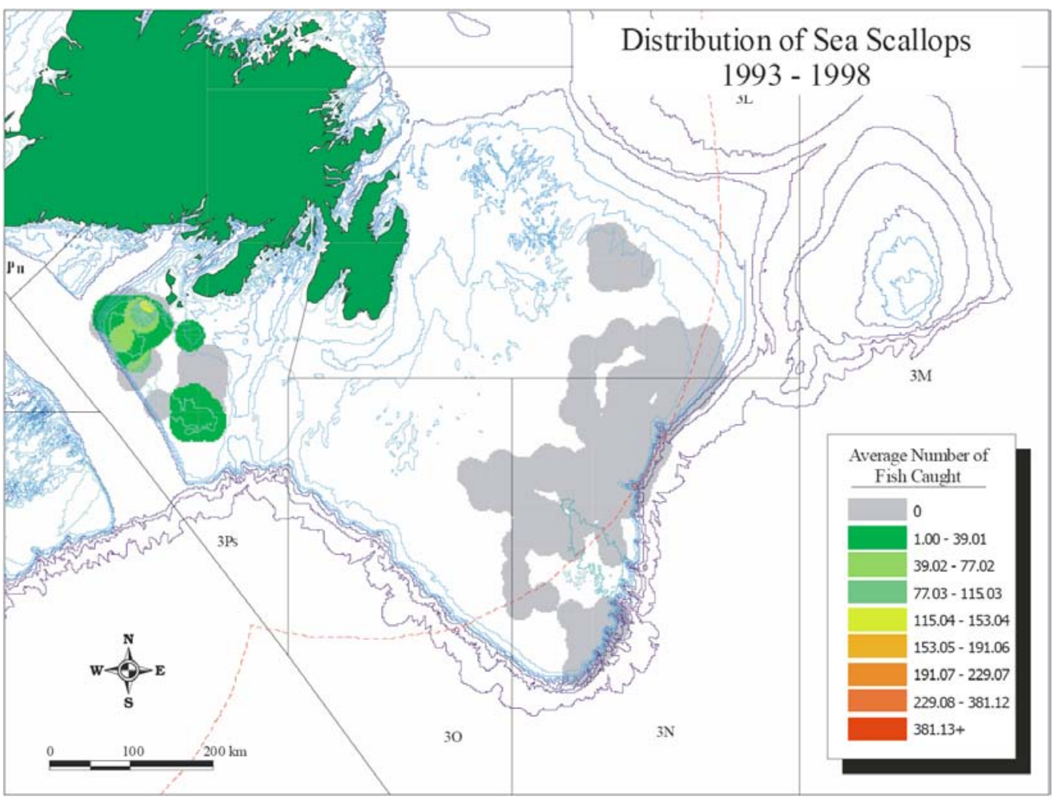
Snow crab feed on fish, clams, benthic worms, brittle stars, shrimps and crustaceans, including smaller snow crabs. Their predators include various groundfish and seals (DFO 2002c).

4.4.1.5 Northern Shrimp

Northern shrimp (*Pandalus borealis*) are crustaceans occurring in the Northwest Atlantic from the Davis Strait to the Gulf of Maine. Their preferred water temperature ranges from 2°C to 6°C and are found from shallow inshore waters to depths of 180 m on soft muddy substrates. Larger individuals generally occur in deeper waters (DFO 2006c). Shrimp undergo a diel vertical migration, moving off the bottom into the water column during the day to feed on small pelagic crustaceans. Female shrimp also undergo a seasonal migration to shallow water where spawning occurs (DFO 2006c). Eggs are laid in the summer and remain attached to the female until the following spring, when the female migrates to shallow coastal waters to spawn (Nicolajsen 1994, in Ollerhead et al. 2004).

Figure 4.6 Distribution of Spawning Sea Scallop, 1965 to 1998

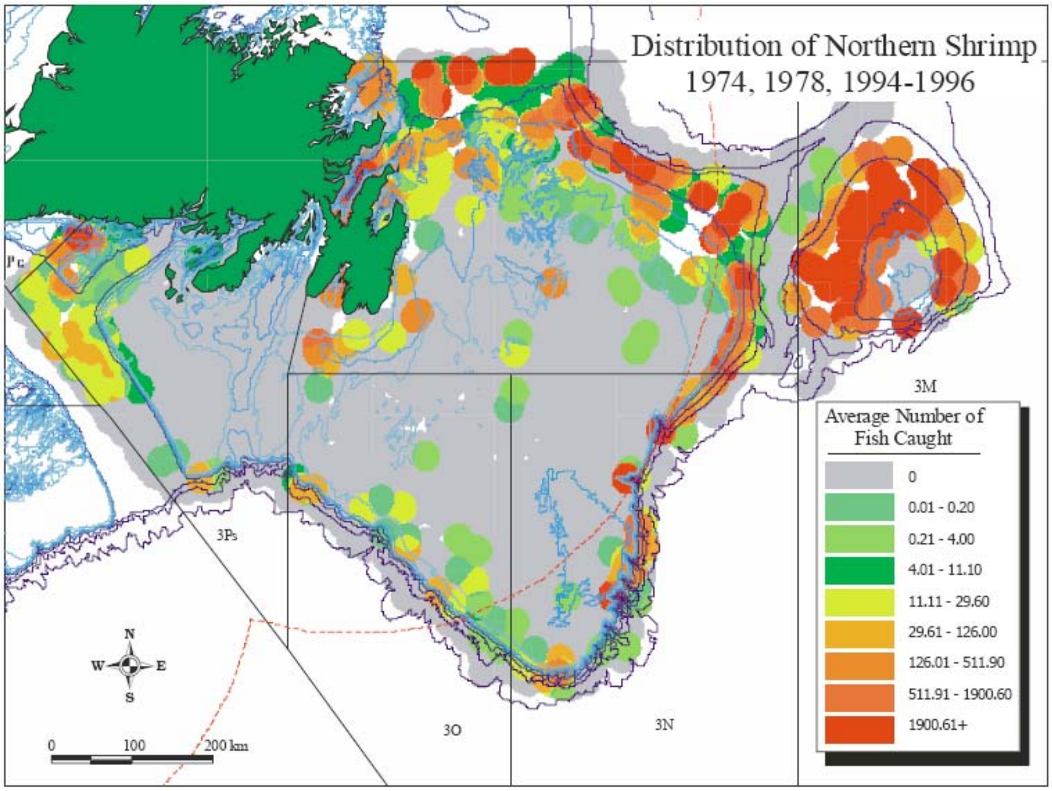




Source: Ollerhead et al. 2004.
Note: The 0 class represents survey sets where no scallops were caught.

Northern shrimp is not commercially fished in the SEA Area (Canning & Pitt 2006), but it is known to spawn in the shallow waters along south coast of Newfoundland (Parsons 1993). Ollerhead et al. (2004) show that spawning occurs in the SEA Area in the western portion of 3Ps (Figure 4.7).

Figure 4.7 Distribution of Spawning Northern Shrimp, 1974 to 1996



Source: Ollerhead et al. 2004.
Note: The 0 class represents survey sets where no shrimp were caught.

4.4.1.6 Whelk

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

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

4.4.2 Finfish Species

SARA-listed fish species at risk that could occur in the SEA Area include the endangered northern wolffish (*Anarhichus denticulatus*), endangered spotted wolffish (*A. minor*), and species of concern Atlantic wolffish (*A. lupus*). These are discussed in Section 4.7.1.7.

4.4.2.1 Atlantic Cod

The Atlantic cod occurring with in the SEA Area are primarily classified as the Northern Gulf of St. Lawrence cod population (NAFO Divisions 3Pn and 4RS). The Northern Gulf cod stock are distributed north of the Laurentian Channel, off Newfoundland and Labrador's west coast and along the north shore of Quebec in NAFO Divisions 4RS and Subdivision 3PN (Méthiot et al. 2005). The majority of these cod migrate to deep water (greater than 400 m) east of the Cabot Strait in the autumn. During the overwintering period, the Northern Gulf cod mix with Southern Newfoundland cod from NAFO 3Ps (DFO 2005b; Méthiot et al. 2005).

In April and May, the Northern Gulf cod migrate towards the Port au Port Peninsula (NAFO Division 4R), where spawning commences (DFO 2005b). As summer progress, the Northern Gulf cod continue migration and dispersion along the west coast of Newfoundland and Labrador (NAFO Division 4R) and towards the North shore of Quebec (NAFO Division 4S). The late spring, summer migration of the Northern Gulf cod stock corresponds with warmer temperatures and capelin presence (DFO 2005b).

Local fishers reported that cod migration commences as early as September and by January, there are very few cod left in the Gulf. Cod were reported to be plentiful in 3Pn by March and as a result, halibut (*Hippoglossus hippoglossus*) fisheries were closed due to heavy by-catch of cod (Canning & Pitt 2006).

Historically, tagging studies suggested the presence of more than one cod stock occupying waters in NAFO Subdivision 3Ps during winter months (Méthiot et al. 2005; Brattey and Healy 2004; 2005; Templeman 1979). Originally it was thought that mixing of the Northern Gulf cod within NAFO Subdivision 3Ps occurred primarily within the Burgeo Bank. Data collected as a result of the Northern Gulf cod sentinel tagging program found that mixing of the Northern Gulf cod into NAFO Subdivision 3Ps extends further east than the Burgeo Bank (Bérubé and Fréchet 2001). Cod tagging in 4R and 4S were recaptured in Hermitage, Fortune and Placentia Bays. Cod tagged in 3Pn were recaptured throughout 3Ps including Placentia Bay.

Tagging experiments have shown that the Northern Gulf cod stock is relatively isolated from adjacent stocks in divisions 4TVn, 2J3KL and 3Ps. However, the stock does sometimes mix in the Northwest Gulf with 4TVn cod, and in the Strait of Belle Isle with 2J3KL cod. However, the greatest mixing occurs on the Burgeo Bank with 3Ps cod (Yvelin et al. 2005). In 2005, surveys were conducted to determine the extent of mixing between the Northern Gulf cod stock and the 3Ps stock. Movement of fish was monitored by electronic fence sensors in the water. The survey found that 60 percent of the Northern Gulf stock mixes with the 3Ps stock during their time spent wintering on the south coast of Newfoundland. The conclusions of the study were presented at the Quebec regional DFO assessment meeting in February 2006, but have not yet been published (M. Castonguay, pers. comm.). Because of the extensive mixing, the 3Pn4RS stock can be thought of as a complex of four sub-populations (Yvelin et al. 2005).

Mixing between 3Pn, 4RS cod and 3Ps cod is an important management issue as total allowable catches (TACs) are higher in 3Ps (15,000 tonnes in 2004) than in 3Pn (3,500 tonnes in 2004). The 4RS and 3Pn stocks are included in the Laurentian North cod population. Incidental exploitation of the 3Pn or 4RS stock during the 3Ps fishery could jeopardize a possible recovery.

The scientific investigations conducted on the mixing of the Northern Gulf cod stock (3Pn, 4Rs) with the Southern Newfoundland cod stock (3Ps) have shown that the duration, timing and extent of the mixing vary annually and may be strongly influenced by oceanographic conditions (Brattey et al. 2003). However despite the extensive research, there are no reliable methods to facilitate the assignment of fishery or survey catches from the mixing area to the appropriate stock. As a result management measures, most notably seasonal closures of the directed cod fishery, have been implemented.

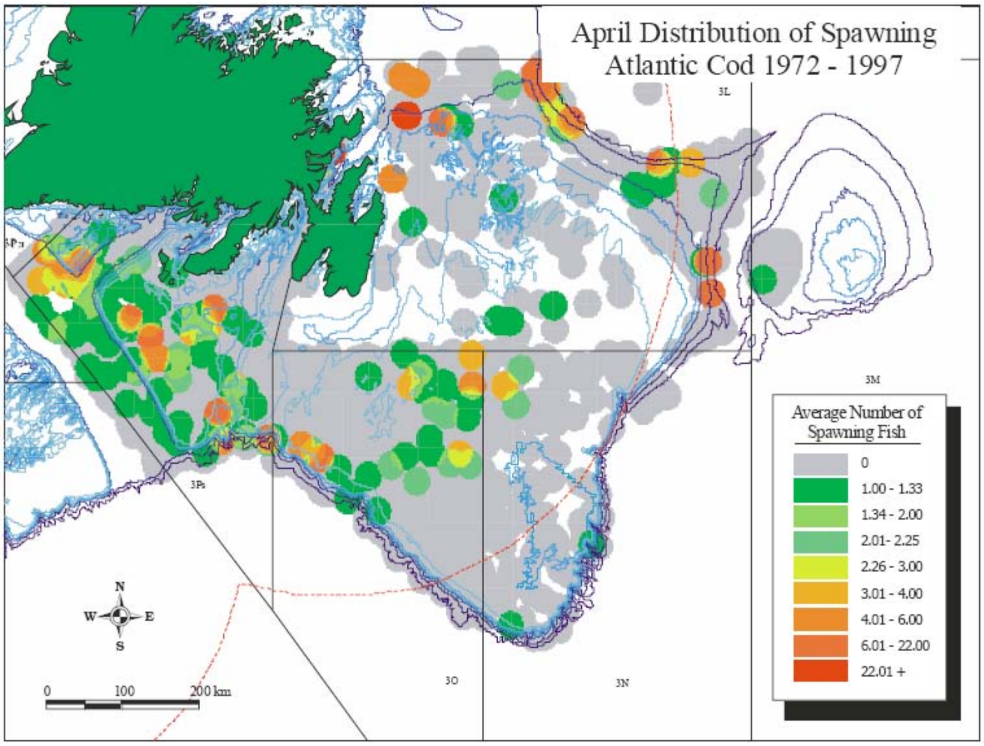
Cod in 3Ps appear to spawn over a considerable portion of the year, within many locations in the stock area, and there appears to be no consistent peak in the spawning time (Brattey et al. 2003). Spawning is spatially wide spread, occurring on Burgeo Bank, St. Pierre Bank, Halibut Channel, Hermitage Bay, Fortune Bay and Placentia Bay. Ollerhead et al. (2004) prepared spawning intensity maps that used modeled DFO research vessel data, in conjunction with published literature to determine spawning season for each species (Figure 4.8). Local fishers have observed the numbers of fish on St. Pierre Bank and Burgeo Bank rebound in recent years since the moratorium. Since the rebound, fishers have observed that spawning now occurs year-round (Canning & Pitt 2006). Analysis of DFO RV data by Ollerhead et al. (2004) shows spawning occurring in the SEA Area during the spring and summer, currently peaking in April in the SEA Area. Within the SEA Area, spawning occurs on the Burgeo and St. Pierre Banks and in the Laurentian and Hermitage Channels, although there are fewer spawning fish now than during the 1980s and mid-1990s (Figure 4.8).

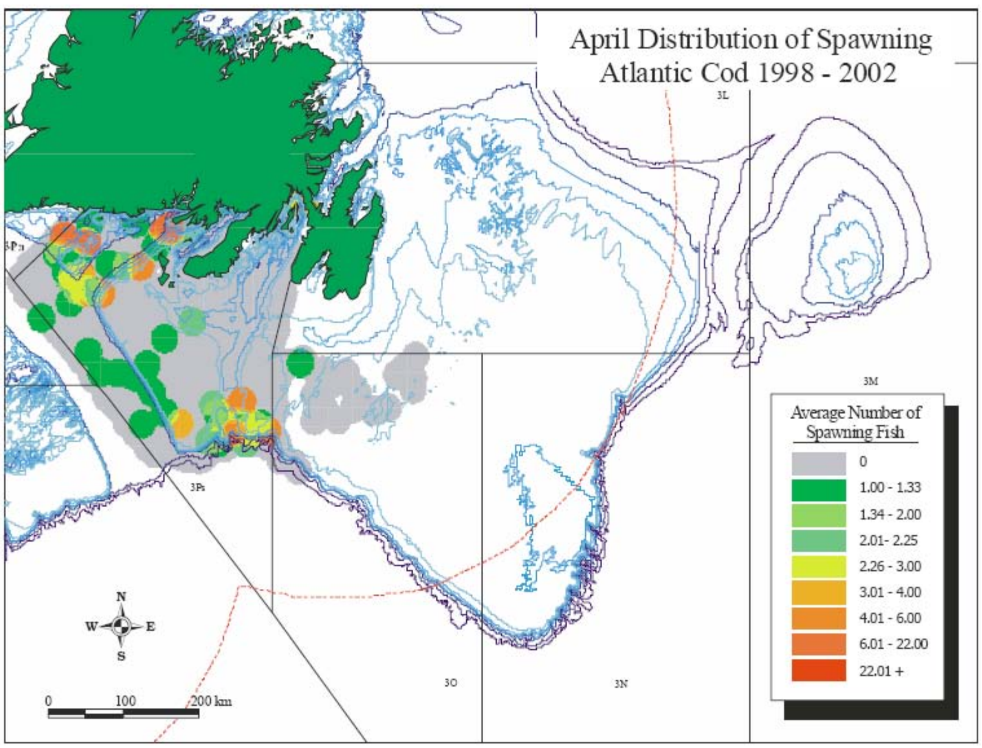
Cod typically spawn at depths ranging from tens (Smedbol and Wroblewski 1997) to hundreds of metres (Brander 1994; Morgan et al. 1997). Despite its commercial and ecological importance, the spawning behavior of Atlantic cod is poorly understood. Spawning has rarely been observed in the field. Recent studies have shown that successful reproduction involved complex behaviour between the sexes. Sound production by males has been shown to occur most frequently during the peak spawning period (Rowe and Hutchings 2006). It is believed that sound communication is an important measure by which females discriminate between males from different cod populations, and that the chorus of sounds produced by large aggregations of males may serve as a long-range signal to attract females to the spawning area (Nordeide and Kjellsby 1999, in Rowe and Hutchings 2006).

After extrusion and fertilization, the eggs slowly rise to the surface waters and remain at or near the surface during incubation. They are spherical, transparent, buoyant and pelagic. Incubation time varies depending on the temperature. Those spawned on Hamilton Bank in March and April hatch in approximately 40 days at temperatures of -1°C to 1°C (Scott and Scott 1988). Hatching occurs when the larvae are 3.3 to 5.7 mm in length. They remain pelagic but move deeper as they grow, until they are 27 to 50 mm in length, when they descend to the seabed (Scott and Scott 1988; Lough 2004). The amount of time to settlement varies by location (Lough 2004). Brattey et al. (2004) indicated that cod in 3Ps appear to spawn over a significant portion of the year and at many locations within the SEA Area (Burgeo Bank, St. Pierre Bank, and Halibut Channel). Therefore, it is possible to find pelagic juvenile cod and larvae in the water column at any time during the year. St. Pierre Bank is a known spawning and nursery ground during the spring and summer (D. Mercer, pers. comm.).

Atlantic cod were assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as endangered in May 2005 but were not added to SARA Legal list (COSEWIC 2006a). They are on Schedule 3 of SARA as a Species of Special Concern (SAR 2006).

Figure 4.8 Distribution of Spawning Atlantic Cod in April, 1972 to 1999 and 1998 to 2002





Source: Ollerhead et al. 2004.
Note: The 0 class represents survey sets where no fish were caught.

4.4.2.2 Haddock

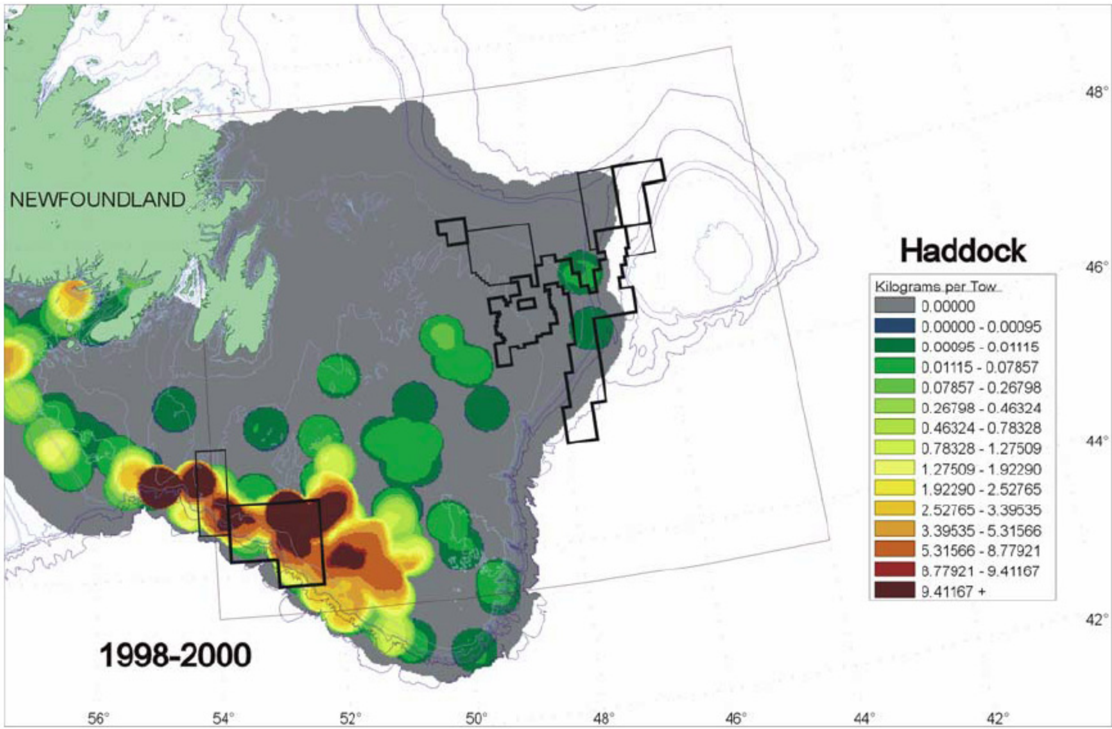
Haddock (*Melanogrammus aeglefinus*) are bottom-dwelling fish, occurring over hard, smooth sand and gravel bottoms. They have a marked seasonal depth distribution, preferring depths of 27 to 366 m and temperatures from 1 to 13°C in the winter, but moving to shallower and warmer waters (depths of 55 to 126 m) during the summer. There are seven populations of haddock in the Northwest Atlantic: southwest Newfoundland, Grand Bank, St. Pierre Bank, Emerald Bank and eastern Gulf, Browns Bank – southwestern Nova Scotia, Georges Bank and Gulf of Maine – Bay of Fundy. Each of these populations are separated by deep channels and has differing spawning times and growth rates (Scott and Scott 1988). Kulka et al. (2003) showed that in recent years haddock are present in the Laurentian Channel and along the slope of the St. Pierre Bank during the spring only and were found further south in the fall (Figures 4.9 and 4.10).

Spawning occurs in June in Newfoundland waters (Scott and Scott 1988). Haddock are known to spawn within the current SEA Area, on the St. Pierre Bank and along its slopes (Page and Frank 1989; Begg 1998; Ollerhead et al. 2004). Historically, spawning in the SEA Area occurred in the spring, peaking March and April (Figure 4.11); however, recent surveys have not shown spawning occurring in the SEA Area (Figure 4.12) (Ollerhead et al. 2004). Larvae are pelagic, settling to the seabed when they reach 50 mm in length, at ages of three to five months (DFO 2001a; Brodziak 2005). Although little is known about their spawning behavior in nature, aquarium observations show that haddock communicate by sound during reproductive rituals. The male emits a series of knocking, rasping and humming sounds during courtship and also changes color during spawning (Hawkins 1986; Scott and Scott 1988).

Haddock are primarily bottom-feeders. Adults consume mostly crustaceans, molluscs, echinoderms, annelids and other fishes. Haddock are preyed upon by harbour (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) (Scott and Scott 1988).

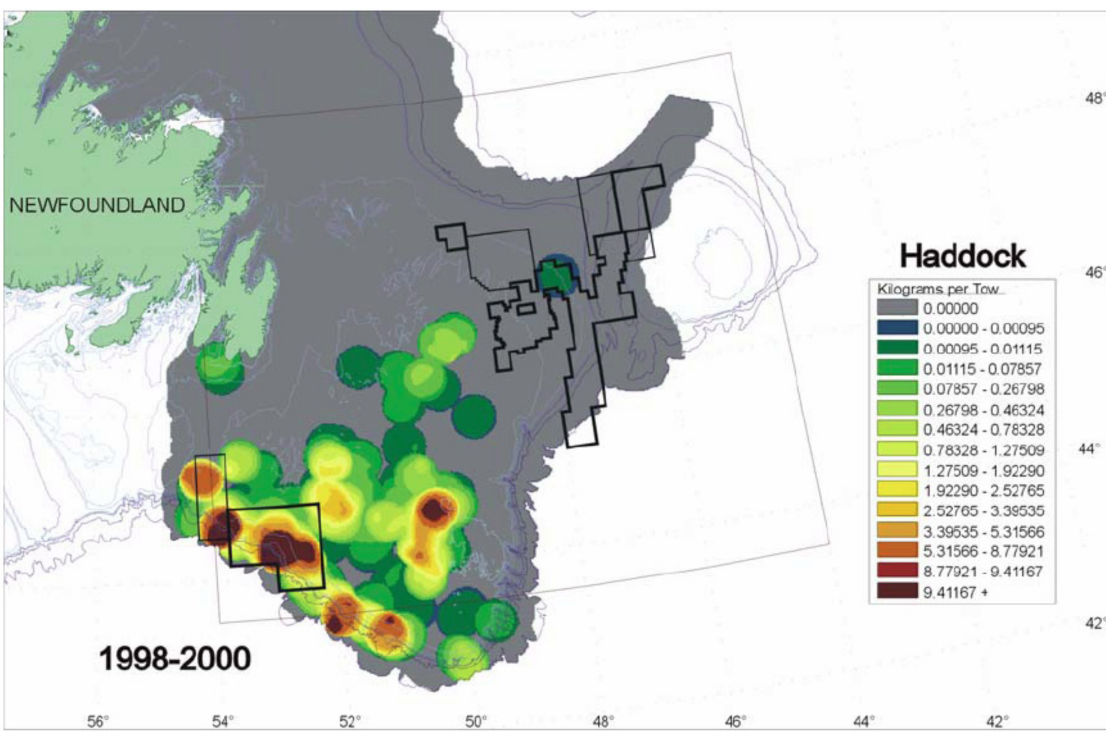
During the mid-1950s, a substantial haddock fishery took place on St. Pierre Bank, harvesting mainly the abundant 1949 year-class. There has not been a large haddock fishery in 3Ps since 1957. Recent surveys have found few haddock. Although recent DFO RV surveys have suggested increases in stock size, the biomass in 3Ps is very low when compared with the mid to late 1980s (DFO 2001a).

Figure 4.9 Haddock Distribution Based on Spring Research Surveys, 1998 to 2000



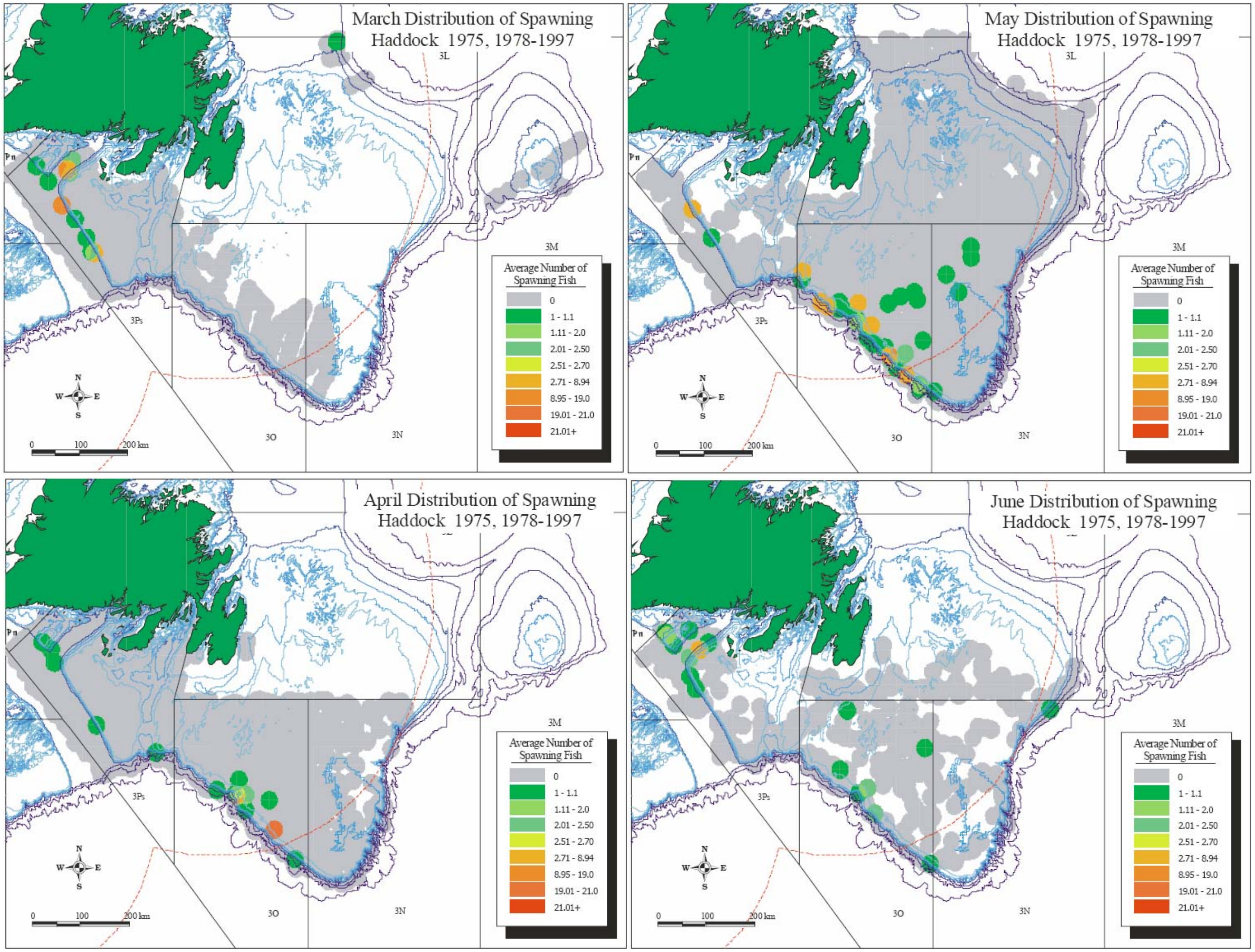
Source: Kulka et al. 2003.
Note: Grey represents areas sampled with no catch data.

Figure 4.10 Haddock Distribution Based on Fall Research Surveys, 1998 to 2000



Source: Kulka et al. 2003.
Note: Grey represents areas sampled with no catch data.

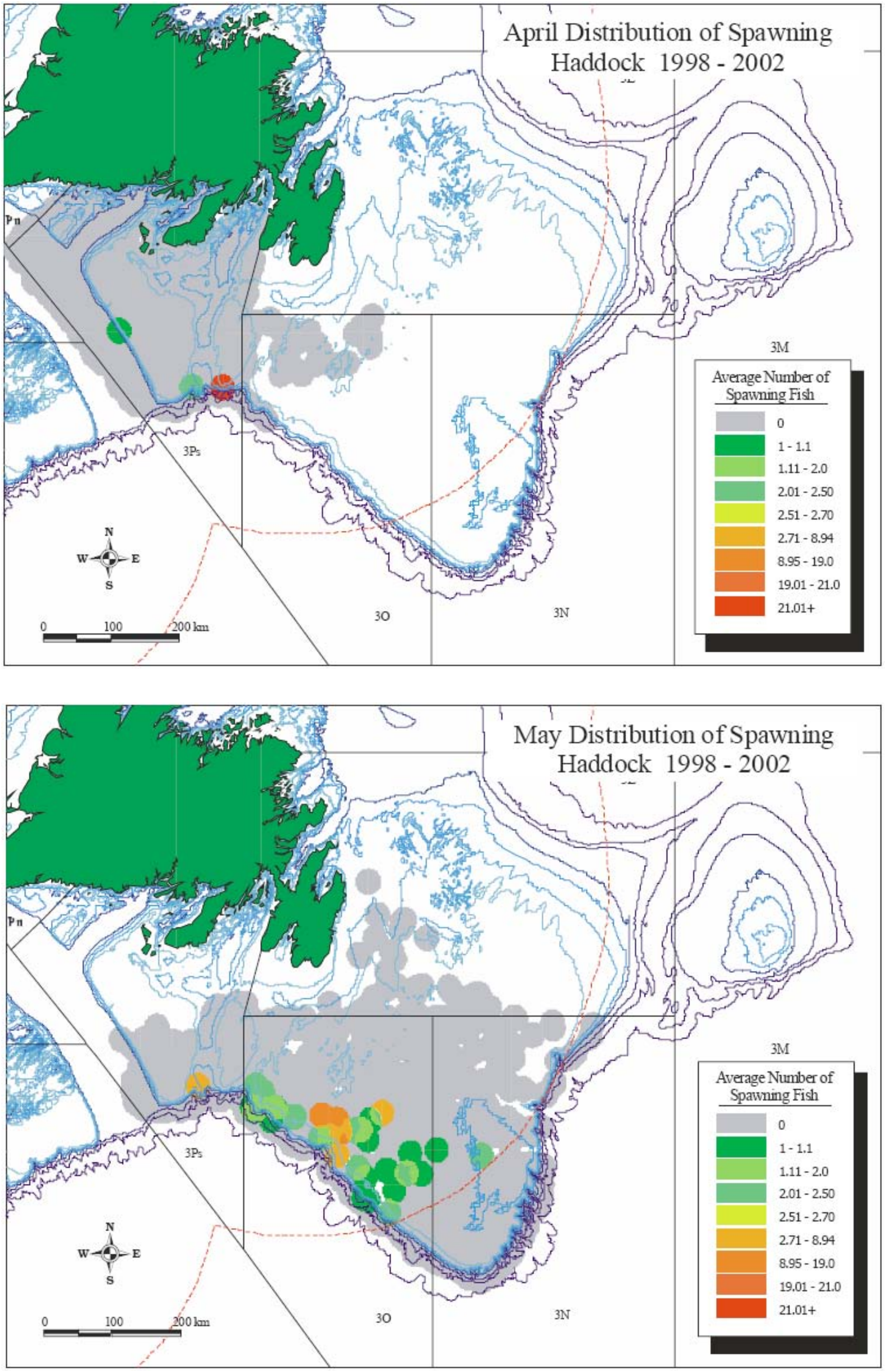
Figure 4.11 Distribution of Spawning Haddock from March to June, 1975 to 1997



Source: Ollerhead et al. 2004.

Note: The 0 class represents survey sets where no fish were caught.

Figure 4.12 Distribution of Spawning Haddock from April to May, 1998 to 2000



Source: Ollerhead et al. 2004.
Note: The 0 class represents survey sets where no fish were caught.