THE HAMILTON BANK-HAWKE CHANNEL REGION: POTENTIAL AS AN OFFSHORE MARINE PROTECTED AREA? A STUDY TO EXAMINE THE PHYSICAL, BIOLOGICAL, ECONOMIC, AND SOCIAL CHARACTERISTICS OF AN OFFSHORE FISHING AREA

THOMAS J. BROWN

0-612-54864-3

The Hamilton Bank-Hawke Channel Region: Potential as an Offshore Marine Protected Area?

A Study to Examine the Physical, Biological, Economic, and Social Characteristics of an Offshore Fishing Area

by

Thomas J. Brown (B. Sc. Honours)

A report submitted to the
School of Graduate Studies
in partial fulfillment of the
requirements for the degree of
Master of Marine Studies
(Fisheries Resource Management)

Memorial University of Newfoundland

August 1999

St. John's Newfoundland

Abstract

The Hamilton Bank-Hawke Channel area is one of the most productive offshore areas in the North Atlantic. This region exhibits outstanding oceanographic features, high primary production, and is important to marine mammals and sea birds. In the past, the region was ecologically vital to Atlantic cod, redfish and capelin and has supported very large commercial fisheries. Since the decline of these species, current commercial fisheries in the area are mainly for northern shrimp and snow crab. These fisheries are worth hundreds of millions of dollars to the harvesters, processors and residents of Newfoundland and Labrador. In addition to commercial species, the Hamilton Bank-Hawke Channel area also has a wide diversity of other fish fauna. The area has been described as 'the engine that drives the northern cod' (deYoung and Rose 1993) and hosts the only known current offshore spawning biomass of northern cod on the Newfoundland-Labrador Shelf (Rose 1999). The region, in the past has also been very important for capelin, which disappeared in the early 1990's. Capelin abundances however, have been increasing over the last several years (R. O'Driscoll 1999. Personal Communication. Fisheries Conservation Chair, Memorial University of Newfoundland). The diversity of fauna, high productivity and oceanographic characteristics make the Hamilton Bank-Hawke Channel unrivaled in terms of its overall impacts on the Newfoundland-Labrador marine ecosystem and as a commercial fishing area. For these reasons this offshore area has high potential to be considered as a Marine Protected Area via the legislation of the *Oceans Act* of the Department of Fisheries and Oceans.

Acknowledgements

I would like to thank my supervisor, Dr. George Rose for his aid and advice in the development and completion of this project. Thanks also go to Mr. Tim Anderson and Joan O'Brien at the Department of Fisheries and Oceans for providing funding which enabled me to complete this project and for providing advice along the way. Thanks to all of the scientists, members of industry, and government officials who were very co-operative during interviews and consultations and provided me with valuable information. To my parents, thanks for the encouragement, support, and of course, for giving me money when I had none.

Table of Contents

List of Tables

List of Figures

Page

Chapter I: Introduction

1.0 Introduction

The marine environment is extremely important from both natural and cultural perspectives. The ocean world supports a great diversity of flora, fauna and habitats and ecosystem services play an essential role in the climatic and chemical cycles critical to the maintenance of life on Earth. In addition, marine fisheries have been the staple of coastal communities for thousands of years, and today, are one of the major sources of world protein and coastal employment.

The oceans cover approximately 70% of the Earth's surface (Skinner and Porter 1995) and contain organisms representative of five Kingdoms and 32 of 33 known Phyla, with 15 of these exclusively marine (Agardy 1997). In the past, there was a delusion that we, as a society, could never destroy such an immense and diverse system. Unfortunately, we were wrong. Many of the World's coastal areas are now heavily polluted, marine habitats have been destroyed with rapid population growth and urban sprawl, and overfishing along with greater fishing technology has depleted the world's commercial fish stocks, reducing some to near extinction.

To date, very few nations have indicated that they recognize the need to develop and implement comprehensive conservation programs aimed at protecting marine ecosystems and the species they support. Even fewer countries have committed to realizing such goals. In most cases attempts to conserve marine biological diversity and habitat occur largely because of crises management needs (Agardy 1997). The Canadian situation has been no different (Fisheries and Oceans Canada 1999).

In recent years, growth in Canada's ocean sector and new developments in technology have resulted in increased pressures on the inshore and offshore ocean environments. This, along with various other causes, resulted in what was thought impossible, a collapse of the Northern cod stock and a drastic reduction of other commercial groundfish and pelagic species (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999). Added pollution of major seaways (i.e. St. Lawrence Seaway) by large urban centers has resulted in the deterioration of valuable freshwater and highly productive estuarine habitats. In many of these areas, the ecological integrity and biodiversity of complex ecosystems are currently in jeopardy (Fisheries and Oceans Canada 1999). The notion of unlimited marine resources is obsolete. The loss of thousands of jobs in Atlantic Canada as a result of the groundfish moratorium and the subsequent economic turmoil forced people and governments to consider what went wrong. It has become obvious that conventional approaches to fisheries and marine resource management have not been fully successful (Hannesson 1997).

It has been recognized that a new approach to marine resource management is needed, one that takes an ecosystem rather than a sectoral approach (Fisheries and Oceans Canada 1999). Sustainability of living ocean resources ultimately depends on productive ecosystems. Consequently, the Government of Canada began working with neighboring countries to address the concerns of the marine environment and have demonstrated a commitment to marine protection by endorsing conventions that pursue conservation and protection goals (Fisheries and Oceans Canada 1998).

It is equally important that the Government of Canada work with Canadians to manage activities in or effecting our marine environment. This vision of oceans management was manifested in the *Oceans Act*, which came into force in January of 1997. The *Oceans Act* confirms Canada's role with respect to oceans management by indicating the need to unite the management of marine conservation and development activities to maintain healthy ecosystems (Fisheries and Oceans Canada 1998). One of the ways in which the *Oceans* legislation suggests that we can better manage and regulate our marine resources is the development of Marine Protected Areas (MPAs) (Fisheries and Oceans 1997).

Marine Protected Areas have been in existence in other areas of the world for many years. In Canada, the MPAs came into existence in 1986 when Parks Canada released the "National Marine Parks Policy" (Billard 1998). The *Oceans Act* legislation was the next initiative that Canada undertook to further its involvement in marine conservation through the use of marine protected areas. The *Oceans Act* enables the Canadian Government to establish a "national system of marine protected areas" and to make regulations that allow marine protected areas to be designated, zoned, and closed to certain activities (Fisheries and Oceans Canada 1997).

1.1 What are Marine Protected Areas?

Marine Protected Areas (MPA) have been defined in a number of ways. The International Union for the Conservation of Nature (IUCN) defines an MPA as: " Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part, or all of the enclosed environment." (Kelleher and Kenchington 1992).

More to the purpose of this report, a Marine Protected Area will be defined in a Canadian context. Canada's *Oceans Act* (section 35 (1)) states: "that a Marine Protected Area is an area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada; and has been designated under this section for special protection for one or more of the following purposes:

1) conservation and protection of commercial and non-commercial fisheries resources, including marine mammals and their habitats;
2) conservation and protection of endangered or threatened marine species, and their habitats;
3) conservation and protection of unique habitats;
4) conservation and protection of marine areas of high biodiversity or biological productivity;
5) conservation and protection of any other marine resource or habitat as is necessary to fulfill the mandate of the Minister of Fisheries and Oceans." (Fisheries and Oceans Canada 1997; Fisheries and Oceans Canada 1999).

1. 2 Offshore Marine Protected Areas

Most of the 1000 or so MPAs established around the world are inshore areas that are set aside for their aesthetic value or for reasons such as eco-tourism. The numbers of offshore marine protected areas designated around the word are limited, and in Canadian context to date, are non-existent. However, several areas are being considered, and are currently defined as pilot projects: these include Race Rocks, Bowie Seamount Area, the Sable Gully, Gabriola Passage, and the Endeavour Hot Vents Area (Taken from: www.oceansconservation.com). None of these areas are within the Newfoundland ecosystem region of the Northwest Atlantic (Harper *et al.* 1993).

The banks on the continental shelf of the northwest Atlantic (Figure 1) are, in general, regions of high productivity and biodiversity, and comprise the spawning and feeding areas for numerous species of fish and shellfish. Because of the high productivity of these areas, they have been, and still are, targets for heavy local and foreign commercial fishing activity. These commercial activities, in addition to the local effects on the fishing grounds, may have had detrimental effects over broader areas as a consequence of the export of young fish and migration of adults. These activities have likely impacted inshore fisheries and the marine ecosystem. The protection of key regions of the continental shelf could have a greater influence on the overall health and productivity of marine ecosystems and commercial fishery yields than the protection of inshore areas.

Continental shelf banks such as Hamilton Bank, Funk Island Bank, and the Grand Banks (Figure 1) are not in direct contact with coastal communities. A limited number of fishermen (vessels >35 feet) fish these areas and in most cases do not have any direct community adjacency claims to them. It therefore seems logical to try to establish MPAs, at least from the Newfoundland context, on the continental shelf away from direct community pressures.

The establishment, and success, of an initial offshore MPA may influence public opinion regarding the MPA program and instigate the establishment of a system of MPAs stretching across the full reach of the Canadian northwest Atlantic from Nunavut to Nova Scotia.

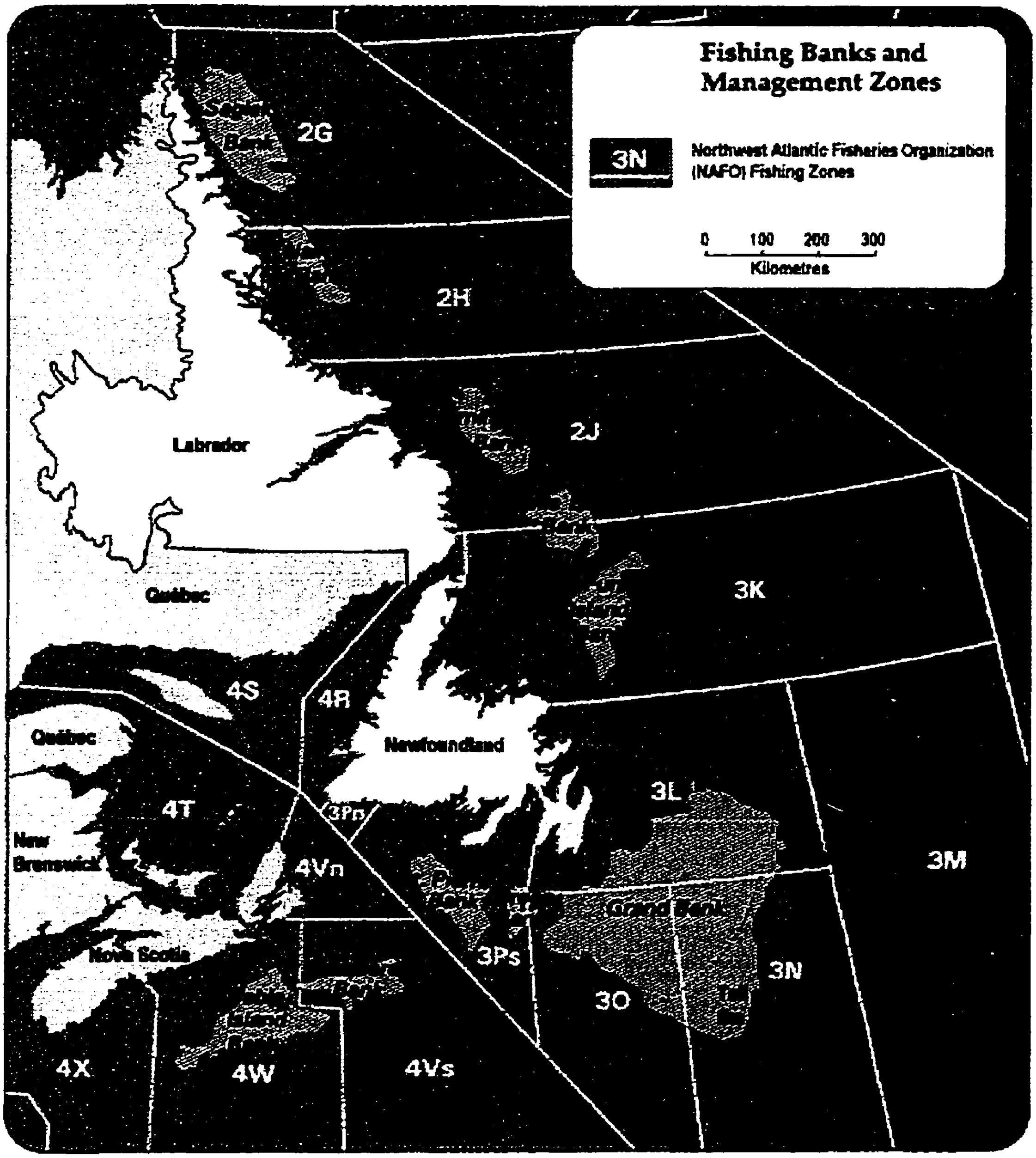


Figure 1: NAFO divisions of the Northwest Atlantic and offshore banks (From: http://www.dfo-mpo.gc.ca)

1. 3 Area of Study

The Hamilton Inlet Bank-Hawke Channel Area

The Hamilton Inlet Bank (hereafter: the Hamilton Bank-Hawke Channel area), comprises a part of NAFO division 2J (Figure 2) and is part of the Northwest Atlantic ecoregion according to the marine ecosystem classification for Canada (Harper *et al.* 1993). In the past this area has been a major commercial fishing area for groundfish species such as redfish (*Sebastes spp.*), Atlantic cod (*Gadus morhua)*, and capelin (*Mallotus villosus*) and presently for shrimp (*Pandalus borealis)* and snow crab *(Chionoectes opilio)*. This area has high productivity and special characteristics that make it an important area in terms of overall impact on the marine ecosystem and as a commercial fishing area.

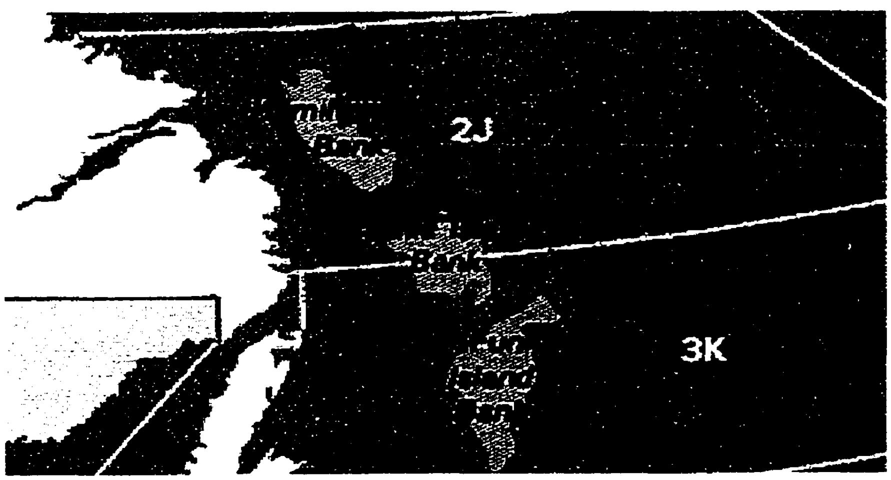


Figure 2: Selected area of study (black outline) which includes the Hamilton Bank and the Hawke Channel. From: http://www.dfo-mpo.gc.ca.

1. 4 Research Goals

The primary goal of this study is to provide a synthesis of existing information on the Hamilton Bank-Hawke Channel area (Figure 2), with emphasis on environmental and ecological status, physical oceanographic and bathymetric characteristics, commercial fisheries, and social and economic characteristics. The information has come from the historical and contemporary literature, and the views of contemporary managers, scientists, and industry. The intent of this synthesis is to enable a detailed evaluation of the Hamilton Bank-Hawke Channel area and its importance with respect to the northwest Atlantic ecosystem and as a fishing area. The synthesis is also intended to provide baseline data and a basis to judge the potential of this region for designation as a Marine Protected Area, as provided under the *Oceans* Act (Section 35 (1)) (Found in: Fisheries and Oceans Canada 1997; Fisheries and Oceans Canada 1999).

1. 5 Research Method

Existing literature on the Hamilton Inlet Bank-Hawke Channel area (NAFO Division 2J) was obtained from scientific journals, NAFO (North Atlantic Fisheries Organization), ICES (International Council for the Exploration of the Sea) and DFO (Department of Fisheries and Oceans) scientific reports. Consultations were carried out with representatives of the Department of Fisheries and Oceans, the Newfoundland Department of Fisheries and Aquaculture and Memorial University of Newfoundland, SABRI (St. Anthony Basin Resources), FANL (Fisheries Association of Newfoundland and Labrador), FPI (Fishery Products International) and Daley Brothers Fisheries.

Chapter II: Physical Characteristics

2.0 Geology, Bathymetry, Topography, and Sediments

The Hamilton Bank consists of a thick wedge of Mesozoic and Cenozoic sediments that overlays a block-faulted, subsiding Precambrian crystalline basement. Subsidence occurred in response to the forces that had caused the opening of the Labrador Sea and the separation of Greenland and North America. The present relief was formed through alternating phases of valley erosion and of deposition corresponding to periods of high and low sea levels related to periodic glaciation (van der Linden *et al.* 1976).

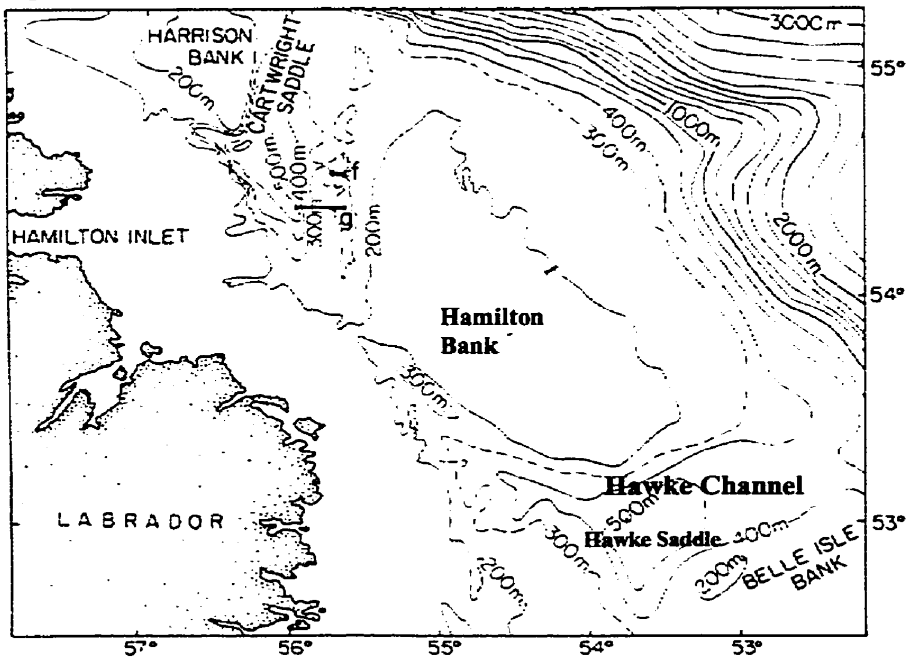


Figure 3: Bathymetric map of the Hamilton Inlet Bank region showing major physiographic features (From: van der Linden *et al.* 1976). Note: the **f** and **g** located between the Hamilton Bank and the Cartwright Saddle are not relevant to this discussion and should be ignored.

The bathymetric characteristics of the Hamilton Bank area are depicted in Figure 3. The Hamilton Bank has an average depth of 200 m on its southern edge. The Hawke

Channel occurs immediately south of the Hamilton Bank and extends from the shelf break to the nearshore region. The channel reaches maximum depths of 500 m (Figure 3). To the south of the channel is the northern limit of the Belle Isle Bank, where depths are comparable to those of the Hamilton Bank.

The topography of Hamilton Bank (Figure 4) consists of kames, which can be recognized by their relatively smooth flat tops, consistent depths, and some evidence of disruption by ice contact near the margins. Kettles appear as circular depressions up to 3 km in diameter and 10 m deep. End moraines 12 m high, subglacial meltwater channels 12 m deep, and lateral moraines up to 45 m high have been identified (Petro-Canada 1982).

The surficial sediment map of the Hamilton Bank is shown in Figure 5. Gravelly sand rims the eastern bank margin, although the margin is bordered in places by an accumulation of pebble to boulder size material partially covered by a thin veneer of sand. The western bank margin is similar, but with less lag material (material such as boulders, cobbles, and pebbles left behind after smaller sediments have been removed) present. Covering the remaining surface there are sandy and silty sediments between 1-10 m thick. The modal grain size decreases towards the center of Hamilton Bank, where it reaches a minimum of 0.031 mm. The central area shows little evidence of current scouring or bed load movement and heavy bioturbation is evident in the area (Petro-Canada 1982). The Hawke Channel area has a surficial sediment makeup similar to that of the Hamilton Bank, although there seems to be a greater proportion of sand veneer on the Hawke Saddle (Figure 4).

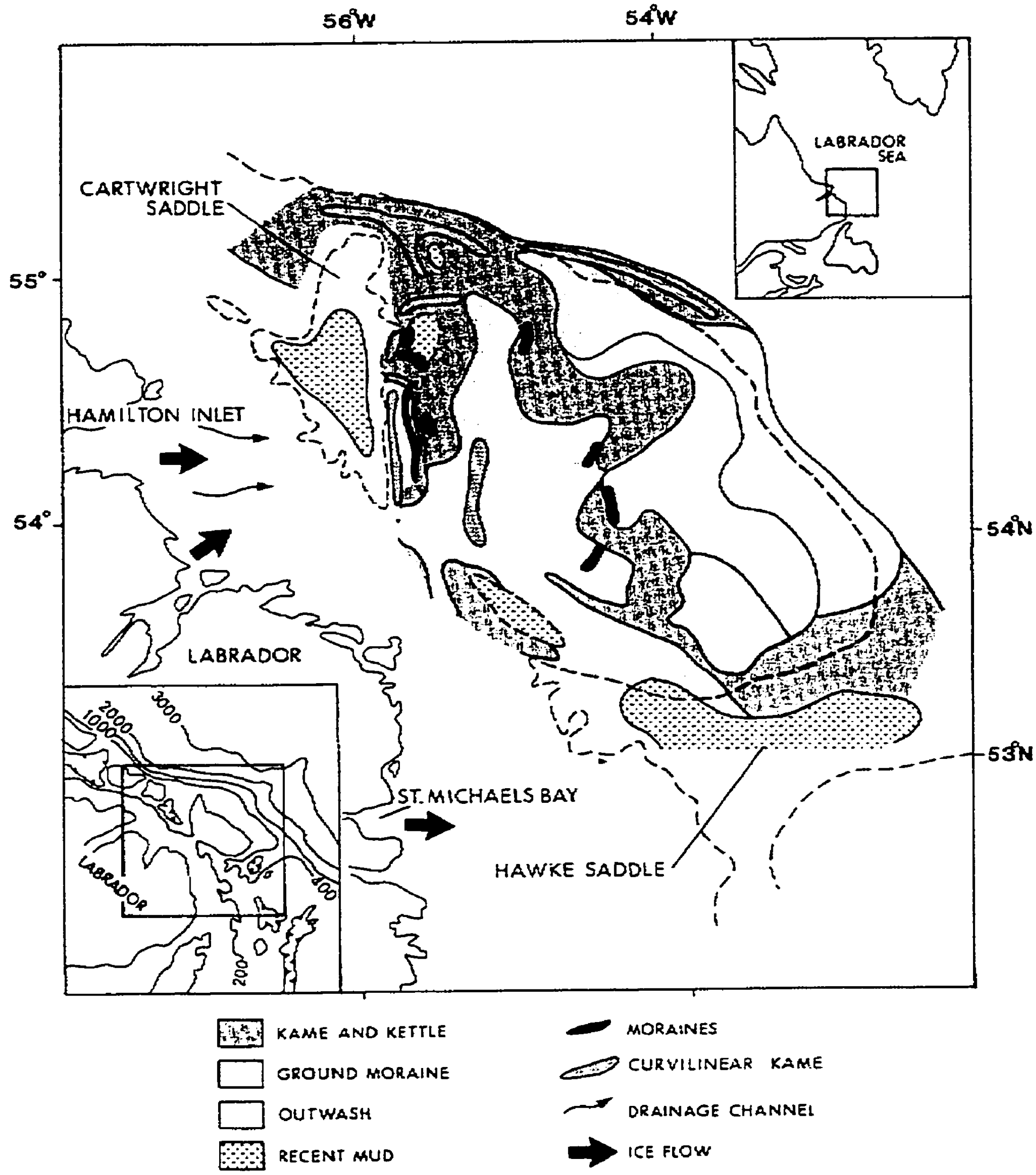


Figure 4: Physiography and surficial geology of Hamilton Bank (After Petro-Canada 1982).

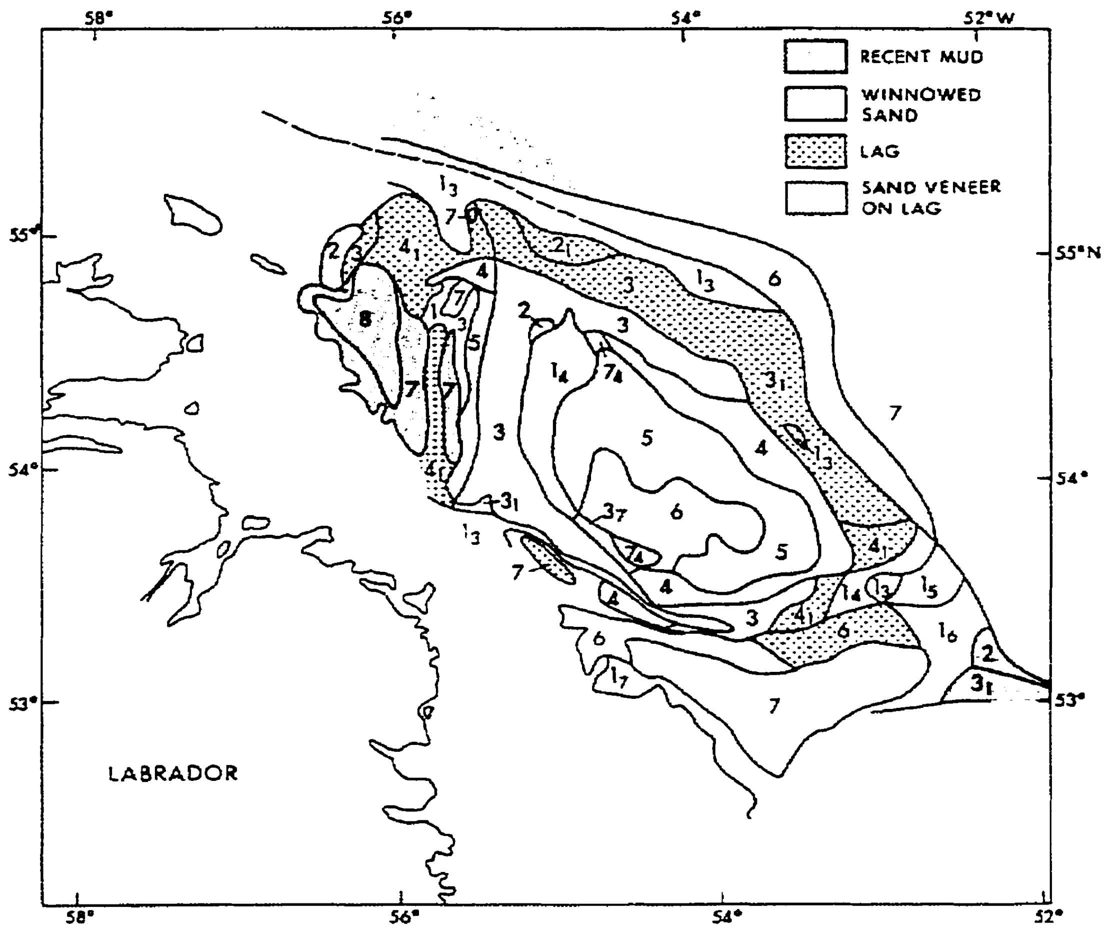


Figure 5: Surficial sediment map of Hamilton Bank-Hawke Channel Area (After Petro-Canada 1982).

2.1 Oceanography

The oceanography of the Labrador Shelf area is dominated by the Labrador Current, which flows south along the Labrador coast to the Grand Banks and beyond (Figure 6). The current consists of two dominant streams: the outer which lies over the continental slope and an inner stream which covers the Labrador Shelf. The outer stream is formed from the West Greenland Current and closely follows bathymetric contours south. In spring the surface waters of this outer stream have a mean temperature of $-1\ ^0C$

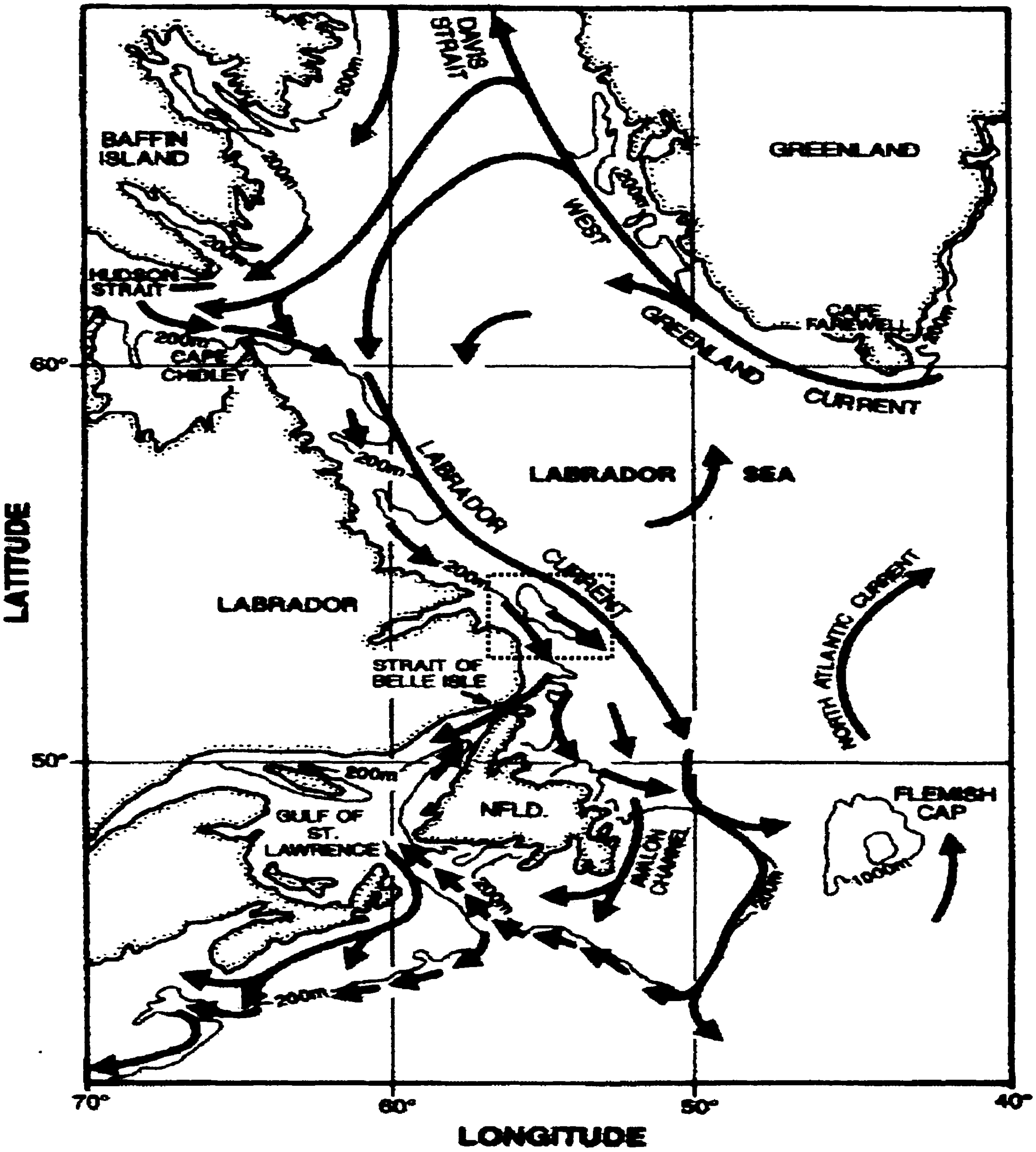


Figure 6: Chart of ocean currents of eastern Canada (After: Colbourne *et al.*1997). The Hamilton Bank-Hawke Channel region is outlined by the dotted line.

and a salinity of 33 ppt. At depths of 300-400 m temperatures typically range from 2–4 ^{0}C, and salinities are near 34.5 ppt. This branch of the Labrador Current has surface speeds of 0.3-0.4 m/sec and an estimated transport of 4 Sv (1 Sv = 10^6 m^3/sec or 10^9 kg/sec) (Drinkwater and Harding 1995).

The inshore stream consists of polar water with additions of fresh-water from land runoff in Hudson Bay, Ungava Bay and along the Labrador coast. Early Spring temperatures are less than –1 ^{0}C throughout the water column and salinities range from 32-33 ppt. This branch of the Labrador Current has surface current velocities of 0.15-0.25 m/s and an estimated transport of 0.8 Sv (Drinkwater and Harding 1995). The surface waters of both the near and outer streams are warmed during the summer and reach temperatures of 4-6 ^{0}C in early fall after which they begin to cool (Scott and Scott 1988).

Both the inside and outside streams of the Labrador Current are in contact with the Hamilton Bank. The deeper waters of the Hawke Channel may not be effected as much by either of the two streams. However, it has been noted by Drinkwater and Harding (1995) that the outer current has been known to intrude onto the shelf through trenches, such as the Hawke Saddle (Figure 3).

2. 2 Temperature and Salinity Profiles

The temperature and salinity characteristics of the Labrador shelf originate in the Hudson Strait. They are formed from a mixture of cold Baffin Land Current waters flowing southward, warm waters of the west Greenland Current and low salinity waters flowing out of Hudson Bay and the Foxe Basin. These water masses converge at the eastern entrance to the Hudson Strait where tidal currents cause vertical mixing. Residual

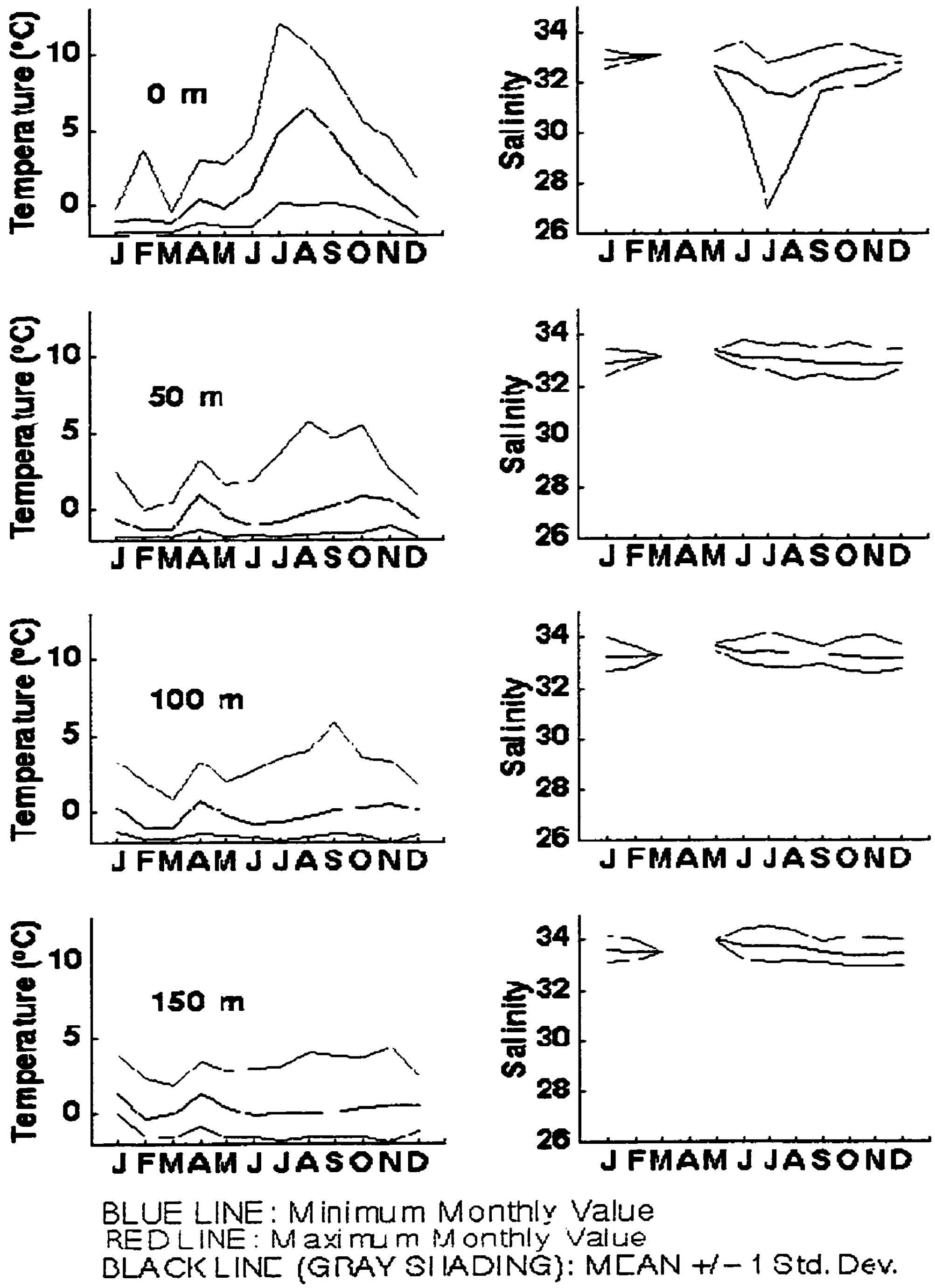


Figure 7: Temperature and salinity profiles from Hamilton Bank (0-150m). Taken from http://dfomr.dfo.ca/science/ocean/labrador/labrador_hydro.html. Note: Statistics are composites for all years that data was available (D. Gregory, Bedford Institute of Oceanography, Dartmouth, N. S., personal communication, 1999)

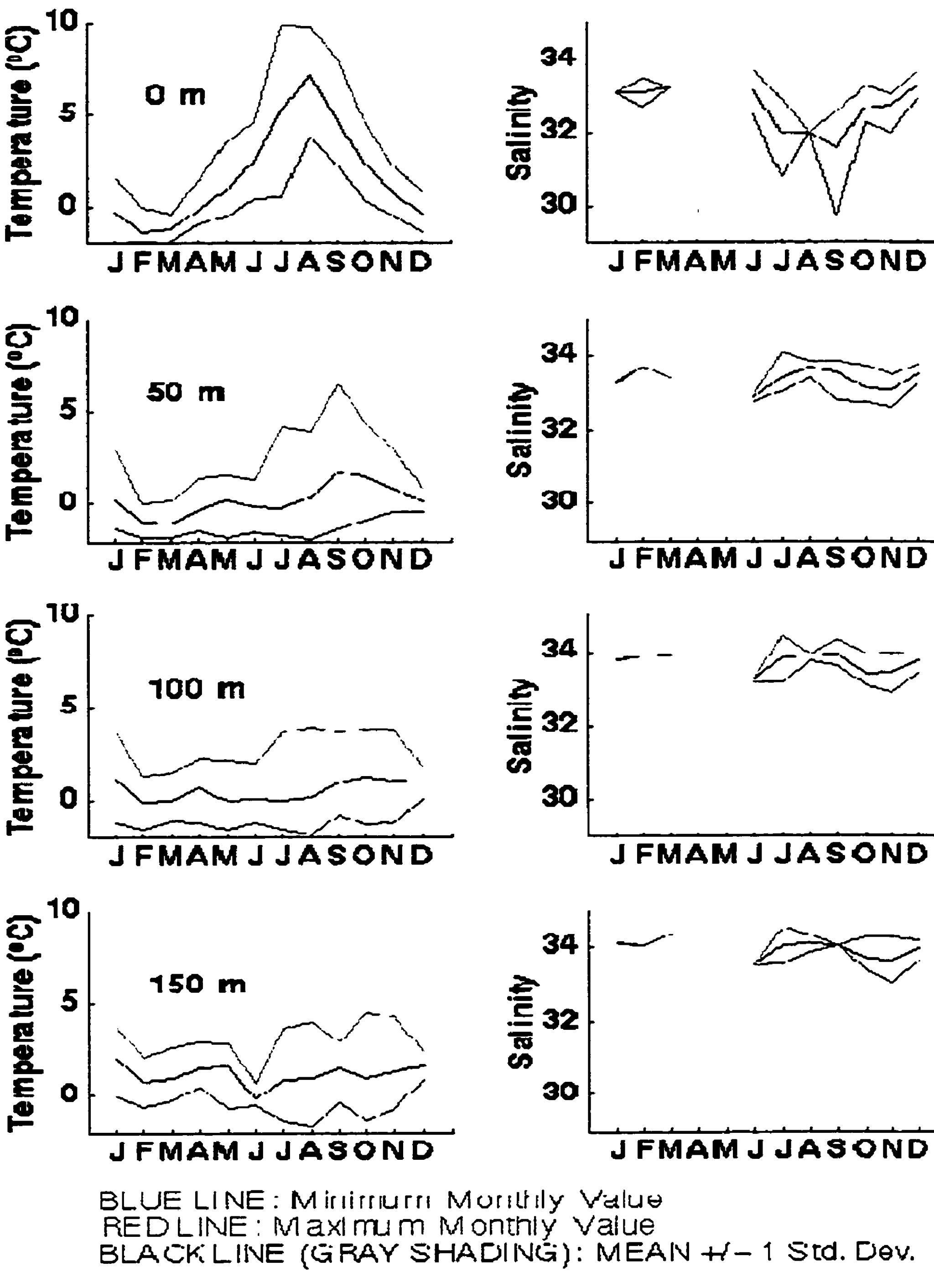


Figure 8: Temperature and salinity Profiles from the Hawke Channel (0-150m). Taken from http://dfomr.dfo.ca/science /ocean/labrador/labrador_hydro.html. Note: Statistics are composites for all years that data was available (D. Gregory, Bedford Institute of Oceanography, Dartmouth, N. S., personal communication, 1999)

currents then carry this mixture onto the Labrador Shelf (Drinkwater and Harding 1995).

The data presented above in figures 7 & 8 are a composite of all years. Data are initially averaged within the appropriate year/month, and then averaged over all years that sampling has been done in the area. In this way, a heavily sampled year does not dominate the overall statistics (D. Gregory, Bedford Institute of Oceanography, Dartmouth, N. S., personal communication, 1999).

2. 3 Nutrients

As mentioned in section 2.2, in the Hudson Strait there is a convergence of cold Baffin Land Current waters, warm waters of the west Greenland Current and low salinity waters flowing out of Hudson Bay and the Foxe Basin. The intense mixing results in a reduction in temperature range, salinity and stratification on the Labrador Shelf. This mixing also increases the surface nutrient concentrations on the northern Labrador shelf (Drinkwater and Harding 1995). Sutcliffe *et al.* (1983) (Found in: Drinkwater and Harding 1995) hypothesized that increased primary production on the northern shelf supports a "conveyor belt" food chain as the community is transported south by the Labrador Current. This was proposed to account for the greater abundance of fish on the southern Labrador Shelf (i.e. Hamilton Bank region). This was partially supported by Drinkwater and Harding (1995), however, they believed that the high fish production on the southern Labrador Shelf was related to upwelling processes near the Hamilton Bank. This process is however, very poorly documented.

Nitrates are generally considered to be the limiting nutrient to primary production during the summer in northern waters. Nitrate maxima occur along the continental slope off southeastern Nain Bank and Hamilton Bank, and in the marginal trough inshore of Hamilton Bank. These maxima are believed to be a result of the aforementioned local upwelling. The distribution patterns of silicate and phosphate are similar to those of the nitrates and have similar sources (Drinkwater and Harding 1995).

There is limited information available on nutrient sources and concentrations in the Hamilton Bank-Hawke Channel area and further research is needed.

2. 4 Ice Characteristics

The sea ice characteristics of the Hamilton Bank-Hawke Channel region are variable from year to year (Drinkwater *et al.* 1999; Drinkwater 1994). However a general seasonal pattern can be described. In late December the majority of sea ice is positioned off the southern coast of Labrador in the vicinity of the Hamilton Inlet (see figure 3 for location of Hamilton Inlet) (Figure 9a). The extent of the ice field offshore is variable at this time of year, however, median values of data from 1962-1987 indicate that the Hamilton Bank-Hawke Channel region is typically covered by sea ice by January. The ice flow then gradually spreads southward to northeastern Newfoundland waters by mid-March (Figure 9a). By April the sea ice begins to retreat northward and by June or July it is nonexistent in the Hamilton Bank-Hawke Channel Area (Figure 9b) (Drinkwater *et al.* 1999).

Ice coverage in the Hamilton Bank-Hawke Channel area may be a hindrance to research surveys and may effect distributions of surface dwelling organisms such as seals whales, and sea birds. In addition, prolonged ice coverage may prevent adequate light penetration and may result in temporal shifts in primary productivity (Skinner and Porter 1995).

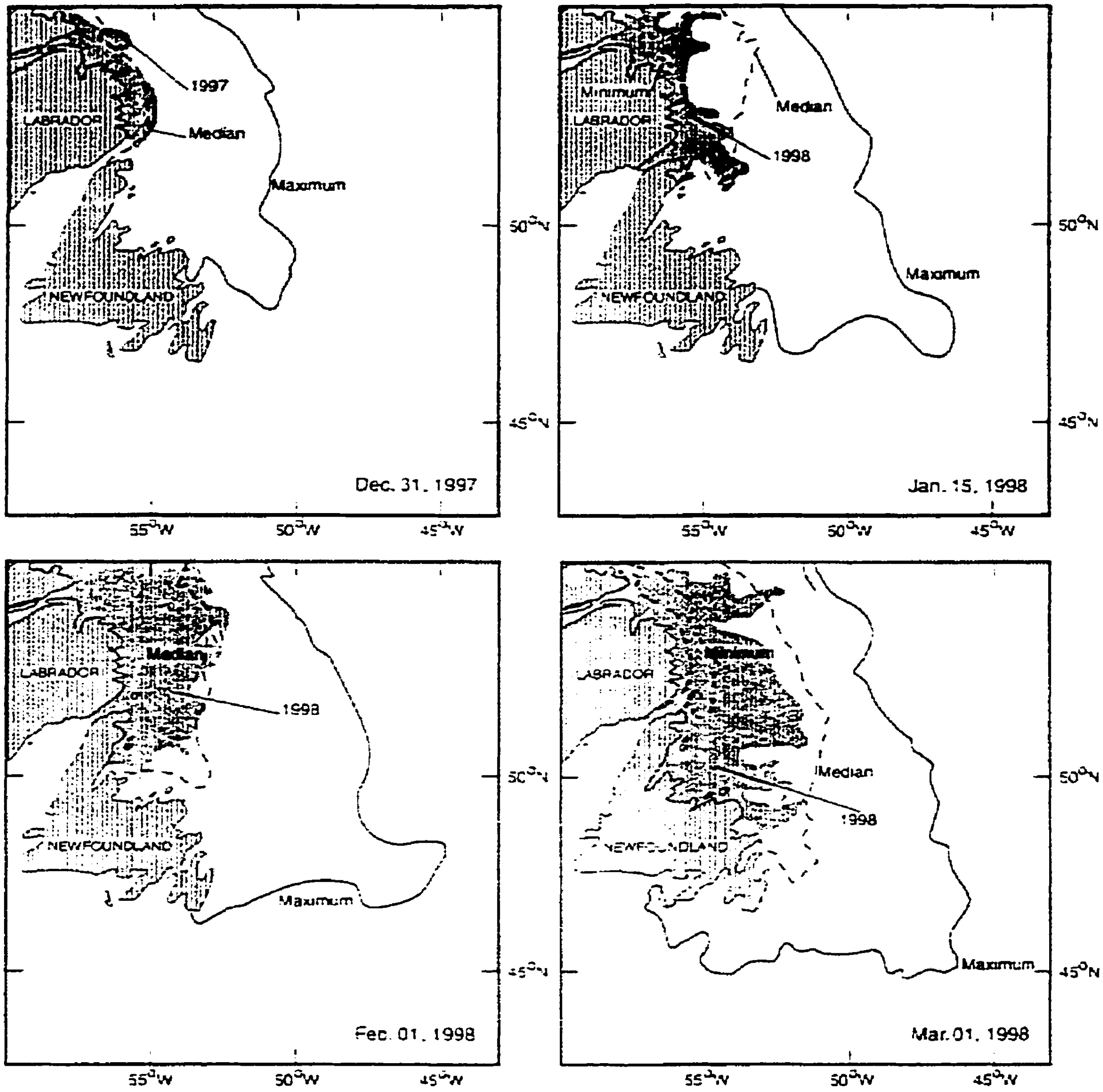


Figure 9a: The location of ice (shaded area) between Dec 1997 and March 1998 together with the historical (1962-1987) minimum, median, and maximum positions of the ice edge off Newfoundland and Labrador. After: Drinkwater *et al.* 1999.

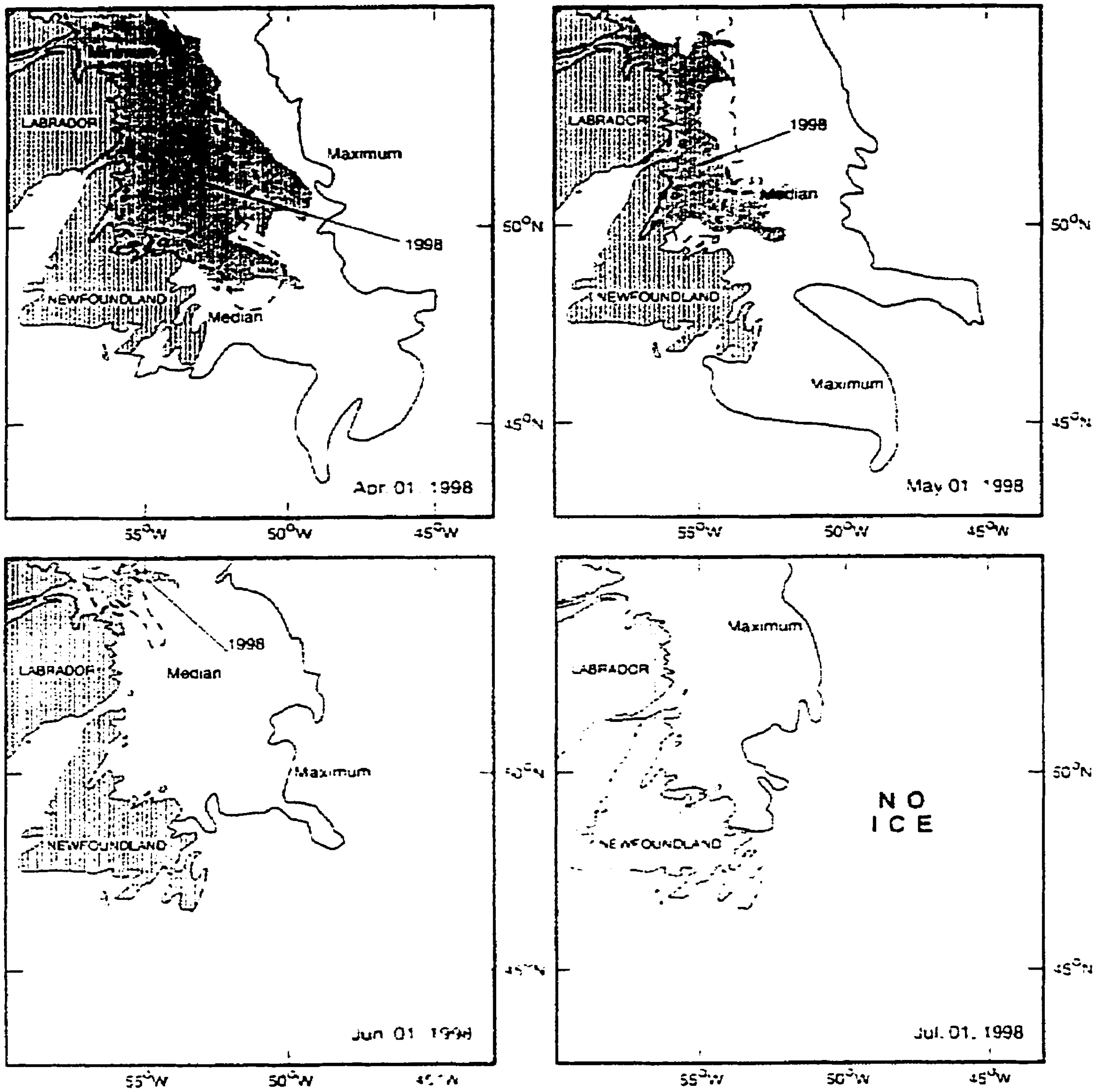


Figure 9b: The location of ice (shaded area) between April and July 1998 together with the historical (1962-1987) minimum, median, and maximum positions of the ice edge off Newfoundland and Labrador. After: Drinkwater *et al.* 1999.

2. 5 Summary

This chapter examined the physical characteristics of the Hamilton Bank-Hawke Channel region. It is relevant to study the physical characteristics such as geology, bathymetry, sediments, and currents that make up such a region in order to better understand its biological attributes.

The physical characteristics of the Hamilton Bank-Hawke Channel region are somewhat unique. The Hamilton Bank has a mean depth of 200 m and is surrounded by deep channels (500 m in depth) on its north and south ends along with deeper water (300 m in depth) on its western side. The areas of deeper water could provide a very good source of nutrients during localized upwelling processes (Section 2.3). In addition, the differences in depth provide a wide range of habitats for different species.

The physiography and superficial geology of the Hamilton Bank-Hawke Channel area cannot be considered unique since data is not available on similar areas (Belle Isle Bank, Funk Island bank, etc.). However the Hamilton Bank has a variety of surface features (Figure 4) and sediment distributions (Figure 5) that may provide suitable habitats for a wide range of organisms.

The oceanography of the area is dominated by the Labrador current which carries nutrient rich waters from Northern areas and plays an important role in temperature, salinity and stratification characteristics. The combination localized upwelling and nutrient transport via the Labrador Current provides a unique environment for a highly productive ecosystem.

Ice characteristics of the area may influence the distribution of marine organisms and may create difficulties in conducting scientific studies from late-Dec to early-May, however conditions are highly variable from year to year. The ice characteristics of the area are not unique since ice flows effect the majority of the Labrador Shelf and parts of the northeast coast of Newfoundland.

Further research is needed to update the information presented in this chapter. Additional studies of nutrient availability, current profiles, the effects of sea ice and especially upwelling features are required before conclusions about the uniqueness of the physical characteristics of this area can be presented.

Chapter III: Primary Production, Zooplankton and Benthos

3.0 Phytoplankton

Phytoplankton production in northern latitudes depends on light and nutrients. Productivity is therefore lowest during winter, increases to a maximum during spring and summer, and decreases in the late fall. The dominant phytoplanktons in the Labrador Sea are diatoms, microflagellates, and chrysophytes (Petro-Canada 1982). Figure 10 shows the levels of phytoplankton production in the Labrador Sea.

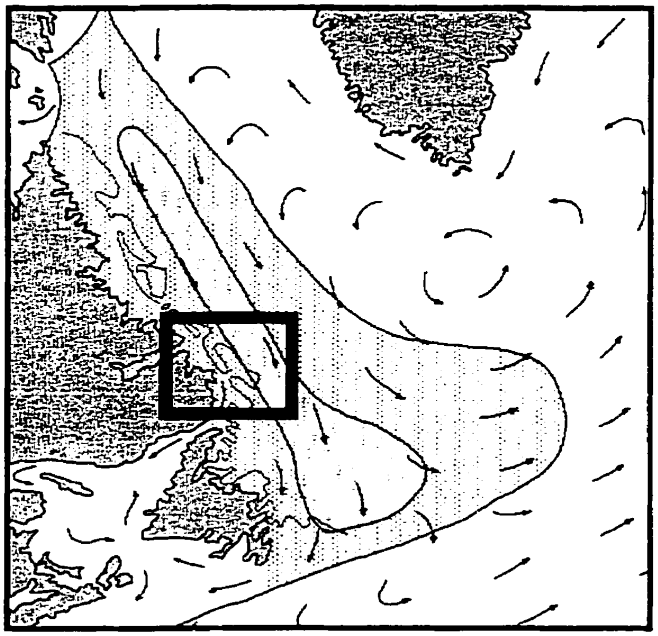


Figure 10: Annual levels of phytoplankton production in the Labrador Sea. The study area is outlined in black The darker area represents production greater than 500 mg C/m^2/day whereas the lighter area represents production equal to 500 mg C/m^2/day (After Petro-Canada 1982).

The spring phytoplankton bloom begins late April to early May, and reaches a maximum in June, when phytoplankton numbers are greatest in the upper 25 m of the water column (Petro-Canada 1982). A smaller, secondary peak occurs in October.

Phytoplankton densities decline to their lowest values in November-April. Figure 11 demonstrates the average changes in primary productivity of the Newfoundland -Labrador region through the use of satellite imagery.

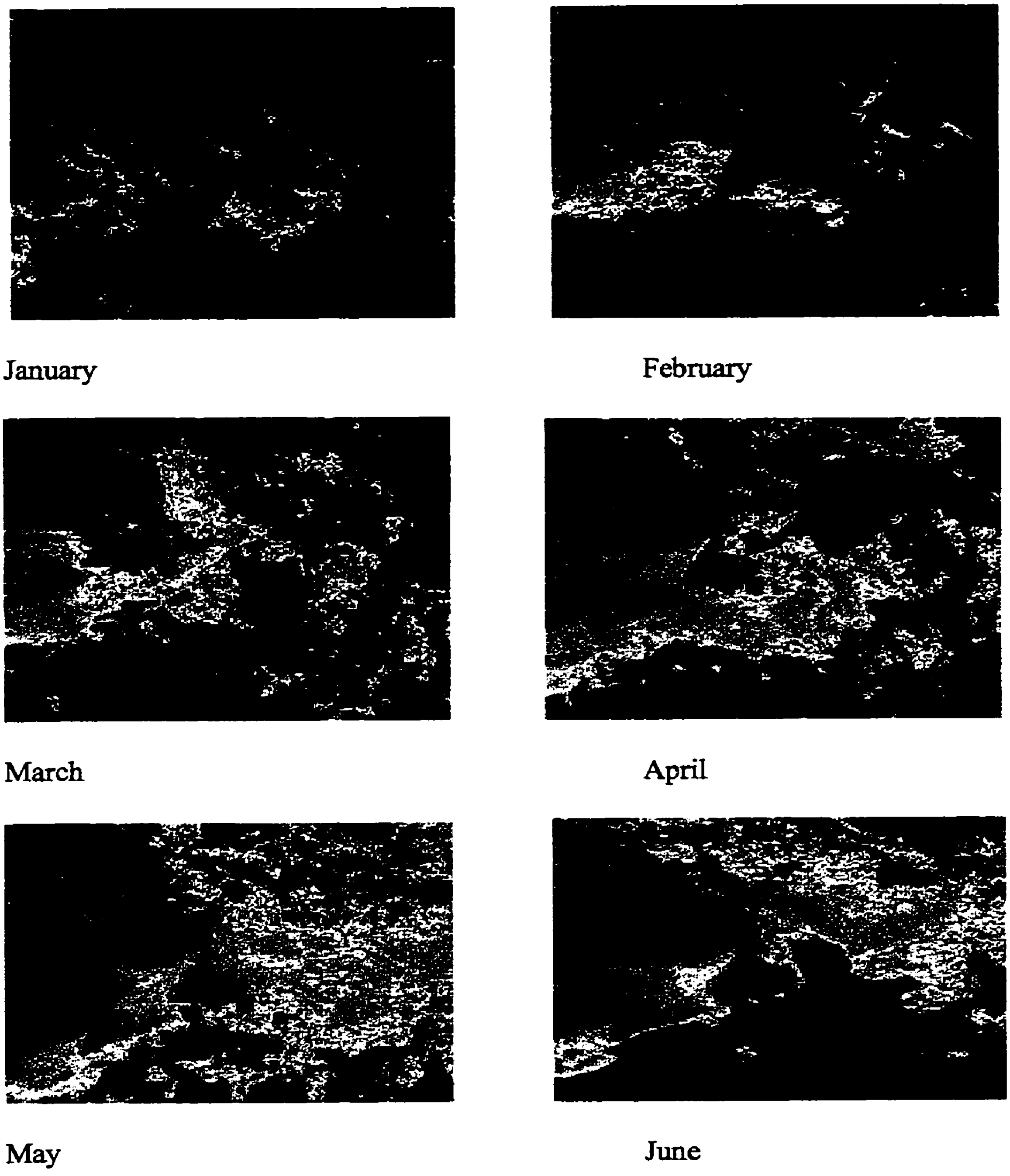
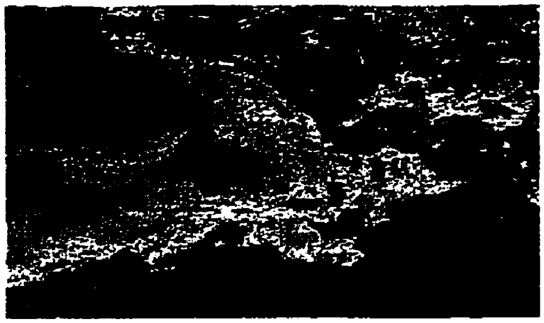


Figure 11: Composite monthly satellite images of primary production in the Newfoundland-Labrador Region. From http://daac.gsfc.nasa.gov /WORKINPROGRESS/OCDST/ocdst_north_atlantic_productivity.html.

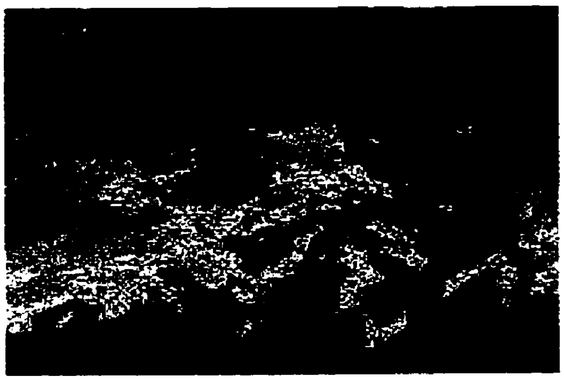
July

August

September



October



November

December

<u>Figure 11 Cont'd:</u> Composite monthly satellite images of primary production in the Newfoundland-Labrador Region. From http://daac.gsfc.nasa.gov /WORKINPROGRESS/OCDST/ocdst_north_atlantic_productivity.html.

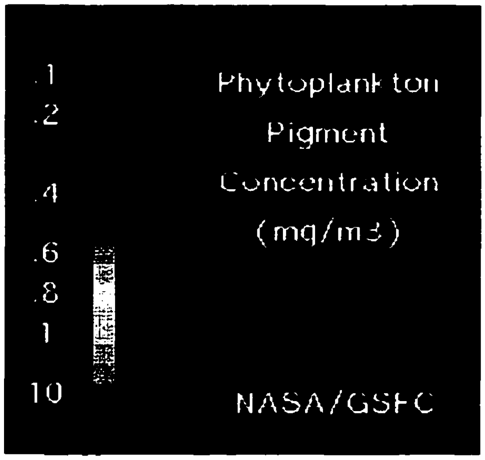


Figure 12: Colour bar which relates to phytoplankton pigment concentration (mg/m^3). From http://daac.gsfc.nasa.gov/WORKINPROGRESS/OCDST/ocdst_north_atlantic_productivity.html.

In examining Figure 11 it is apparent that primary production in the Hamilton Bank-Hawke Channel region is higher than in most areas of the northwest Atlantic (see Figure 2 for reference location) (Figure 13). Production exceeds 10 mg/m^3 in May, June, and October and remains above 0.4 mg/m^3 (see Figure 12 for colour-chlorophyll reference bar) in most other months excluding the winter. It must be recognized however, that these images are composite, and contain data over a number of years. These data are statistically weighted to make all years equal to give an overview of the primary production characteristics of the area (Taken From http://daac.gsfc.nasa.gov/ WORKINPROGRESS /OCDST/ocdst_north_atlantic_productivity.html).

Drinkwater and Harding (1995) have suggested that there is a second phytoplankton biomass that occurs in the Hamilton Bank area. This bloom occurs at 30-50 m depth along the edge of the bank and appears to be situated in a region of upwelling. This additional bloom does not show up on the CZCS (Coastal Zone Color Scanner) satellite images (Figures 11 and 13) as the water depth is too deep for the CZCS sensor.

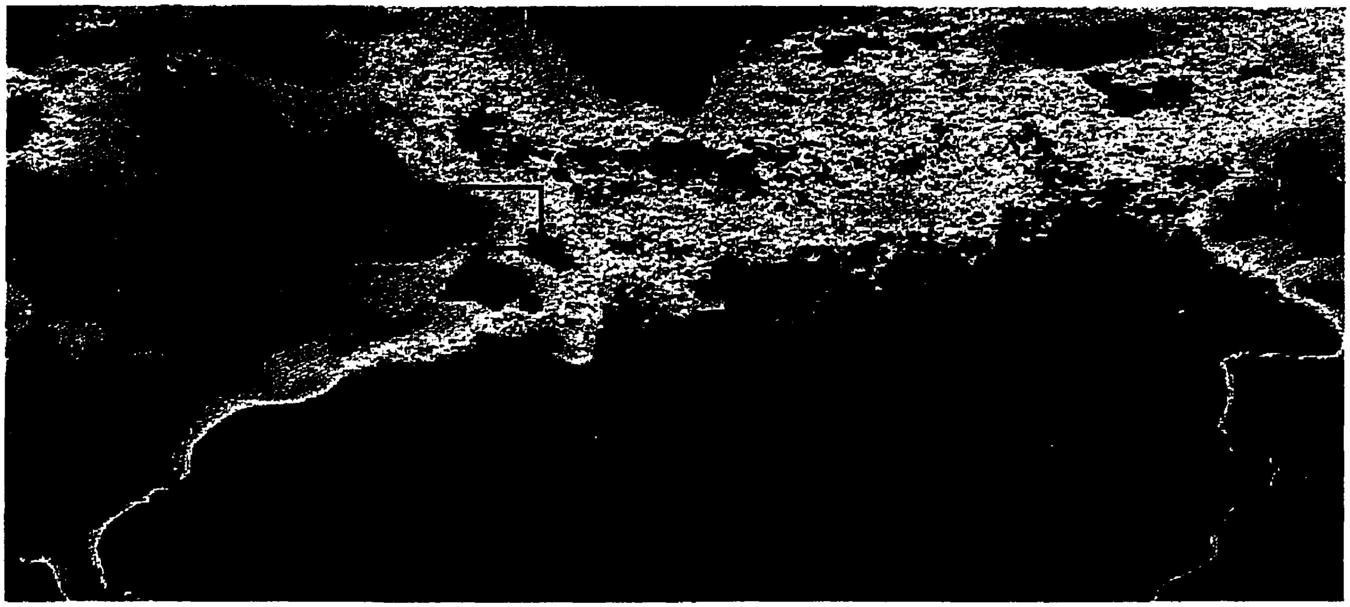


Figure 13: Satellite image that displays the composite of all Nimbus-7 Coastal Zone Color Scanner (CZCS) data acquired between November 1978 and June 1986. Approximately 66,000 individual 2 minutes scenes were processed to produce this image. To see the colorscale that relates screen colors to chlorophyll see Figure 12. The study area is highlighted by the black square. From: http://daac.gsfc.nasa.gov/WORKINPROGRESS/ OCDST/ocdst_north_atlantic_ productivity.html.

3.1 Zooplankton

Zooplankton may be herbivorous or carnivorous, holoplanktonic (life cycle is entirely planktonic) or meroplanktonic (only part of life cycle is planktonic). The dominant zooplankton in the Labrador offshore region are holoplanktonic. Zooplankton are of special interest in the marine production cycle as they provide a large proportion of the grazing animals that feed on phytoplankton and are consequently very important in trophic level interactions with higher order organisms.

The dominant zooplankton species in the Labrador Sea and in the Hamilton Bank-Hawke Channel area is the copepod *Calanus finmarchicus,* which may comprise up to 80% of the zooplankton community. Typically, it is most abundant in early summer, and has a secondary peak in late summer. The population then decreases in late fall and winter (Buchanan and Brown 1981).

Other species of zooplankton which are found in the Hamilton Bank-Hawke Channel area include: Cnidarians such as *Aglantha digitale,* Ctenophorans such as *Pleurobrachia pilus* and *Beroe cucumis,* Pteropodans such as *Limacina helicina* and *Limacina retroversa,* Amphipods such as *Parathemisto libellulua,* Euphausids such as *Thysanoessa inermis* and *Thysanoessa raschii*, Decapod larvae of *P. borealis* and *Pandalus montagui*, Chaetognaths such as *Sagitta elegans* and *Eukrohnia hamata*, Larvaceans such as *Fritillaria borealis* and *Oikopleura vanhoeffeni*, and Copepods such as *Pseudocalanus minutes*, *Calanus hyperboreus*, and *Calanus glacialis* (Buchanan and Brown 1981).

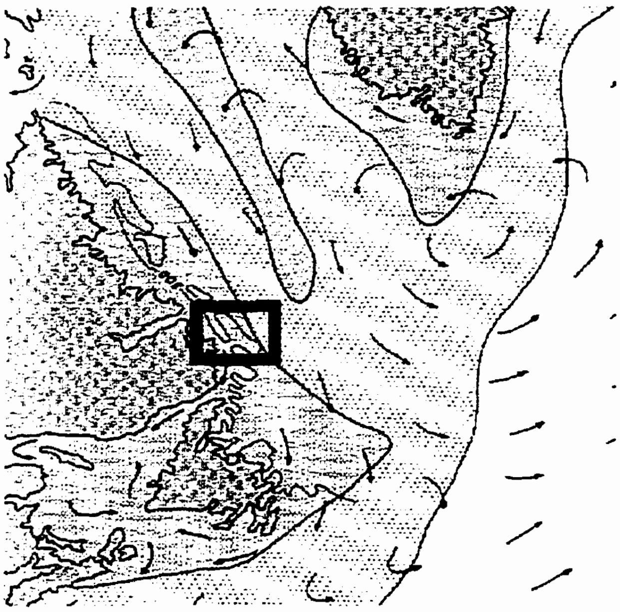


Figure 14: Average annual zooplankton production in the Labrador Sea. The dark grey colour represents areas with zooplankton production over 500 mg/m^3, the lighter grey colour represents zooplankton production equal to 201- 500 mg/m^3 (after: Petro-Canada 1982).

Figure 14 shows the annual zooplankton production in the Labrador Sea. The Hamilton Bank-Hawke Channel area is shown to have a production rate of greater than 500 mg/m^3/year.

3.2 Benthos

Benthic animals live on, in, or just above the sea bottom. They are diverse in their habitats and behavior, and in some cases their presence may modify the environment so that new habitats become available to other species.

Benthic animals may be classified into three broad categories. Infaunal animals live on or buried in soft substrates: these include bivalves, polychaetes, some amphipods, sipunculids, ophiuroids, and some gastropods. Sessile animals live permanently attached to hard substrates. This group includes barnacles, tunicates, byrozoans, some holothurians, and some anemones. Epibenthic animals are active swimmers that remain in close association with the seafloor. This group includes mysids, some amphipods, and decapods (i.e. northern shrimp) (Petro-Canada 1982).

For the Hamilton Bank-Hawke Channel area, there is very limited information on the composition of the invertebrate fauna of the benthic zone. However, it must be recognized that only a few of these species, in particular the shrimps and snow crab, have commercial importance (see Chapter IV). However, marine invertebrates in the benthic area comprise a major source of food for commercial and non-commercial fish species, marine mammals and other invertebrates.

3. 3 Summary

The Hamilton Bank-Hawke Channel area appears to be one of the most productive regions along the Labrador and southeast Newfoundland coasts. As a consequence of the twin branches of the Labrador Current, and the unique bathymetery, the region has two sources of nutrients essential for primary (phytoplankton) production. The first develops from an upwelling of nutrient-rich deeper waters within the channel and on the inshore edge of the bank and the shelf break. The other results from a nutrient flux from the Hudson Strait which flows down the Labrador coast as a part of the inshore stream of the Labrador Current (see Section 2.1) (Drinkwater and Harding 1995). Production in the Hamilton Bank-Hawke Channel region is highest in May-June and again in October. Production at this time exceeds 10 mg/m^3 and is higher than most other areas along the northern Labrador shelf (i.e. Nain Bank, Saglek Bank) (Figure 11) and the northeast coast of Newfoundland. In addition, a second bloom occurs at 30-50 m depth and is associated with local upwelling.

Figure 13 shows the all data acquired by the CZCS satellite between 1978-1986. The Hamilton Bank-Hawke Channel region is shown to be one of the most productive regions in the North Atlantic trailing only the Hudson Strait, the western edge of Hudson Bay, and the St. Lawrence estuary in productivity.

Zooplankton production follows the major phytoplankton bloom in mid-summer. The dominant zooplankton in the Hamilton Bank-Hawke Channel area is the copepod *C. finmarchicus*, but many other species are present. Zooplankton grazing on phytoplankton provides a means of moving energy from phytoplankton to higher organisms such as whales, pelagic fish larvae, cephalopods (squid), capelin and other nekton. However, many of the details of the dynamics of zooplankton production and higher trophic level interactions in this area remain unknown.

The composition of the infaunal and sessile benthic environment of the Hamilton Bank-Hawke Channel area has not been well studied. Further research in this area is needed to obtain an understanding of the species present and the role that they play in the ecosystem.

Chapter IV: Economically Important Invertebrates

4.0 Introduction

Several commercial and potentially commercial species of invertebrates occur in the Hamilton Bank-Hawke Channel area. These include the northern shrimp (*P. borealis)*, snow crab (*Chionoectes opilio*), Icelandic scallop (*Chlamys islandicus)*, and the short-finned squid (*Illex illecebrosus*). The historical and present fisheries and current stock status for these species in the Hamilton Bank-Hawke Channel area will be discussed in this chapter.

4.1 The Northern or Pink Shrimp (*P. borealis)*

Biology and Distribution

The northern or pink shrimp is a decapod crustacean of the family Pandalidae. This species has a distribution that is circumboreal, and ranges from the Davis Strait to the Gulf of Maine in the Northwest Atlantic.

The northern shrimp is a protandric hermaphrodite. Male sex organs develop and function before female organs, which means the shrimp spends the first part of its life as a male, then develops female reproductive organs. Northern shrimp tend to mature as males during the third year, and into females by the fourth year (Figure 15) (Parsons 1984). Females spawn in one or more consecutive years and generally live to be age five or older. An average ovigerous female carries approximately 1,700 eggs which hatch into pelagic larvae. This represents a relatively low level of fecundity. Eggs are usually deposited in summer or fall and hatch in the spring, however the ovigerous period is temperature dependent and may take longer in colder waters (ICES 1994).

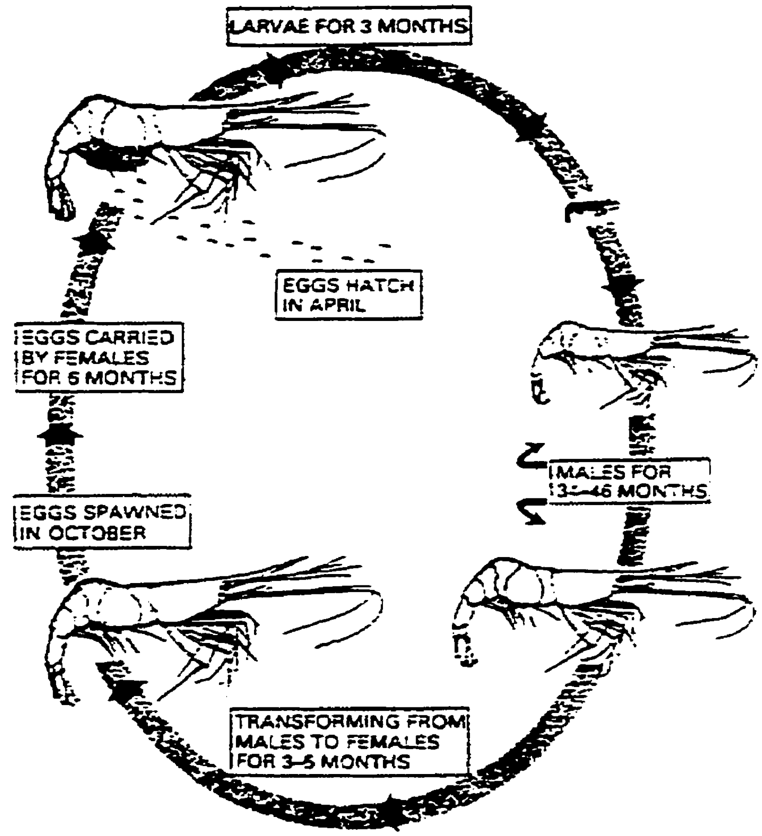


Figure 15: Life cycle of the northern shrimp (*P. Borealis*) (after Apollonio 1969).

The northern shrimp exhibits both horizontal and vertical migrations. Vertical migration takes place during night-time when they ascend in the water column likely to feed. Horizontal migration is seasonal, age-dependent and linked to reproduction. Horizontal migration causes problems when estimating levels of abundance (Savenkoff *et al.* 1995) since midwater trawls are not as effective in catching shrimp as bottom trawls. It is also believed that recruitment is a function of larval abundance and survival (Savenkoff *et al.* 1995). Therefore, it is important to quantify degrees of migration to understand the recruitment relationship. This is a very important factor to consider when estimating stock size biomass.

Northern shrimp prefer a soft and muddy clay bottom habitat in depths ranging from 20-1,380 m (Dore and Frimodt 1987). However, most commercial fishing occurs in depths of 250-450 m, suggesting these are the depths of highest concentration (Rose and Hiscock 1999). The Newfoundland and Labrador region has a large zone of suitable habitat (Anonymous 1997) and larger animals tend to occur in greater proportions in deeper waters (Rose and Hiscock 1999). The temperature range that northern shrimp typically occurs extends from two to six degrees Celsius. Slow growth occurrs at higher temperatures (Parsons 1984).

As the shrimp increases in size, it goes through a moulting process in which it sheds the exoskeleton. During this stage, the shrimp become very soft. This has a significant impact on the quality of catch and vessels will tend to avoid areas of "soft shells". The moulting process also renders the shrimp vulnerable to predation. As the shrimp ages, this moulting process slows (Parsons 1984).

Size at capture depends heavily on gear selectivity. Minimum mesh size for this fishery is 40 mm. Commercial shrimp for this fishery tend to be in the range of 10-40 mm carapace length. There have been studies aimed at developing new gear types that would only retain the larger 30-40 mm shrimp. Average size tends to vary geographically, the shrimp area off the northern tip of Labrador (Cape Chidley), for example, has produced a high proportion of the larger, more valuable sizes in recent years. As the industry tends to target the larger females, important considerations must be given to the biological consequences of such a strategy when setting levels of allowable catch.

Stock Size and Resource Status

The fall multispecies research surveys in 1995, 1996, and 1997 indicated that shrimp were widely distributed and abundant throughout Hawke Channel + Division 3K (SFA 6) each year. The minimum trawlable biomass (Figure 16) estimated in 1995 was 291,000 tonnes with 95% confidence intervals (CI) of 222,000-360,000 tonnes. The 1996 estimate was 518,000 tonnes (CI of 412,000-624,000) and the 1997 estimate was 435,000 tonnes (CI of 389,000-480,000) (Parsons and Veitch 1997). The 1998 estimate for Hawke Channel + Division 3K (SFA 6) is 475,000 tonnes (CI of 423,000-528,000) (Parsons *et al.* 1999).

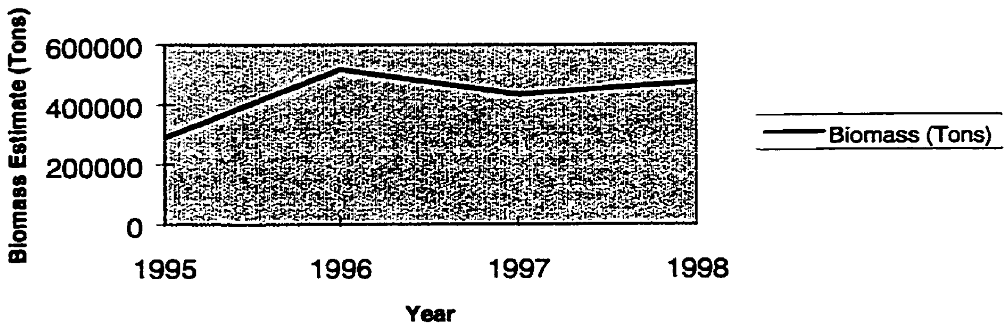


Figure 16: Minimum trawlable biomass (tonnes) estimates for northern shrimp, 1995-98 (Source: Parsons *et al.* 1999).

Catches in the 1998 fishery were highest observed in SFA 6 (45,676 tonnes). Research data suggests that recent year classes (1995-1996) may be weaker than some produced in the early 1990s but it is not yet possible to quantify the effect on future recruitment (Anonymous 1997). In addition, research survey biomass estimates were very similar from 1996-98, this indicates that shrimp abundance is no longer increasing in the area (Anonymous 1999b). Data in Rose and Hiscock (1999) suggests that catch rates in the Hawke Channel may have peaked in 1996, and since have declined to a lower but stable level.

The Fishery

The northern shrimp fishery operates on a year round basis concentrating on *P. borealis*, commonly referred to as northern pink or shrimp. The other commercially important species is *Pandalus montagui* (striped shrimp) which occurs mainly in Ungava Bay, and as a by-catch in other regions. The northern shrimp fishery is a relatively recent industry in Atlantic Canada. It is a capital intensive fishery which uses factory freezer trawlers (FFT) to harvest waters ranging from the south of Newfoundland to Baffin Island in the north. In addition to FFTs, a recent inshore fleet (<65 ft) has been licensed to catch shrimp in Newfoundland and Labrador waters. The shrimp catch is predominantly destined for the European and Japanese markets.

There are currently 17 offshore licenses (vessels >100 ft) issued in the SFA 6 region (Anonymous 1997), which are administered by the enterprise allocation format. All vessels are now currently registered in Canada. In 1993 several vessels were granted licenses to fish on the Flemish Cap area of NAFO Division 3M. To date, this is the only area where Canadian vessels fish shrimp outside of the 200-mile limit. There are an additional 335 licenses for inshore vessels (<65 ft) and one vessel between 65-100 ft that fish for shrimp in Newfoundland waters (R. Coombs, Department of Fisheries and Aquaculture, St. John's, NF, personal communication, 1999)

Hawke Channel + Division 3K (Shrimp Fishing Area (SFA) 6)

The Northern Shrimp fishery in Hawke Channel + Division 3K (SFA 6) (Figure 17) began in 1987 when about 1,800 tonnes were caught. In the 1980s, only a few tonnes had been reported from Hawke Channel in some years. In 1988 catches increased to more than 7800 tonnes and ranged between 5,500 and 8,000 tonnes from 1989-93, inclusive. The annual TAC for the 1994-1996 Management plan was set at 11,050 tonnes (20% greater than the 1993 TAC) and included Hawke Channel, St. Anthony Basin, east St. Anthony, Funk Island Deep as well as three exploratory areas on the seaward slope of the shelf. Catches increased to 11,000 tonnes in each of those three years. The 1997 assessment of research vessel surveys and commercial data by the Department of Fisheries and Oceans concluded that the resource was healthy and exploitation was low. The 1997 TAC was therefore set at 23,100 tonnes in an aim to increase exploitation rates. Most of this increase was reserved for the developing inshore fishery (Parsons and Veitch 1998). Catch rates for 1997 were 21,246 tonnes, the resource was again determined healthy and under-exploited and the TAC was raised to 46,200 tonnes in 1998. Catch rates in 1998 were below the TAC at 45,676 tonnes (Parsons *et al.* 1999). Table 1 gives a summary of northern shrimp fishery data. Figure 17 demonstrates this data graphically.

Offshore catch data provided by Parsons (Department of Fisheries and Oceans, St. John's, NF, personal communication, 1999) shows that of the 16,000 tonnes of shrimp allocated for the Hawke Channel + Division 3K (SFA 6), 88% of this catch (14,134 tonnes) was taken in the Hawke Channel. This offshore fishery was worth around $70 million in 1998 at an approximated price of $5000 Canadian/tonne (R. Coombs, Department of Fisheries and Aquaculture, St. John's, NF, personal communication, 1999).

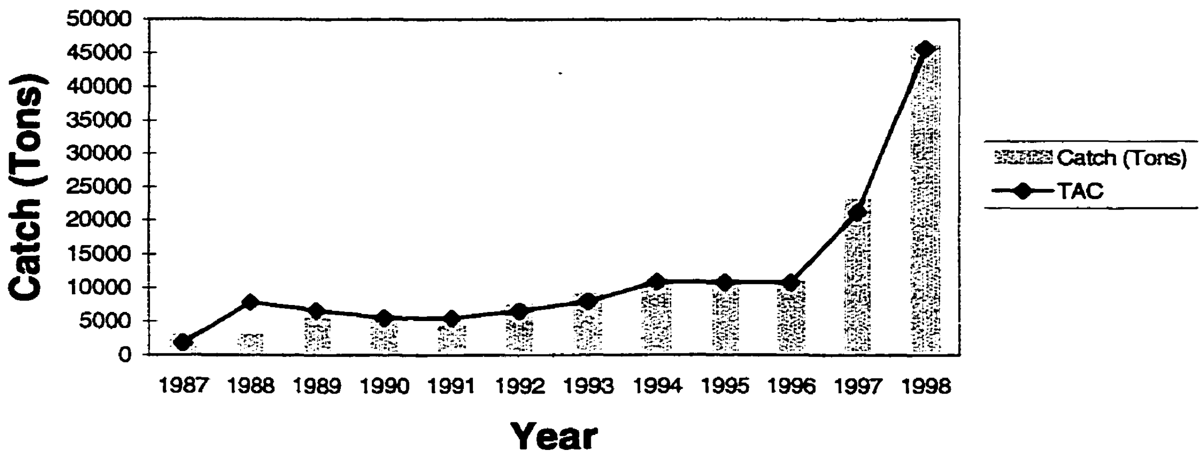


Figure 17: Catch (tonnes) and TAC for of northern shrimp in Hawke Channel + Division 3K (SFA 6), 1987-1998. From Parsons *et al.* 1999

Table 1: Northern Shrimp Fishery Data for Hawke Channel +Division 3K (SFA 6), 1977-1988 (Parsons *et al.* 1999). Note: MT = metric tonnes.

YEAR	TAC (MT)	CATCH (MT)	CPUE (KG/HR)
1977	1300	1	117
1978	2250	0	0
1979	1350	5	189
1980	1350	0	0
1981	1350	135	207
1982	1350	1	151
1983	1350	0	0
1984	1350	0	0
1985	1350	0	0
1986	2050	0	0
1987	3000	1845	333
1988	3000	7849	536
1989	5600	6662	432
1990	5600	5598	507
1991	4301	5500	603
1992	7565	6609	774
1993	9180	8035	891
1994	11050	10978	1287
1995	11050	10914	1836
1996	11050	10923	2012
1997	23100	21246	1966
1998	46200	45676	1790

Table 2: Allocation, catch and number of active vessels in SFA 6, 1998. Note: the 3K allocation includes resident 2J fishers. Source: P. Tucker, Department of Fisheries and Aquaculture, St. John's, NF, personal communication, 1999.

Area of Vessel Origin	Allocation (Tonnes)	Allocation Plus Reserve	Catch (Tonnes)	Vessels With Landings	Permits issued (Dec. 31/98)
2J			2,710	10	10
3Kn	5,080	6,770	2,088	17	18
3Ks	7,400	9,860	6,482	73	95
3L	4,950	6,600	12,847	122	147
4R	4,440	5,870	4,927	54	62
4S	550	740	780	-	-
Reserve	7,460	-	-	-	-
Total	29,840	29,840	29,834	276	332

Table 3: Area of vessel origin, catch (tonnes), value, number of vessels landed and value to each vessel, SFA 6, 1998. This table assumes that average price/lb. is fixed at $0.60.
[1] Assumes that all vessels have equal quotas for SFA 6

Area of Vessel Origin	Catch (Tonnes)	Value $ (000)	Vessels with Landings	Value $ to each Vessel[1]
2J	2,710	3,577	10	357,700
3Kn	2,088	2,756	17	162,117
3Ks	6,482	8,556	73	117,205
3L	12,847	16,958	122	139,000
4R	4,927	6,503	54	120,425
4S	780	1,029	-	-
Total	29,834	39,381	276	-

Inshore vessel (<65ft) catch data for 1998 by subdivision in SFA 6 shows that 29,834 tonnes of shrimp were taken by 276 vessels (P. Tucker, Department of Fisheries and Aquaculture, St. John's, NF, personal communication, 1999). Table 2 gives the allocation, catch and number of active vessels fishing in SFA 6.

Table 2 indicates that most of the inshore fishers that fish in SFA 6 originate from communities in Div. 3L (44%), followed by fishers from area 3Ks (26%) and 4R (19.5%). Landed values for this inshore fleet (<65ft) in SFA 6 total approximately $39 million, with $16 million being caught by fishers from division 3L (Table 3). Table 3 also shows the earnings/vessel of all fishers who harvest shrimp in SFA 6.

Unfortunately, the 1998 inshore catch data is not processed at this time for area 80 (Hawke Channel) of SFA 6 and no firm determinations of fishing activity can be reported. However the data does suggest that the Hawke Channel was clearly one of the most important areas in SFA 6 for inshore vessels (D. Parsons, Department of Fisheries and Oceans, St. John's, NF, personal communication, 1999). Figure 18 shows the distribution of fishing effort in Division 2J-3K (SFA 6), in the years of 1990-1998.

The Hamilton Bank, probably due to shallow waters (~200m), is not as important a location for the commercial shrimp fishery as the Hawke Channel. Figure 18, however does show some activity on the Bank in 1996-1998 but there is no data available to determine specific catch rates. In addition, the localized upwelling and high primary production (see section 3.0) of the Hamilton Bank likely provides nutrients, through the motions of the Labrador current, to the Hawke Channel region, which may contribute to the high shrimp biomass in the area.

Market Value

There are currently 10 Shrimp processing plants that are operating in Newfoundland. They are operated by Quinlans (2), FPI (2), Cliff Doyle (1), SABRI, Jackson's Arm, Daley Brothers (2), and Sea Freeze (G. Blackwood, Canadian Center for Fisheries Innovation, St. John's, NF, personal communication, 1999). There is no data available at this time to determine where these processing plants obtain their raw material and how much this fishery is worth to them individually. However, the overall value to

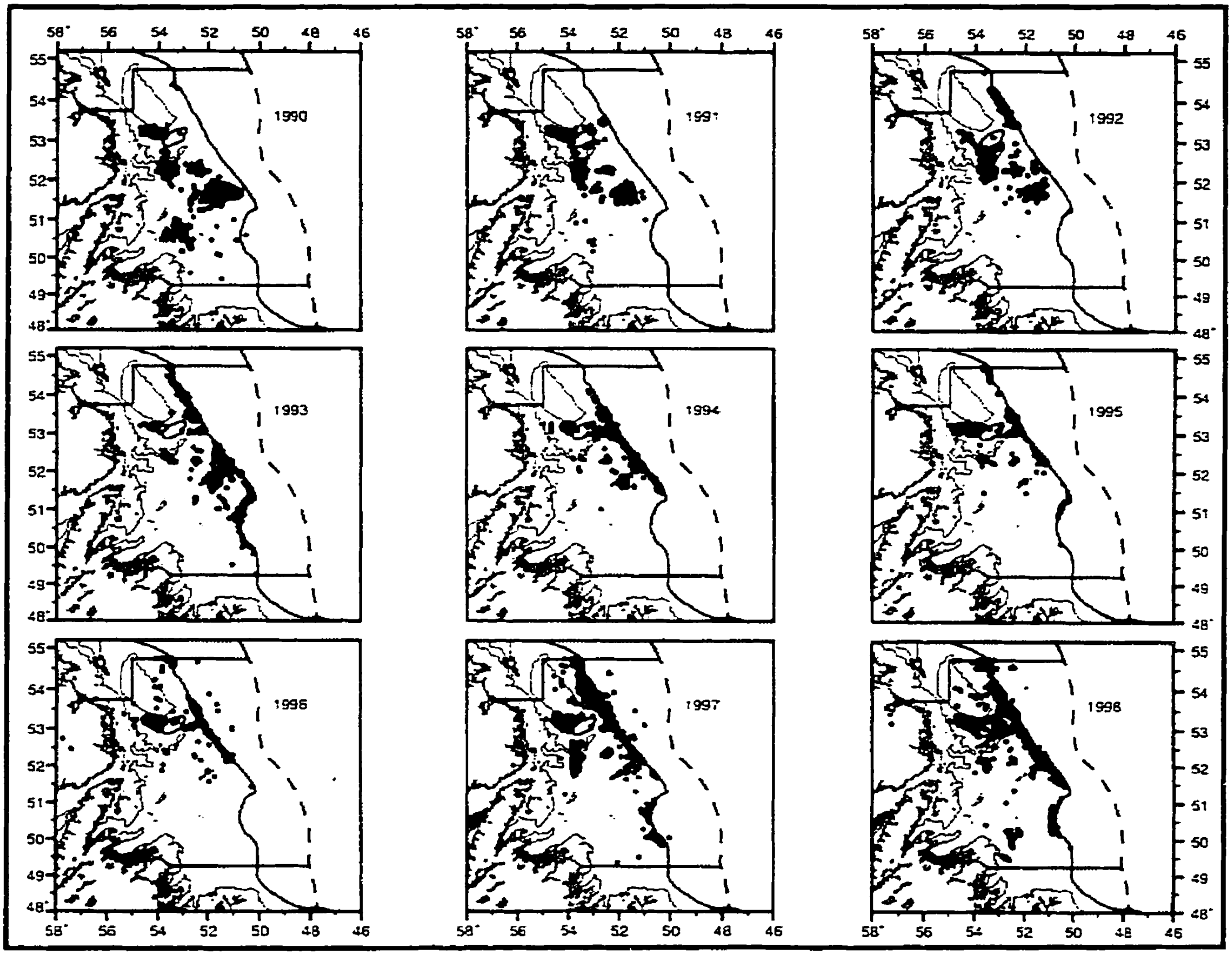


Figure 18: Distribution of shrimp fishing effort in Division 2J-3K (SFA 6), 1990-1998. After Parsons *et al.* 1999.

the processors as a group can be determined. Assuming a 24% processing yield and a average market price of $4.85/lb. (P. Tucker, Department of Fisheries and Aquaculture, St. John's, NF, personal communication, 1999) the value of shrimp caught in SFA 6 by the under 65 ft fleet (29,834 tonnes) has a value to processors of approximately $76.4 million on the open market.

4. 2 Snow Crab (*Chionoectes opilio*)

Biology and Distribution

The snow crab is near circumpolar in distribution and is found in the northwest Atlantic from west Greenland south to the Gulf of Maine in water depths to 630 m. The preferred bottom type of adults of this species is mud to mud/sand. Juvenile crabs tend to like gravel or small rock bottoms. In addition to its bottom type preferences, the snow crab favors colder water of -1 to 4 ^{0}C (Petro-Canada 1982).

The general life history of the snow crab is well documented. Copulation occurs in summer, after which 20,000 to 100,000 fertilized eggs are extruded and carried by the female for approximately one year before hatching. The resultant larvae are planktonic and inhabit the pelagic zone for up to four months before settling. Females reach maturity and stop molting at a relatively small size (40-70 mm carapace width). Males continue to molt until they develop large front claws that are used in competition for females. The development of these large claws occurs over a wide size range of carapace widths (40-100 mm). It is believed that these crabs live no more than 4-5 years after the final molt (Dawe and Taylor 1997). Snow crabs do not seem to make extensive migrations (Petro-Canada 1982)

The snow crab diet includes clams, polychaete worms, brittle stars, bivalves, shrimps, and other crustaceans. Predators of the snow crab include seals, cod, thorny skate, and other snow crabs (Dawe and Taylor 1997).

Stock Size and Resource Status

Minimum trawlable biomass estimates in Division 2J for males and females from fall bottom trawl surveys in 1997 are depicted in Table 4. Survey estimates for 1998 indicated that there was an increase in crab biomass in Division 2J. However, the catchability of the Campelen trawl used in the fall survey is believed to be less than one, and uncertainty of biomass estimates is high. In addition, the sustainable upper limit exploitation rate is uncertain and due to sampling inefficiencies, recruitment cannot be predicted in the intermediate term. Abundance estimates of small crab (<60 mm CW) have declined from 1996-1998 (Department of Fisheries and Oceans 1999).

The Fishery

In 1998, the snow crab fishery in Division 2J had 64 temporary seasonal, 31 supplementary, 4 full-time, 1 exploratory, for a total of 100 licenses. This is the lowest number of licenses for any NAFO division (Table 5) (Department of Fisheries and Oceans 1999). Table 6 summarizes quotas and total landings of Division 2J by Sub-Area. Unfortunately, the data available do not allow for any distinction of catches for the Hamilton Bank-Hawke Channel Area.

Division 2J is separated into 4 management units, all of which are partially included in the Hamilton Bank-Hawk-Channel study area, they are: Area 2JS (Southern Labrador), Area 2JSX extended (east of 53^0 30'W), Area 2JN (Northern Labrador), and Area 2JNX extended (east of 53^0 30'W). Figure 19 displays these divisions. Table 6 gives the landings and quotas for the 4 management units of Division 2J.

For the 1999-2000 fishing seasons in Division 2J, the fishing zones have been changed. The line separating 2JN and 2JNX has been removed and quota separation is based on north or south of a particular line of latitude. Table 7 describes the quotas for 1999/2000 in areas inside 200 miles.

Table 4: Minimum trawlable snow crab biomass estimates in Division 2J for males and females for 1997. Source: Dawe *et al.* 1998.

Size and Classification of Males and Females	Biomass (tonnes) for Area 2J
Legal-size Males (>95mm CW)	11,741
Sublegal 1 (76-94mmCW)	1753
Sublegal 2 (60-75mm CW)	338
Small Males (<60mm CW)	248
Total Males	14,080
Immature Females	124
Mature Females	149
Total Females	273

Table 5: Summary of the number of snow crab license and permit holders for 1998. Source: Department of Fisheries and Oceans 1999. [1] Small supplementary licenses.[2] Large Supplementary licenses

Area	Temporary Seasonal	Supplementary		Full-time	Exploratory	Total
2J	64	31		4	1	100
3K	723	240		29	-	992
3LNO	807	246 [1]	79 [2]	41	4	1177
3Ps	594	93		-	17	704
4R3Pn	311	11		-	48	370
Total	2499	700		71	70	3340

Table 6a: Snow Crab landings and Quotas for Division 2J-Southern Labrador (2JSX) extended, 1994-1997. Source: Taylor and O'Keefe 1998. Note: t = tonnes.

Year	Landings (t)	Landings (Supp)	Quota (t) Full	Quota (t) Supp
1994	330	-	300	-
1995	334	-	300	-
1996	331	-	300	-
1997	178	123	0	0

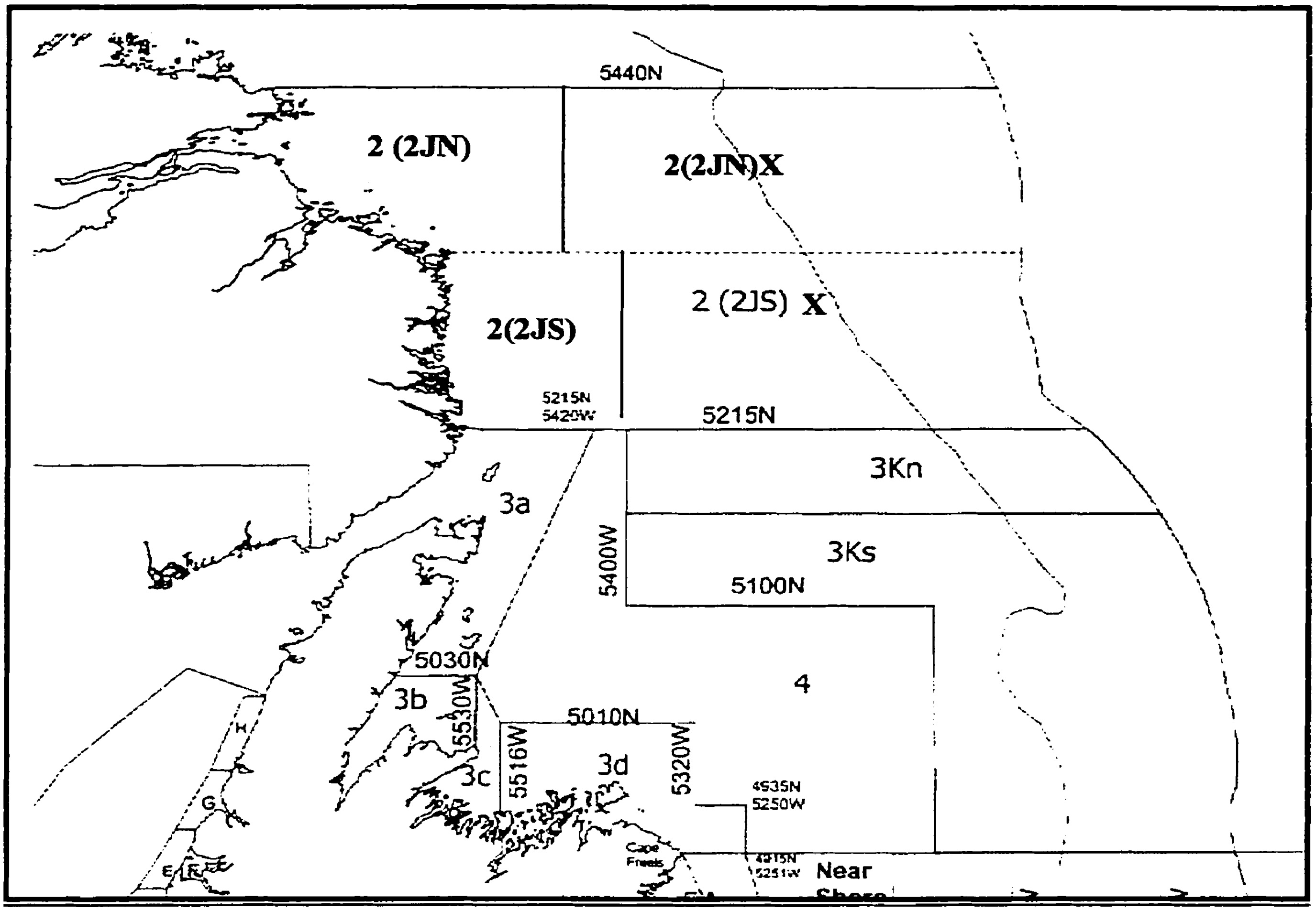


Figure 19: Snow Crab Management Areas for Newfoundland and Labrador. After: Department of Fisheries and Oceans 1999.

Table 6b: Landings and Quotas for Division 2J-Northern Labrador (2JN), 1991-1997. Source: Taylor and O'Keefe 1998.

Year	Landings (t)	Quota (t)
1991	72	500
1992	452	400
1993	984	1000
1994	1182	1300
1995	931	1040
1996	833	900
1997	1459	1325

Table 6c: Landings and quotas for Division 2J-Southern Labrador (2JS), 1985-1997. Source: Taylor and O'Keefe 1998.

Year	Landings (t)	Landings (Supp)	Quota (t)Full	Quota (t) Supp
1985	311	-	-	-
1986	467	-	-	-
1987	256	-	-	-
1988	451	-	926	-
1989	523	-	920	-
1990	645	-	920	-
1991	917	-	920	-
1992	1077	317	720	300
1993	1331	455	860	440
1994	1466	491	860	440
1995	1384	779	600	760
1996	1043	503	500	600
1997	1439	867	500	825

Table 6d: Landings and Quotas for Division 2J-Northern Labrador (2JNX) extended, 1995-1997. Source: Taylor and O'Keefe 1998.

Year	Landings (t)	Quota (t)
1995	529	500
1996	531	275

Table 7: 1999-2000 quotas (tonnes) and 1996-1998 total quotas for Division 2J.

Description	Temporary Seasonal	Supplementary	Full-time	Total
North of 54^0 40'	-	-	-	600[1]
2J-south of 54^0 40'	700	2600	-	3300
2J-south of 53^0 30'	-	-	555	555
Total-1999/2000	700	2600	555	4455
Total - 1998	250	2150	500	3500
Total - 1997	150	2150	500	2800
Total 1996	150	2150	500	2800

[1] 500 tonnes for the LIA communal license, 100 tonnes for Torngat Fisheries Co-op.

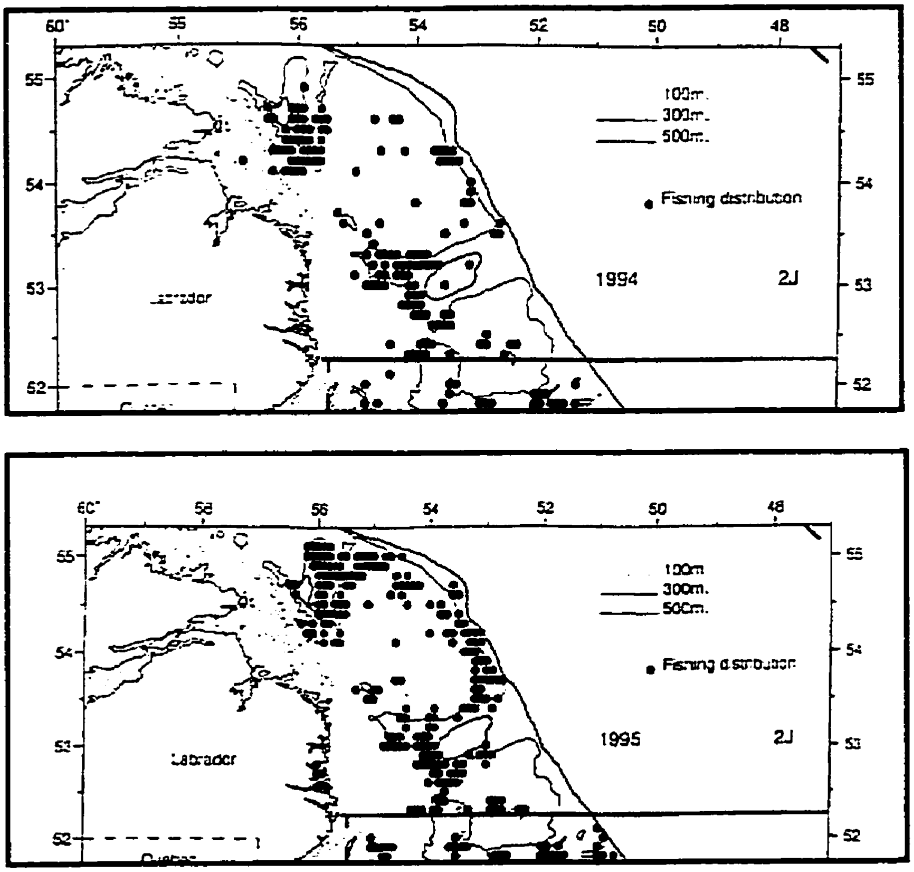


Figure 20: Distribution of snow crab fishing effort in Division 2J, 1994-1998. After Taylor and O'Keefe 1998.

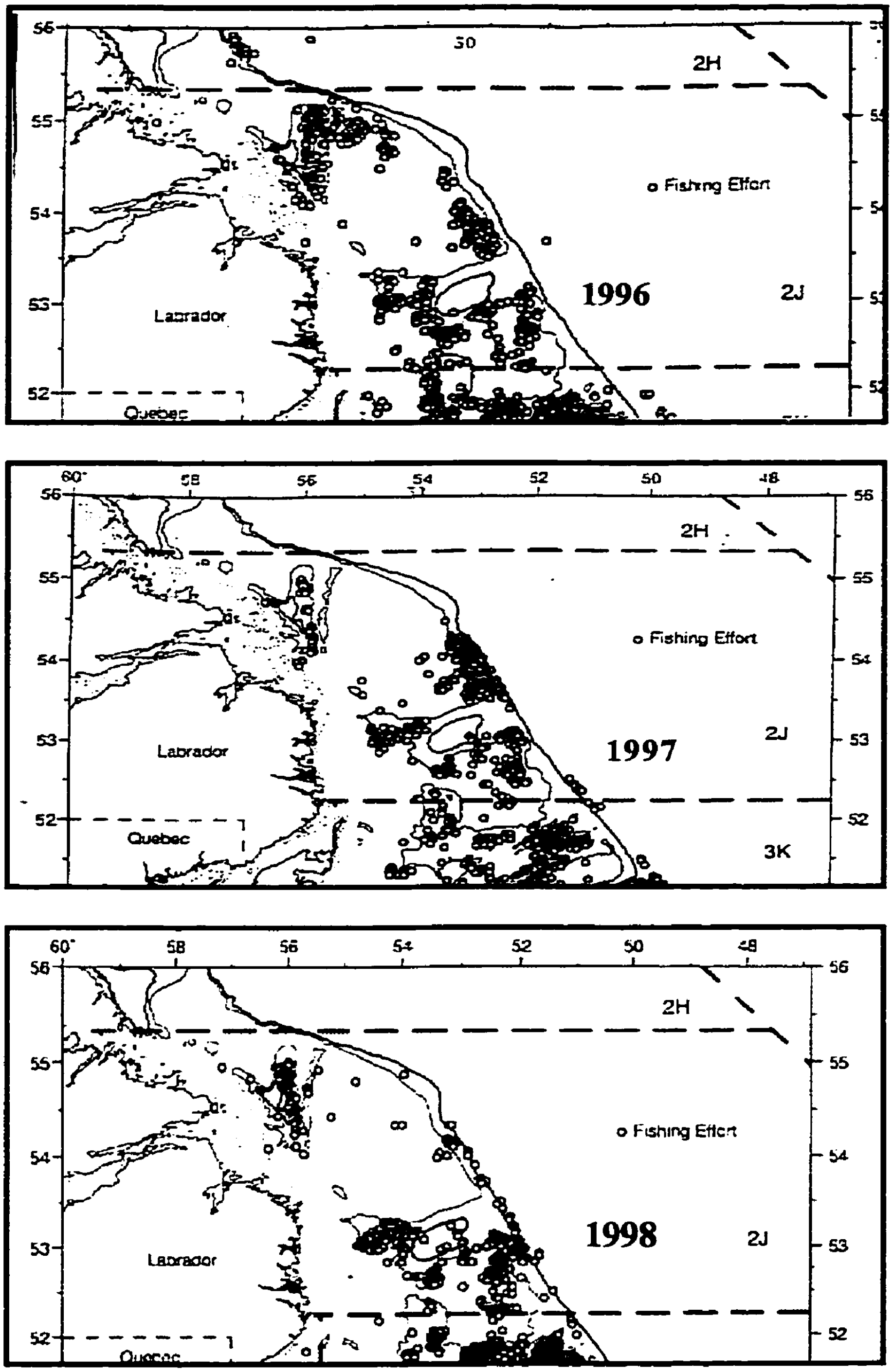


Figure 20 continued: Distribution of snow crab fishing effort in Division 2J, 1994-1998. After Taylor and O'Keefe 1998.

The distribution of fishing effort for Division 2J is depicted in Figure 20. Fishing effort in the Hamilton Bank area in years 1994-96 seems to be most concentrated on the northwestern and southeastern corners. In 1997-98 however, fishing on the bank was limited with only moderate effort on the southeastern corner. In all years (1994-1998), the western corner of the Hawke Channel and the area around the Hawke Saddle have been zones of high fishing effort.

The value of the 2J crab fishery in 1997 was $7.9 million ($0.88/lb. was the consistent price in 1997) to the 100 license holders (on average $79,000 to each license). This fishery was in turn worth $16 million to processors in Newfoundland and Labrador (assuming 60% processing yield and sections having fixed price of $3.05/lb.) (P. Tucker, Department of Fisheries and Aquaculture, St. John's, NF, personal communication, 1999). Landed values and market values for 1998 are not yet available.

4. 3 Icelandic Scallop (*C. islandicus)*, and the Short-finned Squid (*I. illecebrosus*).

There is limited information available on the distributions of the Icelandic scallop and the Short-finned squid in the Hamilton Bank-Hawke Channel area. There are currently no commercial fisheries for scallops or squid in these areas. However, recently there have been feasibility studies carried out in the Hamilton Bank-Hawke Channel area for a scallop fishery (R. Coombs, Department of Fisheries and Aquaculture, St. John's, NF, personal communication, 1999).

4.4 Summary

There are currently two commercially important invertebrates in the Hamilton Bank-Hawke Channel area, the northern shrimp and snow crab. The shrimp fishery in the Hamilton Bank-Hawke Channel region is worth millions of dollars to fishers ($39 million to vessels <65 ft; $70 million to offshore fleet in Hawke Channel), processors ($76.4

million), and communities in Newfoundland and Labrador. The Hawke Channel is the center of this fishery in SFA 6 and is one of the most important areas for shrimp in the northwest Atlantic. As a comparison, shrimp fisheries in NAFO Division OB (SFA 3) had catches of less than 5000 tonnes in 1996, and catches in Division 2G just exceeded 5000 tonnes in 1996. Fisheries in SFA 5 (Hopedale and Cartwright Channels) exceeded 7000 tonnes in 1995-96 (Anonymous 1997). The Hawke Channel produced over 14,000 tonnes alone in 1998 to factory freezer trawlers. The inshore fleet (276 <65-ft vessels) caught an additional 29,834 tonnes from SFA 6.

Fall multispecies research surveys in 1998 indicated that shrimp were widely distributed and abundant throughout Hawke Channel + Division 3K (SFA 6). Minimum trawlable biomass estimates for this area in 1998 was 475,000 tonnes. However, surveys also indicate that abundance levels are no longer increasing and future recruitment is uncertain. It is questionable to whether the current TAC of 46,200 tonnes or an increased TAC can be sustained (Anonymous 1999b).

The snow crab fishery in Division 2J is not as important as in other Divisions such as 3L and 3K (Figure 19 for reference location). The quotas for Division 3L for 1999-2000 is 23,500 + 18,200 tonnes for 3K. In contrast, for 1999-2000, 2J had a quota of 4,455 tonnes (Taylor and O'Keefe 1998). Within 2J the Hamilton Bank-Hawke Channel region is one of the most important crab harvesting areas. The majority of fishing pressure in this area over the last several years (1994-98) has taken place in the western corner of the Hawke Channel and in the Hawke Saddle. There has also been limited fishing activity on the bank and along the western edge of the bank.

Minimum trawlable biomass estimates from 2J in 1997 indicate that there are 14,080 tonnes of male crab (83% are legal size males) and 273 tonnes of female crab (54% mature). However, recruitment cannot be predicted in the intermediate term and abundance of small crab has declined from 1996-1998.

The value of the snow crab fishery in the Hamilton Bank-Hawke Channel region is unknown. However, the entire 2J fishery was worth $7.9 million to fishers (100 license holders) and $16 million to processors in 1997.

Chapter V: Commercial and Non-Commercial Fish Species

5.0 Introduction

Most of the literature that describes the fish species of the Labrador region deals with economically important species, and the fish prey that they consume. There are however, many non-commercial species that also inhabit the area. Below is a list of species that inhabit the Labrador region. Unfortunately, there is limited information on the community composition of the fish fauna of the Hamilton Bank-Hawke Channel area. However, Petro-Canada (1982) reported that there were no species that are endemic to the Labrador offshore region. In addition, fishing set data showing species present in the Hawke Channel area in January and June cruises of 1997 has been provided to allow partial verification with available literature. This information is presented in Section 5.1.

5.1 Fish Species Present in the Hamilton Bank-Hawke Channel Area

Sharks and Rays
Black Dogfish (*Centroscyllium fabrici*)
Spiny Dogfish (*Squalus acanthias*)
Greenland Shark (*Somniosus microcephalus*)
Thorny Skate (*Raja radiata*)
(Source: Scott and Scott 1988)

Anadromous Species
Atlantic Salmon (*Salmo salar*)
Arctic Char (*Salvelinus alpinus*)
American Shad (*Alosa sapidissima*)
(Source: Scott and Scott 1988)

Pelagic and Deepwater Species
Atlantic Herring (*Clupea harengus harengus*)
Capelin (*Mallotus villosus*)
Atlantic Argentine (*Argentina silus*)
Glacier Lanternfish (*Benthosema glaciale*)
Spotted Lanternfish (*Myctophum puntatum*)
Arctic Cod (*Boreogadus saida*)

Atlantic Cod (*Gadus morhua*)
Greenland Cod (*Gadus ogac*)
Atlantic Tomcod (*Microgadus tomcod*)
Pollock (*Pollachius virens*)
Longfin Hake (*Urophycis chesteri*)
White Hake (*Urophycis tenuis*)
Red Hake (*Urophycis chuss*)
Threebeard Rockling (*Gadropsarus ensis*)
Roughhead Grenadier (*Macrourus bergalax*)
Rock Grenadier (*Coryphaenoides rupestris*)
Common Marlin Spike (*Nezumia bairdi*)
Laval's Eelpout (*Lycodes lavalaei*)
Fourline snakeblenny (*Chirolophus ascani*)
Green Ocean pout (*Gymnelis viridis*)
Striped wolffish (*Anarhichas lupis*)
Fourline Snakeblenny (*Eumesogrammus praecisus*)
Snakeblenny (*Lumpenus lumpretaeformis*)
Daubed Shanny (*Lumpenus maculatus*)
Wrymouth (*Cryptacanthodes maculatus*)
Atlantic Mackerel (*Scomber scombrus*)
Bluefin Tuna (*Thunnus thynnus*)
Deepwater Redfish (*Sebastes mentella*)
Acadian Redfish (*Sebastes fasciatus*)
Shorthorn Sculpin (*Myoxocephalus scorpius*)
Arctic Deepsea Sculpin (*Cottunculus microps)*
Spatulate Sculpin (*Icelus spatula*)
Mailed Sculpin (*Triglops nybelini)*
Atlantic Hookear Sculpin (*Artediellus atlanticus*)
Common Alligatorfish (*Aspidophoroides Monopterygius*)
Common Lumpfish (*Cyclopterus lumpus*)
Sea Tadpole (*Careproctus ranulus*)
Sea Snails- Liparidae
Witch Flounder (*Glyptocephalus cynoglossus*)
American Plaice (*Hippoglossoides platessoides*)
Atlantic Halibut (*Hippoglossus hippoglossus*)
Winter Flounder (*Pseudopleuronectes americanus*)
Greenland Halibut (*Reinhardtius hippoglossoides*)

(Source: W. Hiscock 1999. Personal Communication. Fisheries Conservation Chair, Memorial University of Newfoundland; Scott and Scott 1988; Petro Canada 1982)

5.2 Atlantic Cod (*Gadus morhua*)

Biology and Distribution

Atlantic cod occur on both sides of the North Atlantic. In the western north Atlantic they are found from Greenland and southern Baffin Island southward along the continental slope off Labrador, Newfoundland, Gulf of St. Lawrence, Grand Bank and Scotian shelf, southward to Cape Hatteras, N. C (Scott and Scott 1988).

Atlantic cod are adapted for bottom feeding, but they may also spend considerable amounts of time off the bottom and may occur from the surface to depths of more than 500 m. Cod generally prefer cooler temperatures in the range of -0.5 to 10 ^{0}C (Scott and Scott 1988). However, temperature preference may vary with time of year, geographic location, and size of fish.

In the past Atlantic cod have been known to spawn in several areas on the Newfoundland-Labrador Shelf. These areas include the banks of NAFO Divisions 2G and 2H, the eastern-southeastern slope of the Hamilton Bank, the Hawke Channel, the Belle Island Bank, and the areas around the Funk Island Bank (Fitzpatrick and Miller 1979). It is likely that cod spawning was widespread on most of these banks (Hutchings *et al.* 1993). Atlantic cod in the Hamilton Bank-Hawke Channel region usually spawned from March-June (Hutchings *et al.* 1993, Fitzpatrick and Miller 1979) with limited spawning occurring throughout most of the year (Pepin and Helbig 1997). Spawning occurred primarily on the southeastern slope of the Hamilton Bank (Hutchings *et al.* 1993). At present the only known spawning and post spawning concentration that can be located on the Newfoundland and Labrador shelf occurs in the Hawke Channel region (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999; FRCC 1999).

Cod are broadcast spawners. Fecundity is based on size. For example, a 51cm long female fish will approximately produce 200 thousand eggs, while a female 140 cm will produce 12 million eggs. Fertilized eggs spawned on the Hamilton Bank in March-April will take approximately 40 days at temperatures of -1 to 1 °C to hatch (Scott and Scott 1988). Downstream transport is likely to disperse resultant larvae over a large area of the continental shelf (deYoung and Rose 1993). In addition, larger fish have a tendency to spawn over longer periods of time, increasing the chances of hitting conditions that are favorable for hatching and larval development.

Egg and Larval Drift Patterns

Cod eggs are pelagic in nature, and are subsequently at the mercy of currents, wind or density driven, to a depth of 50 m (Pepin and Helbig 1997). Cod larvae are also pelagic, but are free swimming and may be able to some extent, slow their movement in the water column.

Figure 21 shows a satellite tracking experiment carried out by Pepin and Helbig (1997) from 1992-1994. All drifting buoys were deployed near or on the Hamilton Bank. The resultant drift patterns are quite clear. Drifting buoys placed near or on the bank drifted south along the Labrador coast offshore, moved down along the northeast coast of Newfoundland and progressed southeast along the shelf edge of the Grand Banks.

Figure 22 displays the distributions of cod eggs along the Newfoundland-Labrador offshore region in the springs of 1991 and 1992. If compared to Figure 21, the motion of the drift buoys and eggs is similar. However, the distribution of stage 1 eggs is inconsistent with the southern spawning observed in those years (Rose 1993). Figure 23 demonstrates a backtracked time series of cod eggs and larvae at 4-day intervals. From

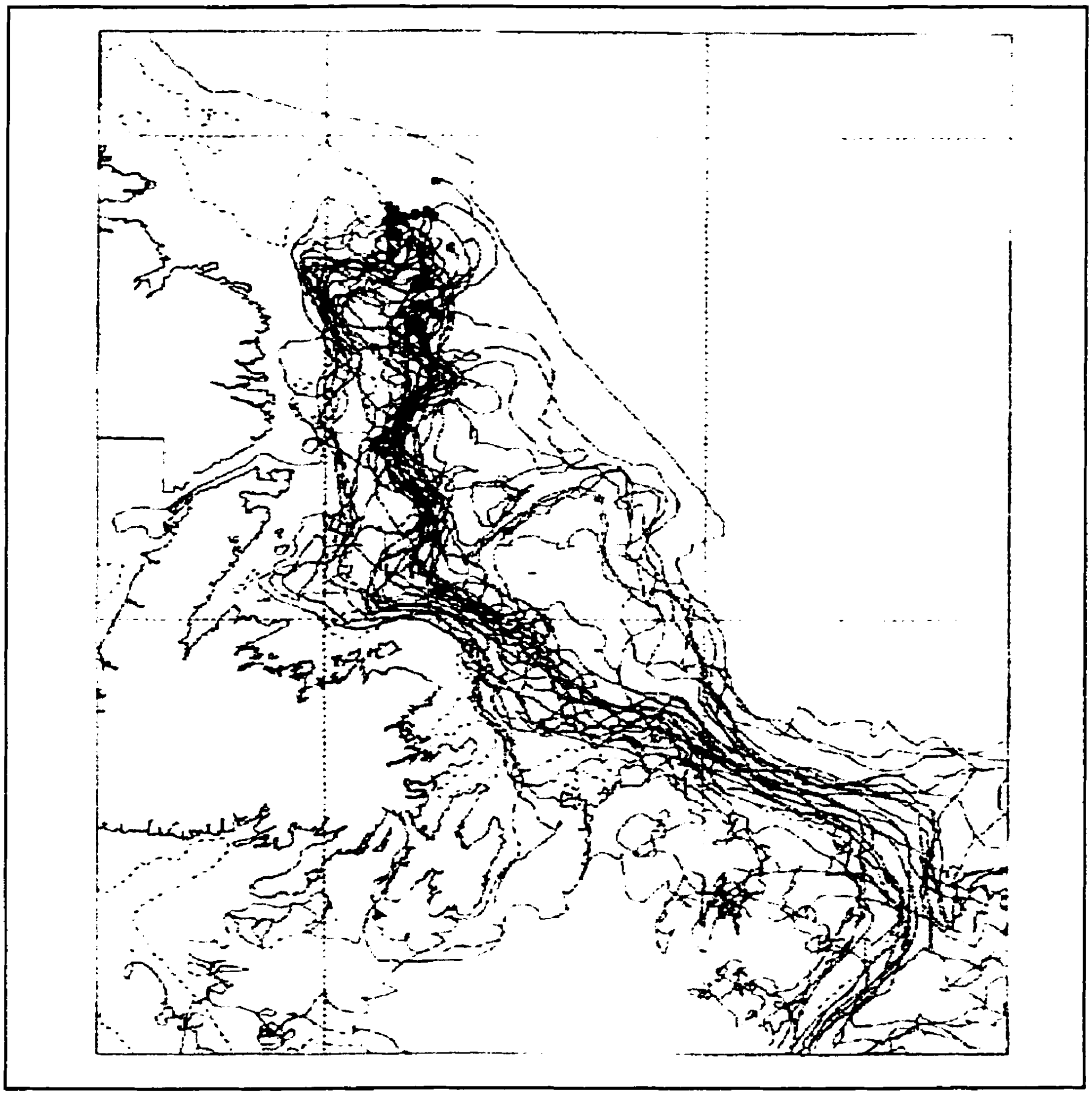


Figure 21: The trajectories of 41 satellite-tracked drifting buoys. The larger dots on or near the Hamilton Bank indicate buoy starting points (After: Pepin and Helbig 1997).

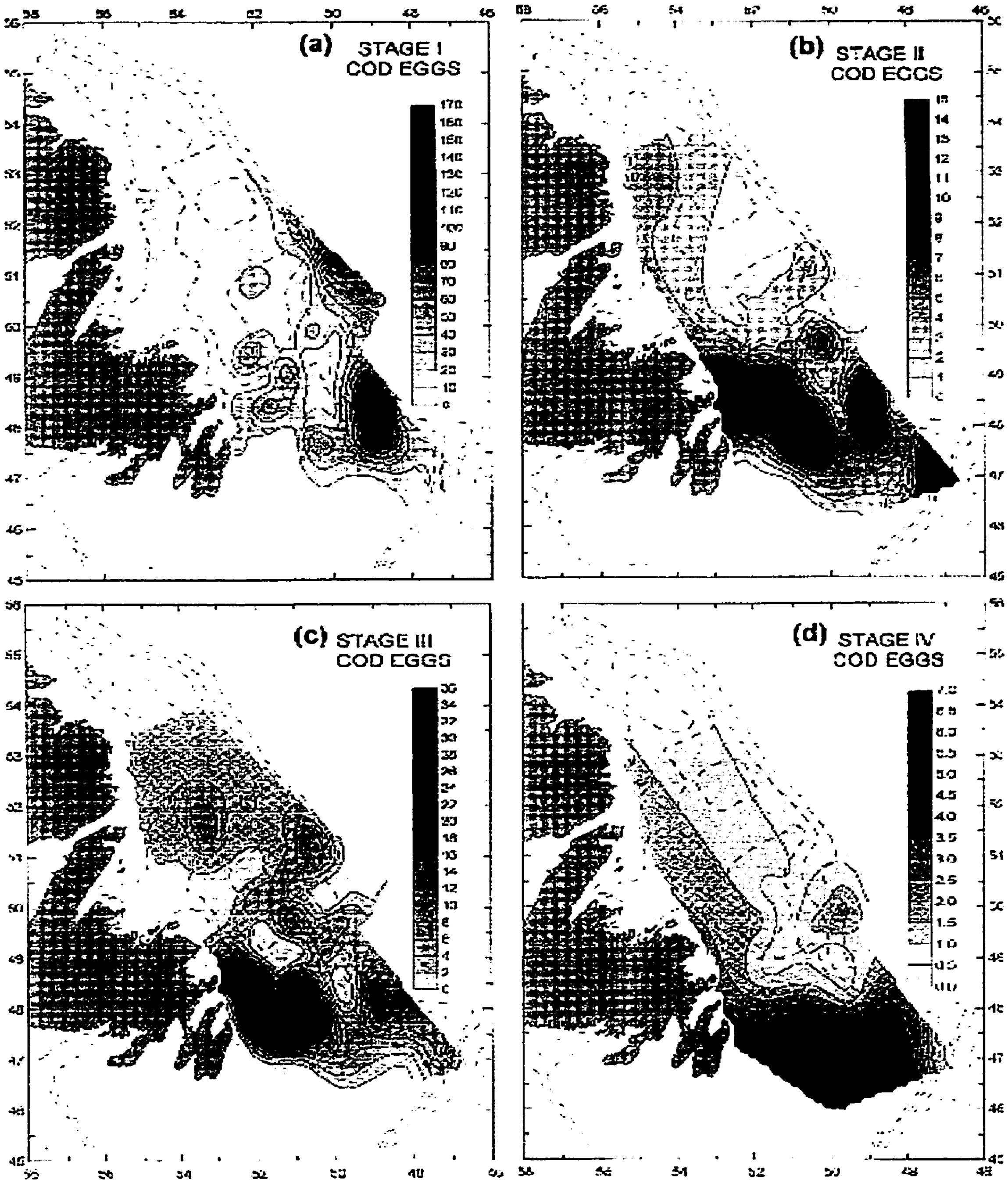


Figure 22: Distribution of the areal density of cod eggs observed by Pepin and Helbig (1997) in 1991-92 surveys. A: stage I (age 1-8 days), B: stage II (age 9-16 days), C: stage III (age 17-22 days), and D: stage IV (age 23-28 days). The shaded scale bar defines the contour levels in individuals/1000m^3.

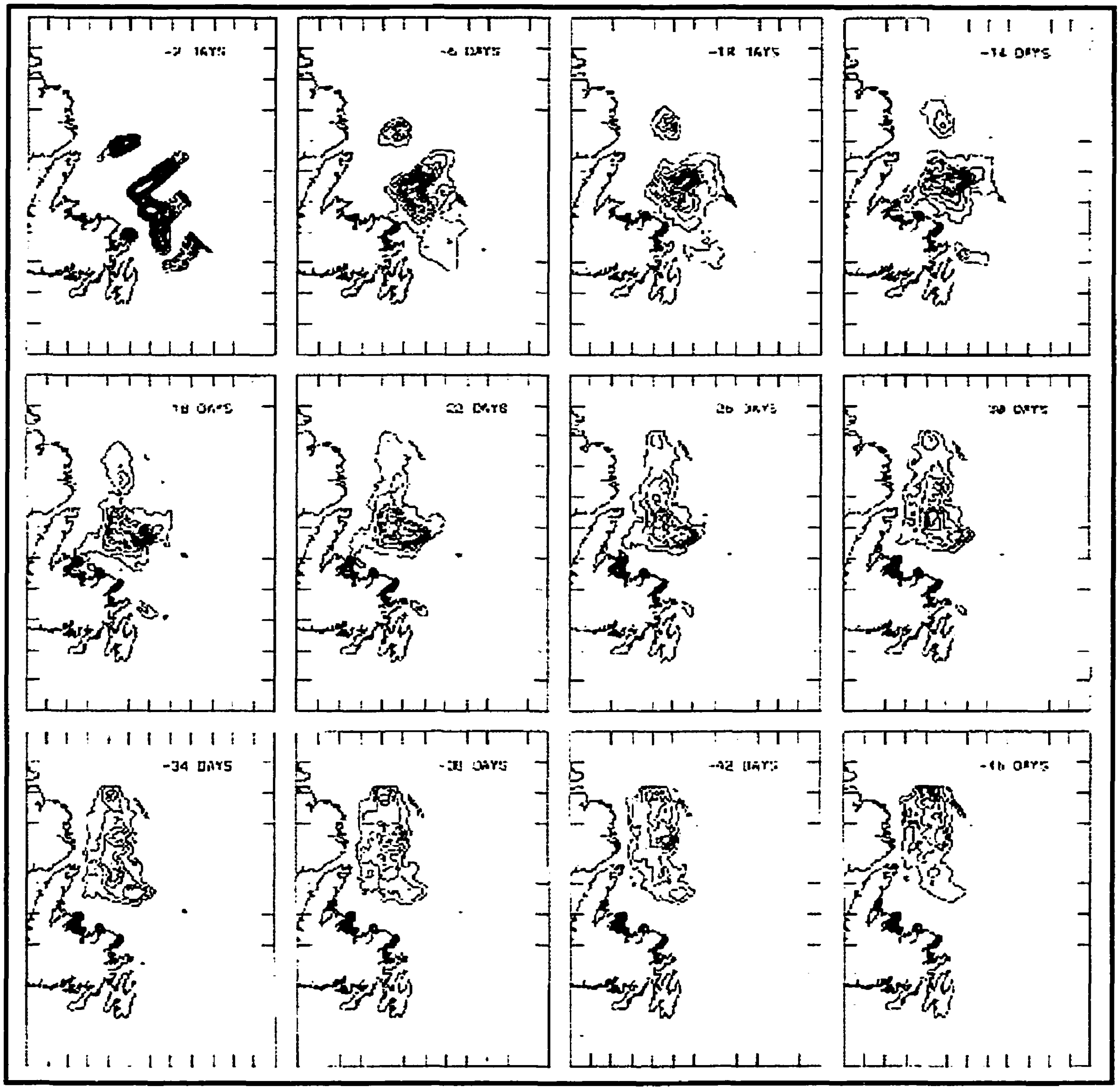


Figure 23: Time series of backtracked cod egg and larvae distributions at 4-day intervals. The contour lines indicate the relative distribution of organisms on a scale of 0-500 with an interval of 50. After: Pepin and Helbig 1997.

these simulations, Pepin and Helbig (1997) predicted that the Hamilton Bank is the source of the major larval concentration off Bonavista Bay (Figure 23) and that few offspring are produced north of the Hamilton Bank. Pepin and Helbig (1997) also predicted that the larvae near the Funk Island Bank originated to the south of the Hamilton Bank, perhaps near the Hawke Channel or Belle Island Bank.

The Hamilton Bank region has been thought to be "the engine that drives the northern cod" (deYoung and Rose 1993). From the information presented above this can easily be seen. Spawning concentrations of cod on or near the Hamilton Bank would produce billions of eggs which would be carried by the Labrador current southward to the northeast coast of Newfoundland, onward to the Grand Banks and inshore zones to nursery areas. The extant spawning concentration currently present in the Hawke Channel may be of great importance to the rebuilding of the offshore stock and inshore zones to the south (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999; FRCC 1999).

The food of the Atlantic cod consists of capelin, sandlance, redfish, herring, alewives, other Atlantic cod and Arctic cod, cunner, flounder, haddock and various other fish. As fry, cod feed on a variety of organisms such as copepods, amphipods, and other small crustaceans. Juveniles and young adults continue to eat crustaceans such as euphausiids, mysids, shrimps, and crabs (Scott and Scott 1988). In Newfoundland waters, capelin is the dominant prey species of mature Atlantic cod (Lilly 1994). Cod have several predators. As juveniles they are eaten by larger cod, squid and pollock and Minke whales (*Balaenoptera acutorostrata*). Larger cod are eaten by mammals such as harbour (*Phoca vitulina*), grey (*Halichoerus grypus*) and harp seals (*Phagophilus groenladicus*).

Stock Size and Resource Status

In the Atlantic region there are at least 12-14 recognized cod stocks, of which the largest has been the southern Labrador-east Newfoundland, or the 2J3KL stock complex (also referred to as the Northern cod stock). Others include the northern and southern Gulf of St. Lawrence stocks, southern Grand Bank stock and the Northern Labrador stocks (Scott and Scott 1988). It is widely recognized that these stocks, in particular the northern cod, comprise a complex of several populations (deYoung and Rose 1993).

There are very few cod presently in the offshore regions, and the cod that are there are broadly distributed. There are some cod present on the plateau of the Grand Bank in Division 3L (Lilly *et al.* 1999) and acoustic surveys in June of 1999 in the Hawke Channel have located juvenile and post spawning cod at low densities (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999). This biomass of cod in the Hawke Channel has been assessed by acoustic/trawl surveys since June of 1994 (in 1997 there was no survey). The dominant year class in 1994 were 5 year olds (1989 year class) (Figure 24a). In 1995, the dominant fish were younger and there were very few older fish. The dominant year classes were from 1991, 1992, and 1993 (4, 3, and 2 year olds) (Figure 24). In the 1996 survey, the dominant year classes were from 1993 and 1994 (3-4 year olds) and a high abundance of 2 year olds (1994 year class) were also observed (Figure 24). There was no survey carried out in 1997. In 1998, approximately 16 million cod were surveyed in the Hawke Channel (Figure 24b shows an echogram of cod taken in 1998 in the Hawke Channel). The majority of these fish were 4 years old (1994 year class) and 50% of females were mature and had spawned. However gonad size was tiny and egg quality was most likely poor. These fish will likely spawn again as five year olds in the spring of 1999.

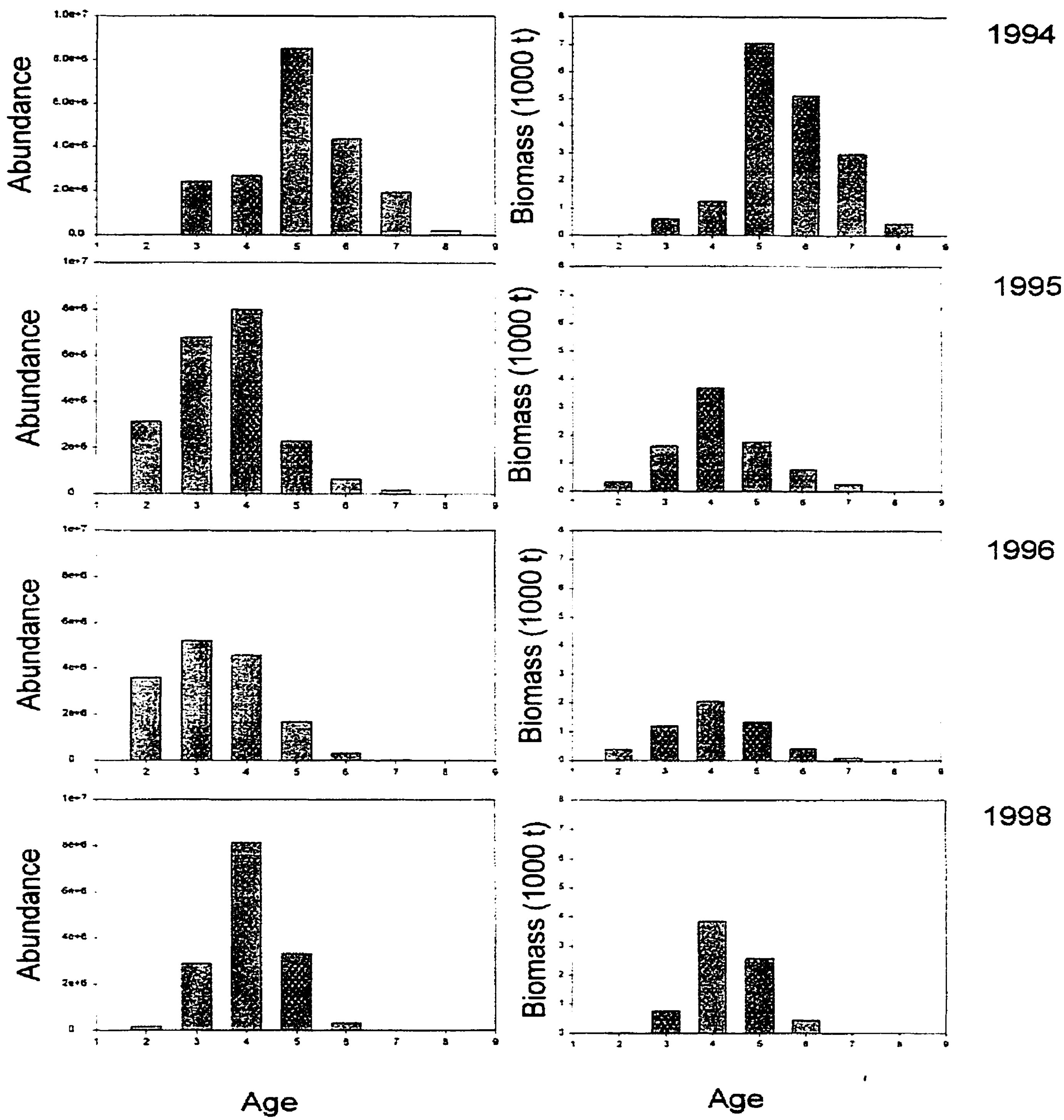


Figure 24a: Hawke Channel cod abundance and biomass, June 1994-98. Note there is no data for 1997. Source: G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999.

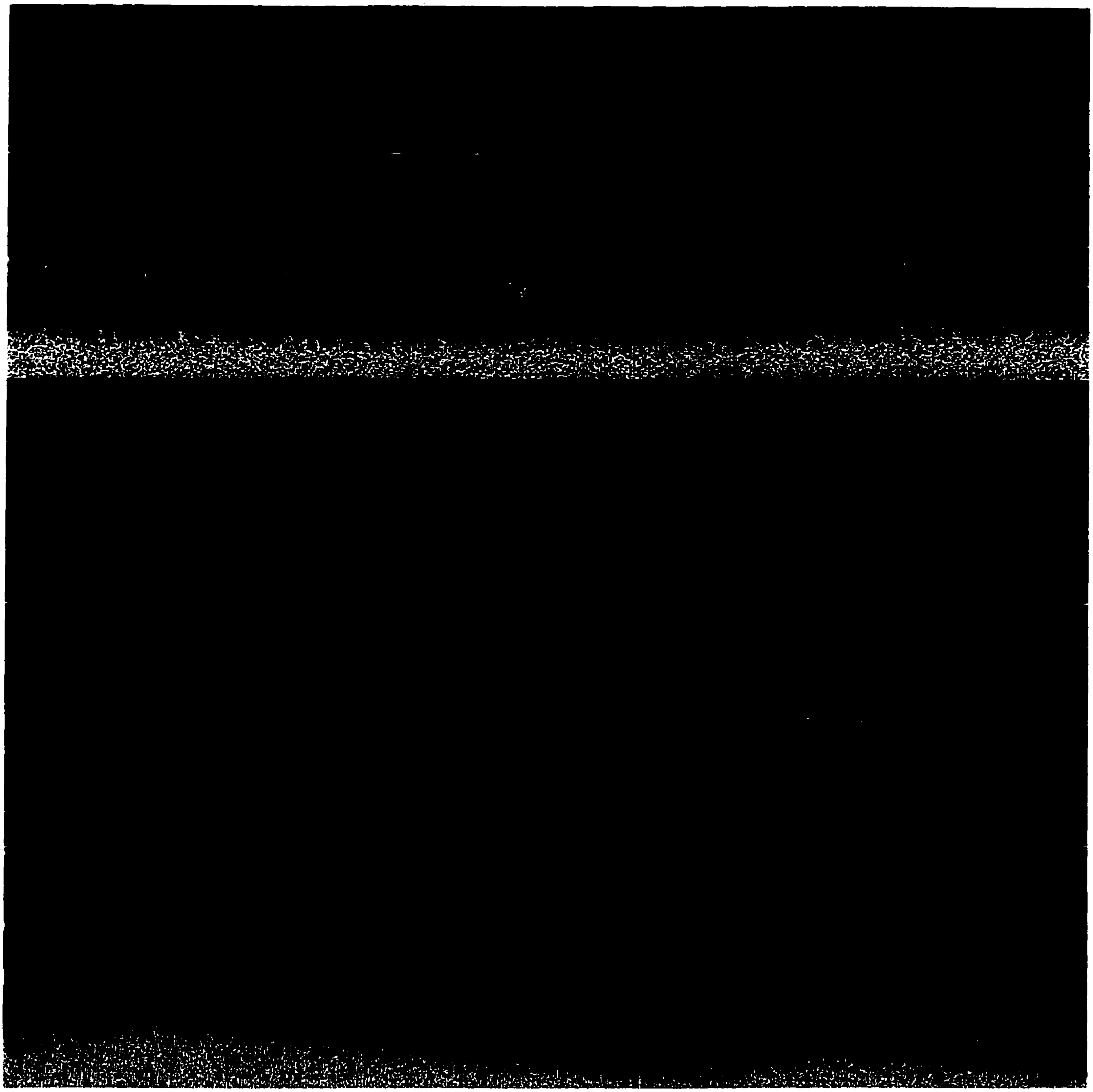


Fig. 24b. Echogram of cod in Hawke Channel in June, 1998. Panel width approximately 5 nmiles.
Top panel is bottom 10 m expanded.

The spawning potential of these fish will increase over the next few years with increased size if excessive morality does not occur (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999).

The total biomass and the spawning potential of the 2J3KL offshore cod stock is extremely low compared to levels measured historically or even in the 1980s. Spawning biomass continued to decline, especially north of Division 3L, even after the moratorium was put in place (Lilly *et al.* 1999). Recruitment and age structures are also very poor on the offshore shelf but have been improving inshore (FRCC 1999). The recovery of this offshore component in the near future through regeneration from the fish that are currently there (Hawke Channel cod), appears unlikely. However, immigration from other regions could play a role in jump-starting recruitment (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999).

The health of the inshore fishery is also uncertain. In the past, cod from offshore areas migrated inshore in the summer feeding on fish species such as capelin and herring. It has been suggested that this historical cross-shelf migration from offshore to inshore is no longer occurring (Rose 1996). There is some evidence that inshore cod may be genetically separate from offshore cod (Ruzzante *et al.* 1997). Genetic studies suggest that coastal populations in Conception, Trinity, Bonavista, and Placentia Bays are not genetically distinct. However, coastal components show broad scale dissimilarity from offshore components, but at small scales these differences are inconsistent (FRCC 1999). Ruzzante *et al* (1997) have also found genetic differences between offshore overwintering cod from the Grand Bank region and cod from Trinity Bay. At present it is unclear how various levels of fishing imposed on the inshore stocks might impact the rebuilding of the offshore components of the northern cod stock.

Table 8a: Historical landings (t) of cod from NAFO Division 2J and total landings from 2J3KL (Source: Lilly *et al.* 1998)

Year	Offshore Canada	Offshore Other	Fixed Gear Canada	Total	Total 2J3KL
1959	0	46372	17533	63905	359572
1960	1	164123	15418	179542	467802
1961	1	243144	17545	260690	505105
1962	0	226841	23424	250265	507026
1963	1	197868	23767	221636	509209
1964	13	197359	14787	212159	602651
1965	0	246650	25117	271767	545053
1966	39	226244	22645	248928	524505
1967	28	217255	27721	245004	611764
1968	4650	355108	12937	372695	810014
1969	30	405231	4328	409589	753690
1970	0	212961	1963	214924	520226
1971	0	154700	3313	158013	439518
1972	0	149435	1725	151160	458295
1973	1123	52985	3619	57727	354509
1974	0	119463	1804	121267	372650
1975	410	78578	3000	81988	287508
1976	94	30691	3851	34636	214220
1977	525	39584	3523	43632	172720
1978	4682	17546	6638	28866	138559
1979	9194	6537	8445	24176	166899
1980	13592	7437	17210	38239	175788
1981	22125	4760	14251	41136	170748
1982	58384	8923	14429	81736	229774
1983	37276	4158	10748	52182	232345
1984	9231	2782	13150	25163	232471
1985	1466	78	10211	11755	231293
1986	5734	7859	12916	26509	266713
1987	39344	3999	16022	59365	239924
1988	41468	9	17112	58589	268677
1989	33626	1003	23304	57933	253990
1990	17883	183	14505	32571	219452
1991	621	82	2214	2917	172012
1992	0	0	18	18	40956
1993	0	0	13	13	11392
1994	0	0	9	9	1363
1995	0	0	0	0	311
1996	0	0	3	3	1501
1997	0	0	3	3	505
Total	301541	3429948	409221	4140710	12070710

Table 8b: 1977-1997 2J cod landings (tonnes) by unit area. Note: catches are by Canadian vessels only. Source: A. M. Russell, Department of Fisheries and Oceans, Statistics Branch, St. John's, NF, personal communication, 1999

Year	2J A	2J B	2J C	2J D	2J E	2J F	2J G	2J I	2J L	2J M	2J N	Total
1977	392.0	1.37	0	633.2	0.349	2.771	0	2.208	45.90	2501	59.18	3637
1978	486.0	4.27	0.171	492.1	4.011	198.8	0	5.687	2519	5655	1237	10602
1979	812.6	1072	85.63	1404	521.0	64.03	3.935	5.332	5006	6826	873.9	16676
1980	634.0	13.1	17.29	3044	14.90	1435	309.1	0	3423	12687	6654	27060
1981	1008	7.06	0	3194	3.944	9476	0	154.6	4598	9841	11406	31649
1982	3391	615	2183	3487	258.3	16524	187.9	1467	1549	7484	25894	55990
1983	2261	172	0	1468	295.4	266.1	118.1	2475	1489	6979	3031	34815
1984	2367	183	105.2	1682	199.4	7.651	0	576.8	1139	9111	3543	19173
1985	1319	44	0	831.7	288.4	1749	0	95.89	303.7	8050	656.9	11598
1986	874.8	4.16	11.20	1194	76.50	10475	0.518	531.1	1168	10730	571.7	16912
1987	724.4	60.3	2329	1202	47.90	9940	0	559.7	8763	14021	7965	46148
1988	1196	674	2688	1390	488.1	14517	154.2	205.0	8829	14021	10772	50360
1989	461.6	932	1661	1648	1967	2528	51.02	2271	4661	20365	2814	51351
1990	308.4	28	7.310	783.1	147.1	44.12	0	1239	5810	12516	6375	29742
1991	0	0	6.911	0.341	0.552	0	0	5.441	11.23	2068	623.4	2760
1992	0.962	0	0	0	0	0	0	0	0	17.38	0	18.34
1993	0.102	0	0	0	0	0	0	0	0	12.76	0	12.86
1994	0.062	0	0	0	0	0	0	0	0	8.580	0	8.642
1995	0	0	0	0	0	0	0	0	0	0	.0140	0.014
1996	0	0	0	0	0	0	0	0	0	0	.0280	0.028
1997	0.423	0	0	0		0	0	0	0	0.258	0	0.681
Totals	16239.9	3812.26	9096.72	22455.1	4314.86	67229.2	826.773	9595.78	49316.3	142896.8	82478.2	408513.5

The Fishery

The offshore fishery for northern cod in Division 2J has been documented back as far as 1959 (Lilly *et al.* 1998). Table 8a shows catches for area 2J using offshore and fixed gear. Figure 25 shows the total catches from Division 2J compared to the total catches of Divisions 2J3KL. Figure 26 compares landings from each Division. 2J accounts for approximately 1/3 (4.14 of 12 million tonnes) of all catches taken out of the 2J3KL stock from 1959-97. The majority of this catch was taken offshore by foreign vessels (primarily

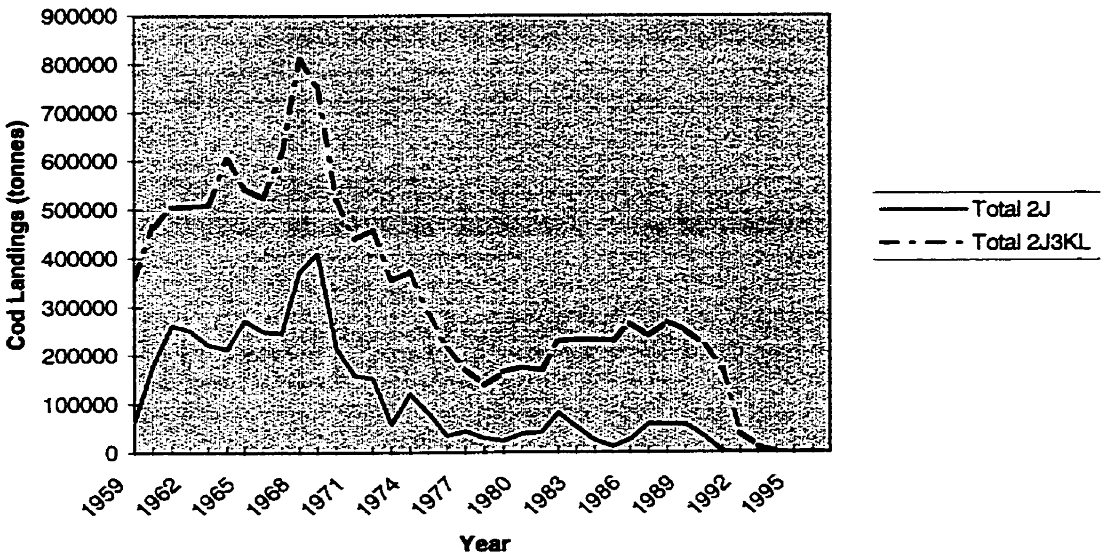


Figure 25: Historical Landings (tonnes) of cod from division 2J compared with total landings from Divisions 2J3KL from 1959-1997 (Source: Lilly *et al.* 1998).

from the former U. S. S. R) from 1960-1975. It must also be noted that Division 2J is smaller in area than both Divisions 3K and 3L and probably did not have the same fishing pressure due to ice conditions in the winter months.

Catch data by unit area of 2J (Table 8b) for Newfoundland (1977-97) has been provided by the DFO statistics branch. This data provides a better overview of the cod fishery in the Hamilton Bank-Hawke Channel area. Table 8b shows that from 1977-97 there were 173,000 tonnes of cod caught in the Hamilton Bank-Hawke Channel area (unit

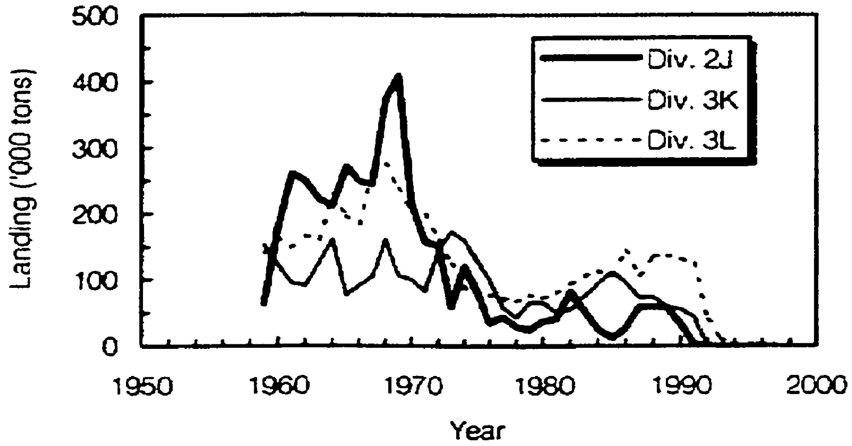


Figure 26: Northern cod landings by Division, 1959-92. (After NAFO 1998a)

areas: 2J C, 2J E, 2J F, 2J I, and 2J N represent the Hamilton Bank-Hawke Channel region). This represented 42% of all landings and had a landed value of approximately $61 million to fishers of Newfoundland and Labrador. (A. M. Russell, Department of Fisheries and Oceans, Statistics Branch, St. John's, NF, personal communication, 1999).

There is no current commercial fishery for cod in Division 2J. However, inshore sentinel fisheries and bycatch in offshore shrimp fisheries in the Hawke Channel do indicate that stock levels are very low. Bycatch of cod in the offshore shrimp fishery in the Hawke Channel must be studied further in order to determine if that fishery is detrimental to the existing cod stock in that area.

5.3 Greenland Halibut (*R. hippoglossoides* Walbaum)

Biology and Distribution

The Greenland halibut (*R. hippoglossoides* Walbaum) is a deep-water flatfish found in both the Atlantic and Pacific oceans. Since it has such a wide geographical range, this species is known under a wide variety of common names including "Greenland halibut" in the United States, "Greenland turbot" or simply "turbot" in eastern Canada and "blue" or "black" halibut in Europe. This species must be distinguished from the true European turbot (*Scopthalmus maximus*) which commands a very high price in European countries (Department of Fisheries and Oceans 1984).

The Greenland halibut belongs to the flatfish order Pleuronectiformes. These fish are similar to the Atlantic halibut but are much smaller. The "turbot" can reach a size of up to 120 cm and a maximum weight of 25 kg. This species, like others of this group, undergo unique changes during metamorphosis out of the larval stage. One eye gradually migrates across the top of the skull to the other side of the head, while the fish turns over and settles to the bottom on its flat, eyeless side. Unlike other flatfish species, however, the Greenland halibut seems to be more mobile and frequently swims up in the water column. The left eye does not completely migrate to the right side of the fish but is located on the upper edge of the forehead, giving the fish a larger field of vision than that possessed by other flatfish. Furthermore, the blind side of the fish is dark grey, whereas, in other flatfish, this side is usually white. The ocular side of the turbot is completely black (Scott and Scott 1988; Department of Fisheries and Oceans 1984).

The turbot is most commonly found at depths of 200-600 m and in water temperatures between 0 and 4.5 ^{0}C in both the North Atlantic and Pacific oceans. Fish have been found, however, at depths as shallow as 100 m and as deep as 1500 m. In the Atlantic, the turbot is found as far northward as the Arctic Ocean to Greenland, southward along the coast of Norway in the east and the coast of Newfoundland and Labrador in the west. In recent years, turbot have also been commonly found in the Gulf of St. Lawrence. The range of the turbot extends as far south as the Scotian shelf and the southwest slopes of Georges Bank (Department of Fisheries and Oceans 1984).

The Greenland halibut is a voracious predator, feeding mainly on capelin, Atlantic and Arctic cod, small Greenland halibut, grenadier, redfish, sandlance, shrimp (*P. borealis*), and various other organisms. These food sources may be taken in midwater or near the bottom. Summer and autumn appear to be the seasons of greatest feeding activity (Scott and Scott 1988).

Northwest Atlantic turbot spawn in winter or early spring, probably in the Davis Strait in depths of 650-1000 m. Other known spawning grounds include the Gulf of St. Lawrence and the Laurentian Channel. Females can produce 30,000 – 300,000 eggs. The number of eggs is positively correlated with the length of the female. Fertilized eggs drift at middle depths for a number of weeks before hatching, after which larvae rise to about 30 m. Once they reach a size of about 70 mm, the young sink to depths of around 750 m after being carried southward by the Labrador Current to the continental shelf area off Newfoundland and Labrador where they grow and mature (Scott and Scott 1988; Department of Fisheries and Oceans 1984). It is unknown if Greenland Halibut eggs and larvae follow the same patterns of distribution as cod (Section 5.2). Further research is needed to determine actual distributions and nursery areas of Greenland Halibut.

Male and female Greenland halibut have been reported to grow at the same rate up to a length of 45 cm (5-7 years), after which females grow faster, reach larger sizes and live longer than males of the species. Males can reach an age of about 12 years and a size of 70-80 cm, whereas females have been recorded up to 20 years old and can reach sizes of up to 110 cm. All fish above 90 cm are females (Scott and Scott 1988).

Stock Size and Resource Status

In the northwest Atlantic, Greenland halibut are divided into three separate sub-stocks for management purposes. These include the Baffin Island/West Greenland stock (NAFO divisions OAB + 1A-F), the Labrador/East Newfoundland stock (NAFO divisions Subarea 2 + 3KLMNO) and the Gulf of St. Lawrence stock (NAFO division 4RST) (Department of Fisheries and Oceans 1984).

Labrador/East Newfoundland stock

The Greenland halibut stock in Subarea 2 and Div. 3KLMNO (referred from this point onward as the Labrador/East Newfoundland stock) is considered to be part of a biological stock complex that includes Subareas 0 and 1 (NAFO 1998). The FRCC (1997) indicates that the total biomass is showing signs of recovery from low levels in the early 1990s (the biomass of this stock in 1997 was estimated to be approximately 225,000 metric tonnes). The fishable biomass of this stock at this time remained below average as compared to the 1980s but increase is expected with high recruitment to the fishery in 1998-1999 (Figure 27) (FRCC 1998).

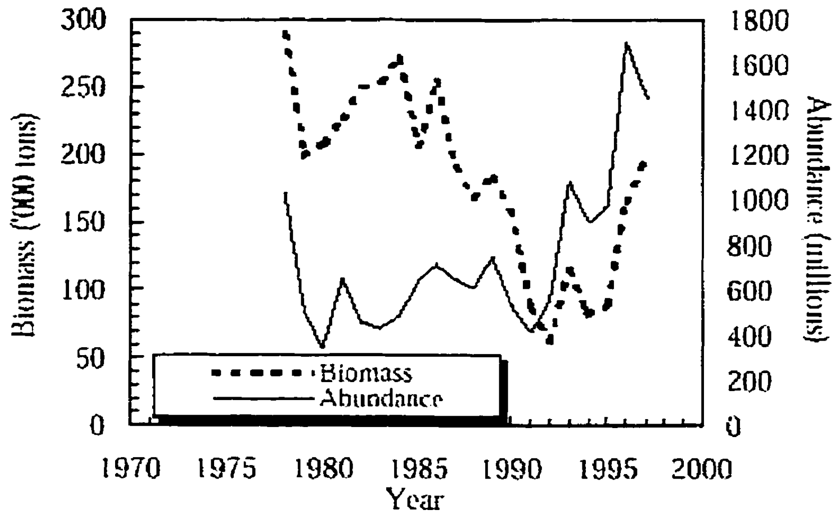


Figure 27: Biomass and Abundance of Greenland halibut from the Labrador/East Newfoundland stock (Subarea 2 and 3KLMNO) (Taken from: NAFO 1998).

NAFO could not advise on a TAC for 1999 in this area but suggested that an increase in catch from 1996-97 levels (20,000 tonnes) to about 30,000 tonnes would not affect recovery of the stock (NAFO 1998).

Unfortunately, there is no way to determine the biomass estimates for Division 2J or even more specifically the Hamilton Bank-Hawke Channel area. However, there are some fishers that feel that the Greenland halibut are making a strong recovery in this area and are hopeful that a prosperous fishery will develop in the near future (R. Gibbons, Fisheries & Marine Institute, St. John's, NF, personal communication, 1999).

The Fishery

The sale of Greenland halibut from this particular stock has been dated back as far as 1857. This fishery was a local, traditional long-line fishery until about 1964 when gill nets were introduced. Also, in the late 1960s, Polish and Soviet fleets began fishing the continental shelf area off Newfoundland and eventually moved to deeper waters off the coast of Labrador. The Newfoundland landings at this time declined to low levels. In addition, from 1970 - 1977, landings stabilized at approximately 30,000 tonnes per year. In 1977, however, after Canada declared its 200 mile EEZ (Exclusive Economic Zone), foreign effort on the Greenland halibut stock was greatly reduced (Department of Fisheries and Oceans 1984). The Newfoundland gillnet fishery in this area proved successful over the next few years and averaged approximately 20,000 tonnes until the late 1980s (FRCC 1997). In 1990 a deep-water fishery emerged using otter trawls which further increased the catch rates in this area (Figures 27 and 28).

In the early 1990s annual turbot catches increased from 60,000 - 70,000 tonnes (Figures 27 and 28), mainly due to a developing fishery in 3LMN. TACs at this period were set at 50,000 tonnes but were reduced to 27,000 tonnes in 1995 and subsequent years (Figure 29) (NAFO 1998). Catches have been well below TACs from 1995-97 (NAFO 1998).

During the 1997 FRCC consultations there were concerns raised about the effects of a deep-water fishery on this stock. There were some suggestions that catch rates are declining and fishermen are reducing mesh sizes and moving to shallower water. This may be some indication that this particular stock is being overfished.

In 1997, total Greenland halibut landings for Atlantic Canada were estimated to be 16, 411 tonnes with a total value of $20,351,000 Canadian. Newfoundland harvests the greatest percentage of this total at 13, 565 tonnes ($15,090,000 landed value).

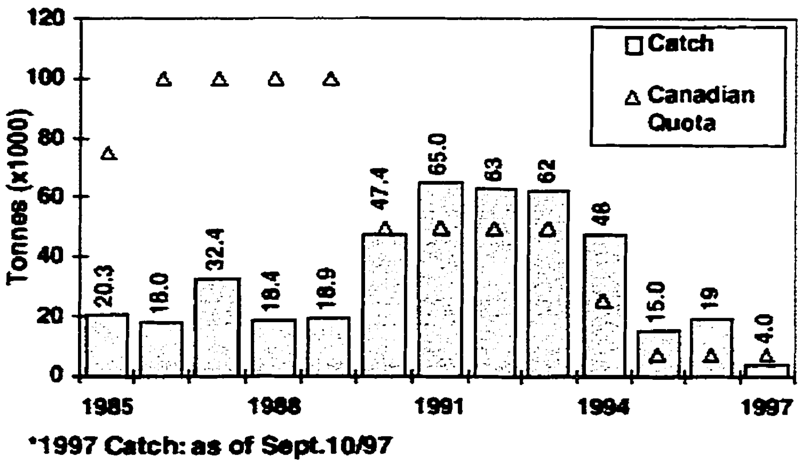


Figure 28: Harvesting levels and Canadian quotas for Labrador/East Newfoundland Greenland halibut stock (FRCC 1997).

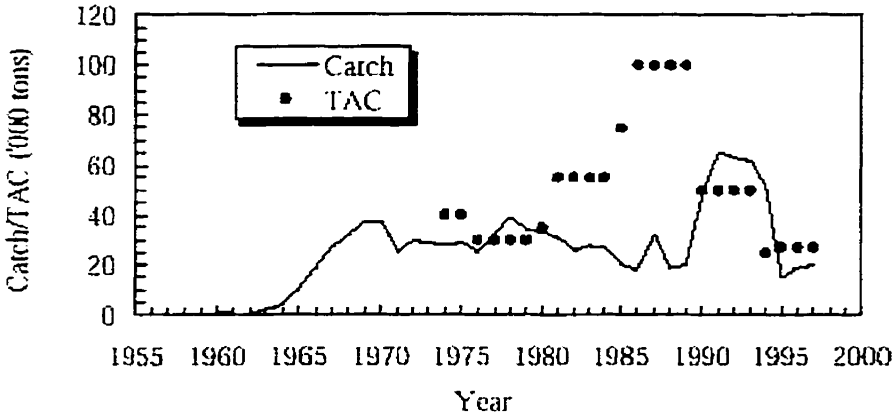


Figure 29: History of harvesting levels and TACs for Labrador/East Newfoundland Greenland halibut stock (NAFO 1998).

Quebec landed 2,146 tonnes ($3,439,000 landed value), Nova Scotia landed 670 metric tonnes ($1,761,000 landed value) and New Brunswick landed the lowest percentage with a total of 49 tonnes ($60,000 landed value) (Found at http://www.dfo-mpo.gc.ca/). Only 4 (Figure 28) tonnes of the 16,411 tonnes harvested by fishers of

Atlantic Canada in 1997 came out of the Labrador/East Newfoundland stock. The numbers of vessels and fishermen involved in this fishery are not available at this time.

5.4 Capelin *(M. villosus)*

Biology and Distribution

The capelin is a marine fish of cold, deep waters, found in the Atlantic in coastal areas and on offshore banks. The capelin is circumpolar in distribution and is found from Hudson Bay to Nova Scotia and the Grand Banks on the east coast of North America with the greatest quantities occurring off the coasts of Newfoundland and Labrador. In the 1980s capelin were widely distributed from Division 2J-3L, with a cline of larger to smaller capelin occurring from north to south. In the early to mid-1990s, very few capelin have been observed in 2J and northern 3K. Most capelin during this period were observed in southeastern 3K and northern 3L. However, capelin distribution in recent years appears to be changing to more closely resemble the distribution of the 1980s when capelin where widely distributed from Division 2J to 3L. These changes in distribution may be the first indicators that capelin are reverting to behaviour and distributions more typical of historical norms than previously observed in the early 1990s (Anonymous 1999a).

Capelin undergo extensive migrations to inshore areas to spawn, however, offshore spawning also occurs. On the south and east coasts of Newfoundland and Labrador spawning begins around the first part of June and may continue through July, depending on sea temperature and weather conditions. Large females may produce up to 50,000 eggs and hatching takes place 9-11 days (high tide zone) or 22-24 days (low tide zone) (Scott and Scott 1988). No information is given on development time for offshore spawning fish, however it would be expected that development time would take longer as water temperatures would be considerably lower.

The food of capelin is made up entirely of planktonic organisms with euphausiids and copepods being the dominant prey. Amphipods and other invertebrates are also taken. Feeding is the highest in the prespawning period (late winter-early spring), declines as the spawning season approaches, and essentially stops during spawning. Several weeks after spawning, any surviving capelin begin feeding again until cessation in early winter (Scott and Scott 1988).

There are at least 10 fish species, several species of marine mammals, and 9 marine bird species that feed on capelin. They include: Atlantic cod, haddock, Atlantic salmon, herring (feed on larvae and juveniles), flounders, eelpout, sculpins, dogfish, Minke whales (*Balaenoptera acutorostrata)*, Fin whales (*Balaenoptera physalus*), Sei whales (*Balaenoptera borealis*), killer whales (*Oricinus orca*), harbour porpoise (*Phocoena phonoeca*), harp seals (*Phagophilus groenladicus)*, grey seals (*Halichoerus grypus*) and various seabirds such as the thick-billed murre (*Uria lomvia*). The role of capelin as a food source for other marine species is very significant and has been estimated to be in the order of 5 million tonnes annually at virgin population levels (Scott and Scott 1988).

Stock Size and Resource Status

No biomass estimates could be determined for the Hamilton Bank-Hawke Channel area as data was not available. In historic times however, seasonal biomass levels in the Hamilton Bank-Hawke Channel may have been in the order of millions of tonnes. Capelin virtually disappeared from the area in the late 1980s (Frank *et al.* 1996;

Carscadden and Nakashima 1997). However, recent hydroacoustic surveys carried out in the Hawke Channel area suggest that the capelin abundance in the area has been increasing since 1997 (R. O'Driscoll, Fisheries Conservation Chair, Memorial University of Newfoundland, St John's, NF, personal communication, 1999). The annual biomass index of the capelin stock in Subarea 2-Division 3KL, based on inshore surveys, was estimated to be at an historically high level during the 1993-96 period but not dramatically higher than the mid to late 1980s (Figure 30) (Anonymous 1997a). Data is very limited from the years 1996-1998. The outlook for 1999 predicts that the 1995 and 1996 year classes are expected to be major contributors to the 1999 spawning stock. Results from mathematical models suggest that both the 1997 and 1998 year classes are weaker than the 1995-96 year classes (Anonymous 1999a).

The stock status has been difficult to determine in recent years because of the divergence between inshore indices and offshore acoustic surveys (Anonymous 1997a). In addition, the capelin acoustic survey has not taken place in the last few years. This lack of data has reduced the accuracy of correctly predicting capelin biomass in the offshore regions. There is concern that the scientific investigations have been reduced to such an extent that it may not be possible to assess the status of the capelin stock in the near future (Anonymous 1999a). Given the importance of capelin to the Newfoundland/Labrador Shelf ecosystem, it is imperative that more information be obtained on the health and status of the 2J3KL-capelin stock.

The Fishery

Historically, a small domestic fishery (annual harvest estimated at about 25,000 t) for capelin on the Newfoundland spawning beaches existed to provide food, bait, and fertilizer. Foreign fisheries began in the early 1970s and were closed in Div.3L in 1979 and Div. 2J3K in 1992. During the late 1970s, an inshore fishery for roe capelin began (Anonymous 1999a).

Figure 31 shows the reported catches of capelin from 1960-98 in Subarea 2-Division 3K. The majority of this catch was taken by the former Soviet Union (83% of all catch) mostly for reduction to animal feed (NAFO 1995). Unfortunately, there is no way to determine the percentages of catches that came from the Hamilton Bank-Hawke Channel region during this period. The value of this fishery to harvesters from Newfoundland cannot be determined. However, it must be noted that prices for capelin during this time were very low, as were the overall Canadian landings. It therefore must be assumed that the importance of this fishery as an economic producer was minimal.

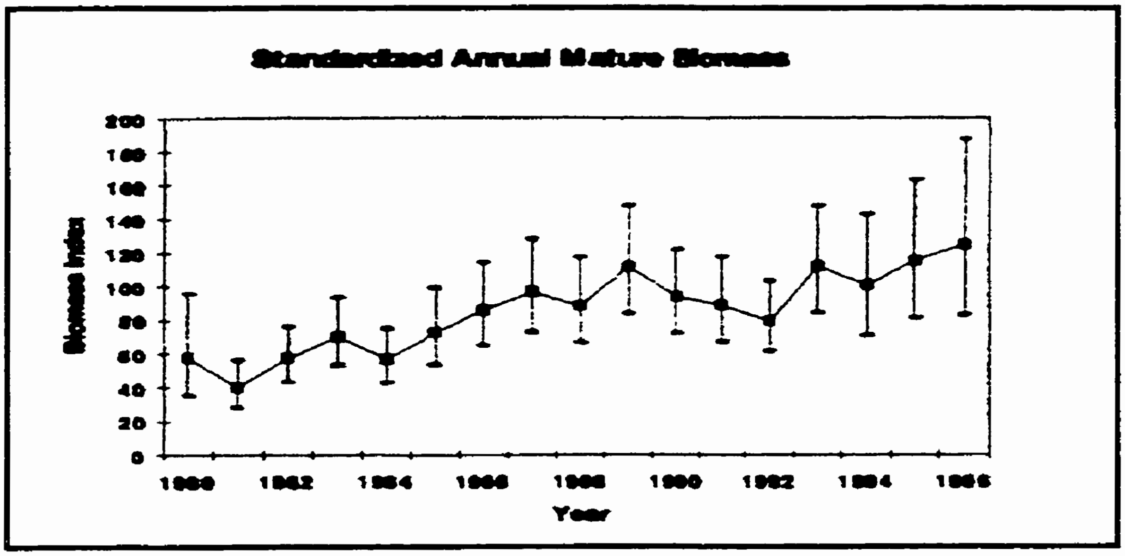


Figure 30: Standard annual mature biomass index for capelin in Subarea 2+ Div 3KL. 1980-95. After: Anonymous 1997a.

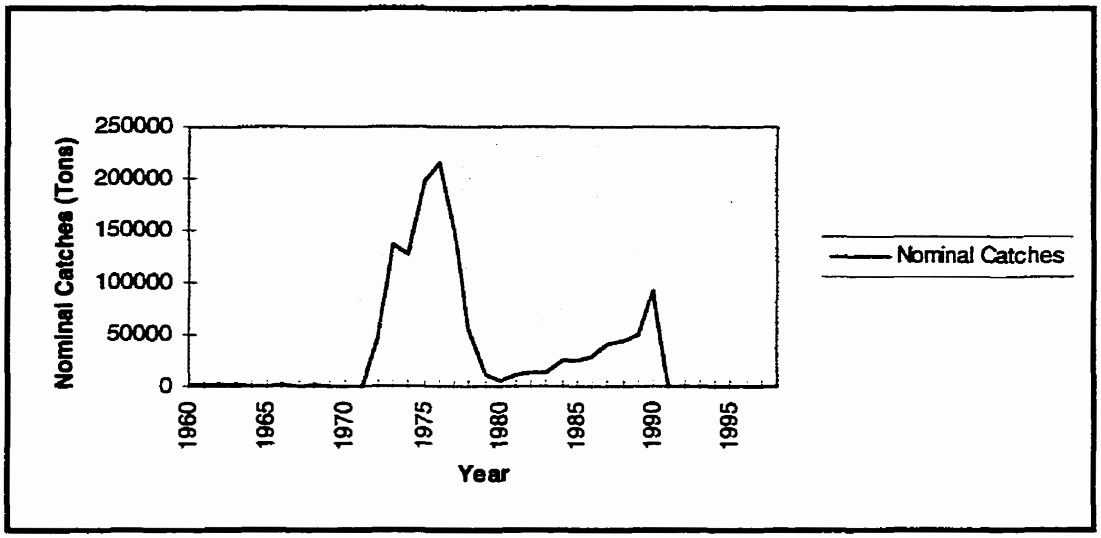


Figure 31: Nominal catches of capelin from Subarea 2 + Division 3K, 1960-90. (Source: NAFO 1995). Note: catches from 1990-1998 are Canadian inshore landings, all catches prior to this date are all countries.

5.5 Redfish (*Sebastes mentella, Sebastes marinius, Sebastes fasciatus*)

Biology and Distribution

The redfishes of the genus *Sebastes* are represented in the Canadian Atlantic waters by three species: *S. mentella, S. marinius, S. fasciatus*. The three species are very similar in appearance (not distinguished commercially, and are marketed simply as Redfish or Ocean Perch) and have overlapping distributions. *S. mentella* is the most widely distributed of these three species. *S. mentella* occurs throughout the range of the *Sebastes* genus (from northern Greenland to Virginia, U. S. A), except in the North Sea and the Gulf of Maine. *S. mentella* ranges further north, occurs further offshore and into deeper water than the other two species. *S. fasciatus* is essentially a North American species, however, it is rare on the Labrador shelf. It ranges further south and inhabits shallower water than the other two species. *S. marinius* is said to be common off

Greenland, Iceland, Norway, and in the southern Barents Sea, but is much less common off North America than *S. fasciatus* and *S. mentella* (Scott and Scott 1988).

All three species are benthic in nature, favouring rocky or clay-slit bottoms. However redfish exhibit strong vertical migration patterns, in which they remain near or on the bottom during the day and rise off the bottom at night to feed. *S. fasciatus* inhabits the shallowest waters, preferring depths of a few meters down to 592 m. *S. marinius* also inhabits shallow waters, occurring from depths of less than 300 m to 750 m. *S. mentella*, occurs at depths from 300-700 m, but has been caught as deep as 1100 m (Scott and Scott 1988).

All redfishes are slow growing (7.6 cm in the first year, 2.5 cm/year until they reach age 10), and long-lived. They are an ovoviviparous group, meaning they reproduce by giving birth to live young. Size at reproductive maturity varies between the three groups. For *S. fasciatus* and *S. mentella*, reproductive maturity occurs when males are 18.5 cm, and when females are 29.5 cm. Spawning for these two species occurs from March to July, however females are pregnant with eggs and developing larvae as early as February. For *S. marinius* females are 40.5 cm at maturity and spawning takes place from April to May. For all three species the age of first spawning is 10 (Scott and Scott 1988).

Redfish are pelagic and/or bathypelagic feeders. They feed on amphipods, copepods, and euphausiids primarily and also eat some fish. Feeding is thought to take place at night during vertical migrations. The chief predators of the redfishes are Atlantic halibut and Atlantic cod.

Stock Size and Resource Status

There is very limited information on the biomass of redfish in Division 2J at this time. The most recent stock status report available was published in 1995 and data from that point onward is limited. Results from research vessel surveys in Divisions 2J and 3K from 1994 suggest that population biomass indices in both areas were at historically low levels. There has been a general decline in the 2J biomass index from an average of 200,000 tonnes (1978-1981) to an average of 1,600 tonnes (1992-1993). In addition, there has been over 20 years of recruitment failure since the strong year classes of the early 1970s. There has been no information presented that would indicate that the status of this stock is likely to improve in the near future. Any good recruitment coming into this stock will need a minimum of 10 years before it will contribute to a fishery and/or the spawning biomass (Anonymous 1995).

The Fishery

In the late 1950s and early 1960s there was a strong foreign (the former U. S. S. R) presence in Division 2J. The highest catch of redfish taken from this stock was 187,000 tonnes in 1959 (Anonymous 1995), 80,000 tonnes of which was taken by the former U. S. S. R. (Travin and Pechenik 1963). Between 1961 and 1986 harvest rates averaged approximately 27,000 tonnes, with no less than 14,500 tonnes taken in any one year. Since 1986 catches declined from 18,500 tonnes to 280 tonnes by 1991 due to a reduction in effort. It must be noted however that the aforementioned statistics are Canadian landings only and were primarily taken from Division 3L (Anonymous 1995). A summary of total catches from all countries is summarized in Figure 32. The majority of these catches were taken by Canada and the former U. S. S. R. There has not been any directed effort on this stock since 1990 when 2,000 tonnes were landed.

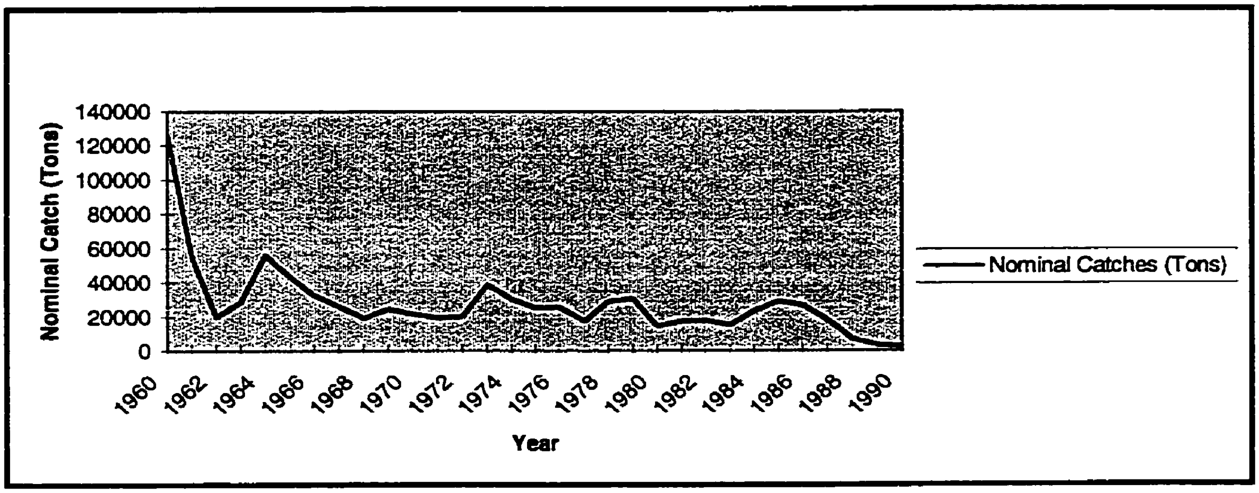


Figure 32: Nominal catches of redfish from Subarea 2+Division 3K from all countries, 1960-90. Catches are in tonnes (Source NAFO 1995).

The Canadian redfish fishery has been under regulation since 1974 when 30,000 tonnes TAC was implemented. The TAC was increased to 35,000 tonnes in 1980, decreased to 20,000 tonnes in 1990, and reduced further to 1,000 tonnes in 1994. In 1995, 200 tonnes were set aside for test fisheries (Anonymous 1995).

5.6 Atlantic Salmon (*Salmo salar*)

Biology and Distribution

The Atlantic salmon is an anadromous species, living in fresh water for at least the first 2 to 3 years of life before migrating to sea. During its early life, large cool rivers with extensive gravelly bottom headwaters are essential. As salmon parr reach approximately 15cm in length they are recognized as smolts and migrate to the ocean, where they live for 1, 2 or more years before returning to freshwater to spawn. Once at sea they exhibit extensive movements. Atlantic salmon from some Canadian rivers are known to travel as far as Greenland whereas salmon from other rivers may remain in Canadian coastal waters throughout their sea lives. Atlantic salmon also naturally occur as landlocked or freshwater populations in eastern North America. These salmon may be physically prevented from returning to the sea by obstructions but, for reasons unknown, they may also simply remain in fresh water, especially when there are large lakes in the system (Scott and Scott 1988).

Atlantic salmon at sea are typically found where water temperatures are within the range of 4-12 ^{0}C. The lower lethal in sea water of 30 ppt. salinity has been established at -0.7 ^{0}C, the upper lethal temperature has been found to be 27.8 ^{0}C. Salmon may withstand temperatures in excess of these limits for only brief periods of time (Scott and Scott 1988).

Atlantic salmon occur on both sides of the North Atlantic Ocean. In the northeastern Atlantic salmon populations occur along the European coast from the White Sea, the coasts of Norway, Sweden, and into the Baltic sea, including Finland and the former USSR, southward around the British Isles and the coasts of western Europe to the border region of Spain and Portugal (Mino River). The Atlantic salmon also occurs in Iceland. On the western side of the Atlantic the distribution of the salmon ranges from Ungava Bay, Hudson and Davis straits, and southern Greenland southward in most rivers along the Labrador coast, Newfoundland, Quebec, and the Maritime Provinces to the Connecticut River (where salmon have been reintroduced). Many landlocked populations

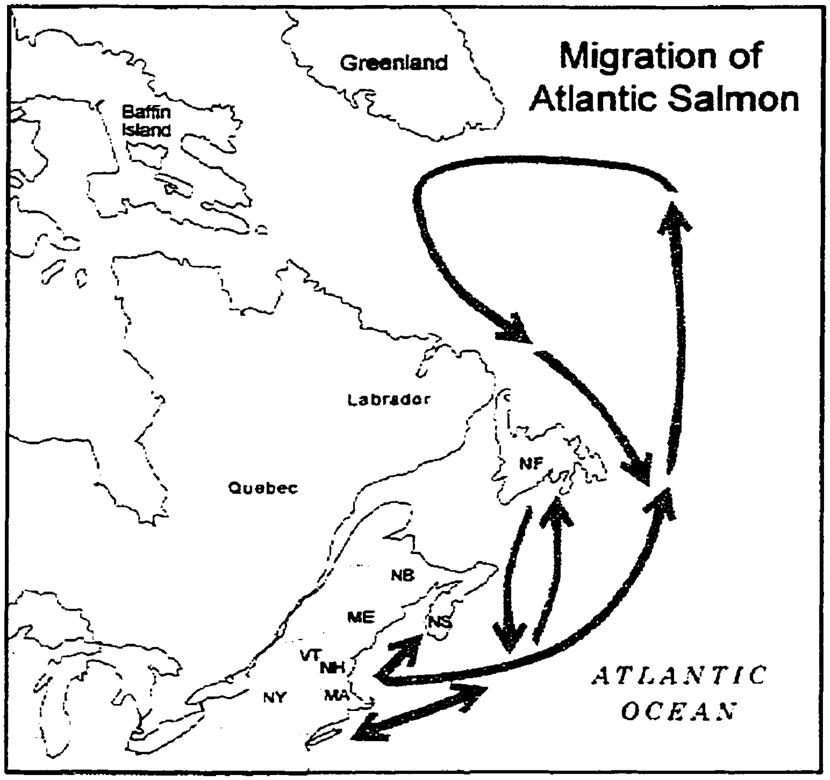


Figure 33: Atlantic salmon migration routes (*Salmo salar*) (Taken from: www. nmfs.gov/prot-res/fish/atl-salm.html

also exist throughout eastern Canada, particularly in Quebec, Newfoundland, Nova Scotia, and New Brunswick, and also in northeastern New England (Scott and Scott 1988).

The migration routes of Atlantic salmon are depicted in Figure 33. It is likely that the Atlantic salmon's offshore migration route passes over the Hamilton Bank-Hawke Channel region. Many of the best salmon rivers are in southern Labrador, inshore and south of the Hamilton Bank-Hawke Channel region. Salmon is a very valuable sport fish to many communities in Newfoundland and Labrador.

5.7 Summary

It is estimated that fish fauna of the Hamilton Bank-Hawke Channel region is made up of 51 species, none of which are endemic. In the past, many of these species have been important to commercial fishers of Newfoundland, other Atlantic Provinces, and various other nations. But unfortunately, the majority of the major fish stocks are now much reduced in the area.

The Hamilton Bank-Hawke Channel region has been thought to be "the engine that drives the northern cod" (deYoung and Rose 1993). Spawning concentrations on or near the Hamilton Bank would produce billions of eggs and larvae that would be carried by the Labrador Current to nursery zones to the south. The extant spawning concentration of cod currently present in the Hawke Channel may be of great importance to the rebuilding of the northern cod stock. The biomass of this spawning concentration was estimated at approximately 8000 tonnes in 1998 (Figure 24a). The cause of the decline in this major stock has, and will be debated for many years, but the most obvious cause was the massive overfishing of the 1950s and 1960s.

The offshore fishery for cod in Division 2J accounts for 1/3 of all catches (12 million tonnes) from the 2J3KL stock in years 1959-1997. Foreign vessels (former U. S. S. R.) took the majority of this catch. Canadian fisheries in the Hamilton Bank-Hawke Channel region harvested 177,000 tonnes (43% of all Canadian landings for 2J) of cod from 1977-1997 (worth an estimated $62 million).

Information on the biomass of Greenland halibut present in the Hamilton Bank-Hawke Channel area is unknown. However, it is believed that this region may be a potential nursery area for juveniles (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999). Estimates for the entire Labrador/East Newfoundland stock, which includes Division 2J, indicate that the stock is showing signs of recovery from low levels in the early 1990s. However, the biomass still remains below levels observed in the 1980s. The outlook for 1998-1999 was promising as a high level of recruitment to the fishery was expected. The current fishery for Greenland halibut from the Labrador/East Newfoundland stock is minimal compared to other areas. In 1997, only 4 tonnes of 16,411 tonnes total catch by Canadian fishers were taken from this stock.

Capelin biomass estimates for the Hamilton Bank-Hawke Channel region are unavailable at this time. However, historical seasonal biomass levels may have been in the order of millions of tonnes until the capelin virtually disappeared from the area in the late 1980s. Recent surveys carried out in the Hawke Channel suggest that capelin abundance has been increasing in the area since 1997. The importance of capelin as a food source for other species, such as cod, is very significant, and will play an important role in the health of the entire ecosystem of the Hamilton Bank-Hawke Channel region. There is concern that research on capelin has been reduced to such an extent that it may not be possible to assess the status of these stocks in the near future. Given the importance of capelin this problem must be remedied.

There is very limited information on the current stock size of redfish (*Sebastes* spp.) in the Hamilton Bank-Hawke Channel region. Stock assessment from 1994 suggests that population biomass indices are at historically low levels. Division 2J biomass estimates were estimated at 1,600 tonnes in 1992-1993 with very little recruitment. The redfish fishery in Division 2J was phenomenal in the late 1950s-early 1960s with the majority of the catch taken by foreign vessels (former U.S. S. R). It is clear that this stock was overfished at this time and it has not since recovered.

The Hamilton Bank-Hawke Channel region has characteristics that make it an ideal habitat for many species of commercial and non-commercial fish stocks. Due to overfishing, environmental factors, or a combination of both, most of the large stocks of these fish species have been drastically reduced. There is however, some promise for the future as small populations, compared to historical values, of cod and capelin have returned to the Hamilton Bank-Hawke Channel area.

Chapter VI: Marine Mammals

6.0 Introduction

Off the coast of Labrador, there is a diverse community of marine mammals. Several species are resident, though most migrate north into the coast and shelf waters off Labrador each summer to take advantage of the brief, but highly productive, plankton blooms (See Chapter III) and the forage species, in particular capelin, that feed on zooplankton.

6. 1 Pinnipeds

Seven pinniped species occur in the Labrador Sea and coastal Labrador. Six of these species are Phocids (true seals) and the seventh is the walrus. The ringed (*Phoca hispida* and bearded seals (*Erignathus barbatus*) are the most common species along the Labrador coast, however, bearded seals are more numerous in more northern areas. Harbour seals (*P. vitulina*) and grey seals (*H. grypus)* occur along the coast in small numbers compared to the ring and bearded seals (Petro-Canada 1982). Harp (*P. groenladicus*) and hooded seals (*Crystophora cristata*) are common in offshore waters during the winter months and have large whelping concentrations on large ice flows in areas over major offshore banks. However, yearly distributions of these species are dependent on ice flow characteristics (G. Stenson, Department of Fisheries and Oceans, St. John's, NF, personal communication, 1999). As a consequence of the primarily coastal distributions of the other Phocids only the harp and hooded seals will be discussed in this section

Harp Seal (*Phagophilus groenladicus*)

The harp seal is a sub-arctic seal that has a close association with the ice flow edge. This seal is highly gregarious and commonly associates in dense herds during breeding, migrating, and feeding periods.

The male and female harp seals reach sexual maturity at the same age (4-6 years). Breeding occurs in the water in mid to late march and females gestate for 11.5 months. The young are born on the ice at the end of February and early March and are weaned after three weeks (Petro-Canada 1982).

Harp seals eat a variety of foods, depending on their age and location. Weaned young usually feed on accessible organisms such as euphausids, although capelin may be taken. Adult females, while lactating, feed lightly on organisms such as shrimp (*P. borealis*) and other decapod crustaceans. In the molting season seals feed on a variety of organisms such as Atlantic cod, Arctic cod, Greenland cod, various species of flatfish (such as small Greenland halibut), sandlance (*Ammodytes americanus*), pelagic crustaceans and especially capelin (Stenson and Sjare 1997; Petro-Canada 1982).

The general migratory pattern of harp seals is depicted in Figure 34. During the summer, the majority of this species reside in the Arctic, occurring as far north as Thule in Northwest Greenland and Lancaster Sound in the Canadian Arctic, and extending as far west as Hudson Bay. In autumn, they migrate southward along the coast of Labrador, usually reaching the entrance to the Gulf of St. Lawrence by early winter. Once there they split into two groups, one moving into the Gulf and the other remaining off the coast of

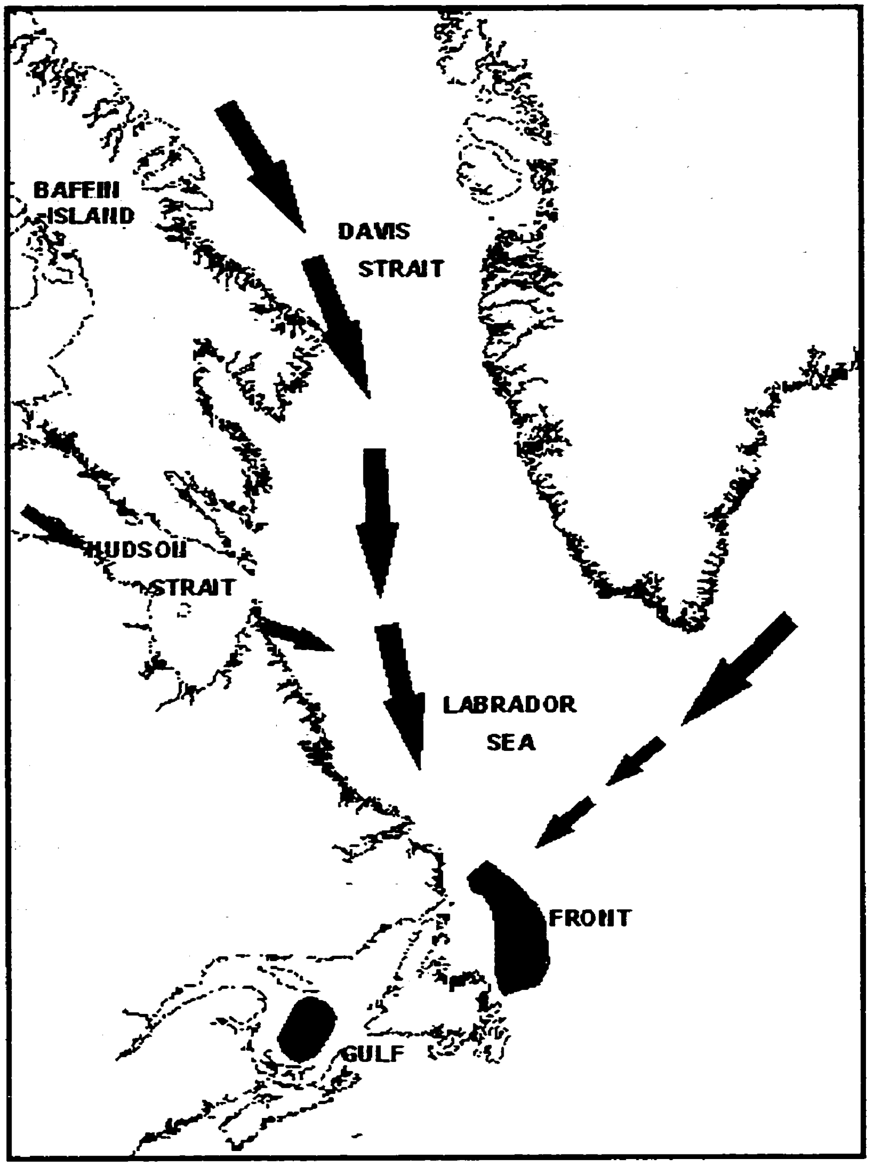


Figure 34: The general migratory patterns of harp seals showing the whelping areas (Gulf and Front) (Source: www.dfo-mpo.gc.ca/COMMUNIC/seals)

Newfoundland and Labrador. The latter group disperses across the continental shelf to feed until early March when they form large whelping concentrations off southern Labrador near areas on or near the Hamilton Bank-Hawke Channel region in the region known as the Front (Figure 34). Following mating, the seals disperse to feed, and in late April, the again congregate in large numbers on the ice to moult. These seals are then thought to remain in Newfoundland waters until June at which time they migrate north to Arctic feeding grounds (Stenson and Sjare 1997). Figure 34 also displays the "Front" (large whelping concentration) off southern Labrador. This "Front" is not fixed in space but varies from year to year with ice conditions (see Section 2.4). Pup production on the Front has been estimated by Stenson *et al.* (1993) in 1990 using photographic surveys to be 467,200.

Stock Status

The total harp seal population was estimated at 4.8 million in 1994. The replacement yield was considered to be approximately 287,000 harp seals for 1996. A replacement yield range of between 275,000 and 290,000 was calculated, depending on the age of the seals taken in the hunt. The replacement yield is the number of seals that can be taken in a given year while allowing a herd to maintain its population (Anonymous 1999).

A harp seal population survey will be undertaken in 1999 to update the population estimate. In addition, Canada will be discussing Greenland catches with the Greenland Government, because they are hunting seals from the same herd (Anonymous 1999).

Hooded Seal (*Crystophora cristata*)

The hooded seal is a large Phocid, which occurs in the North Atlantic as far north as Ellesmere Island. These seals are common in the summer near Greenland and progress to the Davis Strait in early September. They then migrate to the Labrador Sea in late fall and overwinter in waters near Newfoundland (Petro-Canada 1982). Whelping occurs on the heavy pack ice off the south coast of Labrador on the aforementioned 'Front'. The larger hooded seals tend to be on the thicker ice, further offshore, whereas the smaller harp seals are typically found further inshore on thinner ice (G. Stenson, Department of Fisheries and Oceans, St. John's, NF, Personal communication,1999).

The male and female of this species reach sexual maturity around three years of age. Whelping occurs in the last half of March. The total gestation period lasts about 11.5 months and the pups are weaned after 12 days (Petro-Canada 1982). The 1990 hooded seal pup production on the Front was estimated by Stenson *et al.* (1997) to be 49,600 pups.

The hooded seal is an opportunistic feeder capable of diving up to 200m. These seals feed on small pelagic crustaceans, squid, mollusks, and many fish including Atlantic cod, capelin, herring, redfish, and Arctic cod (Petro-Canada 1982).

Stock Status

Hooded seals are considerably less abundant than harp seals. The 1990 hooded seal population estimate was 400,000 to 450,000. The 1997 TAC for hooded seals (10,000 seals) is considerably below the replacement yield, which is estimated at 24,000 to 34,000 animals, depending on the age composition of the hunt (Anonymous 1999).

A hooded seal population survey is planned for the year 2000 to update the population estimate. In addition, Canada will be discussing Greenland catches with the Greenland Government, as they are hunting seals from the same herd (Anonymous 1999).

The Seal Fishery

In Atlantic Canada, harp and hooded seals are hunted commercially. In addition, a number of grey seals are also taken for commercial purposes under licences issued for that purpose. This practice was extended to ringed seals in Labrador beginning in 1997, and will continue in 1999. Apart from the commercial hunt, some harp, hooded, grey, ringed, harbour and bearded seals are taken in subsistence hunts in Labrador and the Canadian Arctic. Some harp and hooded seals are also taken for personal use by residents adjacent to sealing areas (Anonymous 1999)

In 1998, there were 10,851 commercial sealing licences issued. The majority of licences (9,447) were issued to residents of coastal communities in Newfoundland. Residents of the Magdalen Islands (827), the Quebec North Shore (518) and Cape Breton (59) account for the remainder. In most cases, licensed commercial sealers engage in fishing for other species or have economic ties to the fishing industry. The groundfish moratorium has increased the relative importance of sealing as a source of livelihood (Anonymous 1999).

Although the movement of ice floes and ice conditions often determines the degree of effort in any given area, the majority of the seal hunt occurs on the "Front", off the north and east coasts of Newfoundland and off southern Labrador (see Figure 34 for seal migration patterns). In 1998, 77 per cent of the commercial hunt and almost the entire personal use hunt took place in this area. About 15 per cent of the commercial hunt was undertaken in the Gulf of St. Lawrence by sealers from western Newfoundland. The hunt in the Gulf of St. Lawrence by sealers from the Magdalen Islands and Cape Breton accounted for 6 to 7 per cent of the commercial catch (Anonymous 1999).

The season for the commercial hunt of harp and hooded seals is from November 15 to May 15 as established in the Marine Mammal Regulations, although this season can be altered by Variation Order to deal with circumstances that may arise (Anonymous 1999).

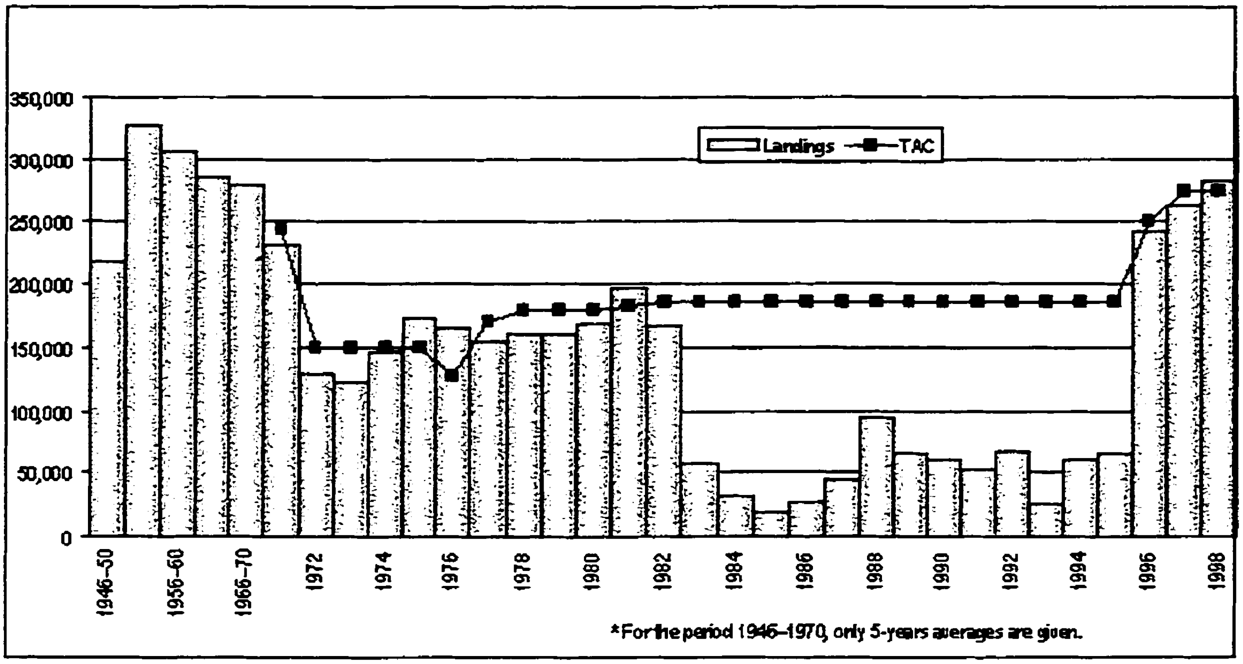


Figure 35: Recent harp seal landings 1972-1998 (After Anonymous 1999). For the period of 1946-1970, only 5-year averages are given.

Harp Seal Fishery

The nature of the present Atlantic coast commercial harp seal hunt took shape in the late 1980s after the collapse of the historic European markets for blueback and whitecoat pelts. As shown in Figure 35, the harvest levels for harp seals prior to this collapse ranged between approximately 150,000 and 300,000 animals/year. The earlier catch levels were followed by a reduction of the population to a level of just less than two million in the early 1970s (Anonymous 1999).

After the market collapse in 1983, the harp seal hunt did not approach the Total Allowable Catch (TAC) of 186,000, which was in effect from 1982 to 1995. In this period (see Figure 35), the hunt ranged from a low of about 20,000 in 1985 to a high of about 94,000 in 1988. Market constraints and ice conditions limited hunting. The TAC was increased to 250,000 in 1996, and raised to 275,000 in 1997 to meet a growing market demand and was within the replacement yield of 287,000 (calculated for 1996) (Anonymous 1999).

In 1998, 282,070 harp seals were landed in Atlantic Canada, with 71% of these harvested on the "Front" off southern Labrador (TAC was 275,000). This slight over shooting of the TAC occurred was because the season was reopened to allow a limited commercial hunt in the Strait of Belle Isle area and additional personal use hunting (Anonymous 1999).

The Hooded Seal Fishery

Hooded seals normally make up only a minor part of the commercial and personal use hunts. The TAC for hooded seals in recent years (Figure 36) has been 8,000 animals, but this was increased to 10,000 for 1998. The TAC is well below the replacement yield, estimated in 1990 at between 24,000 and 34,000, depending on the age of the animals to be hunted (Figure 36) (Anonymous 1999).

6. 2 Cetaceans

There are 12 species of cetaceans in the waters of the Labrador region. Most of these species are migratory, occurring along the Labrador coast and offshore on their way to and from summer ranges in the Arctic Ocean. These 12 species include: the Northern bottlenosed whale (*Hyperoodon ampullatus*), the Sperm whale (*Physeter catodon*), the

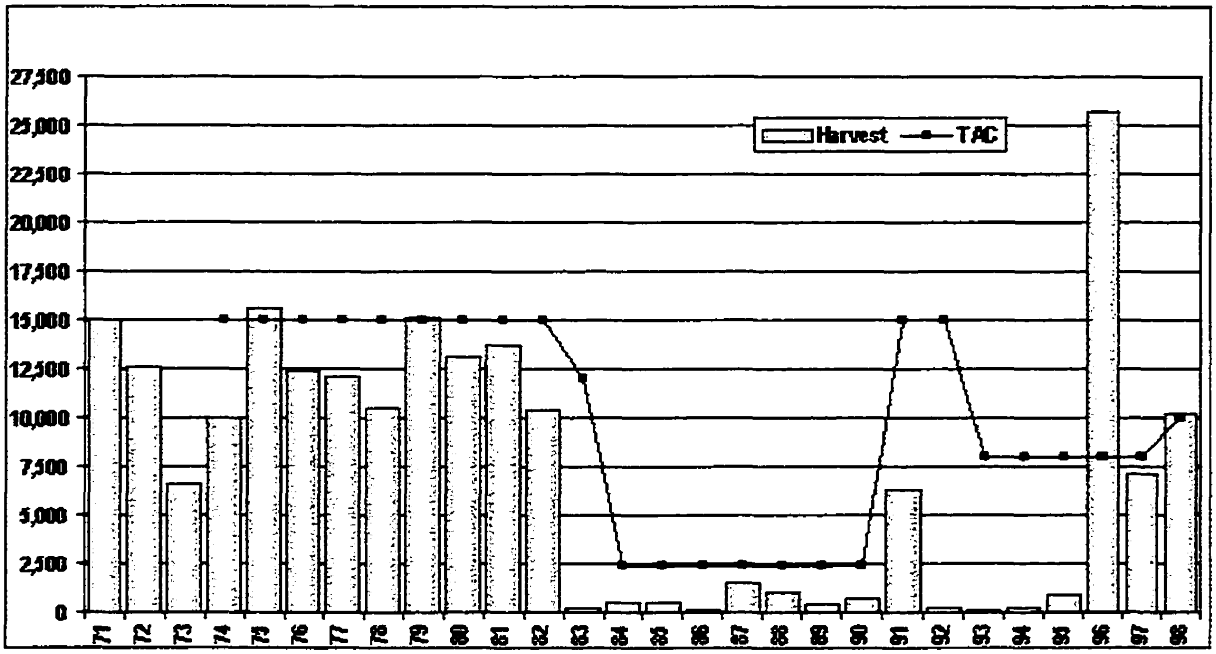


Figure 36: Recent hooded seal landings 1971-1998 (after Anonymous 1999).

Bowhead whale (*Balaena mysticetus*), the Blue whale (*Balaenoptera musculus*), the Fin whale (*Balaenoptera physalus*), the Sei whale (*Balaenoptera borealis*), the Minke whale (*Balaenoptera acutorostrata*), the Humpback whale (*Megaptera novaeangliae*), the Killer whale (*Orcinus orca*), the Long-Finned Pilot whale (*Globicephala melaena*), the Right whale (*Eubalanea glacialis*), Sowerby's Beaked whale (*Mesoplodon bidens*) the Atlantic white-sided dolphin (*Lagenorhynchus acutus*), Harbour porpoise (*Phocoena phonoeca*) and the White-beaked dolphin (*Lagenorhynchus albirostris*) (J. Lien, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999; Petro-Canada 1982).

The abundance and frequency of these cetaceans in the Hamilton Bank- Hawke Channel region is largely unknown, but there is little doubt that they utilize this area (Petro Canada 1982). One of history's largest whaling factories in the northwest Atlantic was located at Red Bay on the Labrador coast, inshore and south of the Hamilton Bank-

Hawke Channel region. It is likely that abundances of capelin attracted cetaceans to this region to feed.

Campbell (1997; 1998) gives the COSEWIC (Committee on the Status of Endangered Wildlife in Canada) designation for cetaceans in the North Atlantic (Table 9).

Table 9: Whale Species with assigned COSEWIC status for the North Atlantic region as of 1997.

Species	COSEWIC STATUS
Northern bottlenosed whale (*Hyperoodon ampullatus*)	Not at Risk
Sperm whale (*Physeter catodon*)	Not at Risk (Campbell 1997)
Bowhead whale (*Balaena mysticetus*)	Endangered (Campbell 1997)
Blue whale (*Balaenoptera musculus*)	Vulnerable (Campbell 1997)
Fin whale (*Balaenoptera physalus*)	Vulnerable (Campbell 1997)
Sei whale (*Balaenoptera borealis*)	Unknown (Campbell 1998)
Minke whale (*Balaenoptera acutorostrata*)	Unknown (Campbell 1998)
Right whale (*Eubalanea glacialis*)	Endangered (Campbell 1997)
Humpback whale (*Megaptera novaeangliae*)	Vulnerable (Campbell 1997) (Present Nfld. Population is 10,500 [1])
Sowerby's Beaked whale (*Mesoplodon bidens*)	Vulnerable (Campbell 1997)
Long-Finned Pilot whale (*Globicephala melaena*)	Not at Risk (Campbell 1997)
Killer whale (*Orcinus orca*)	Unknown (Campbell 1998) (Present Nfld. Population is estimated in low 100's [1])
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	Not at Risk (Campbell 1997)
White-beaked dolphin (*Lagenorhynchus albirostris*)	Unknown (Campbell 1998)
Harbour porpoise (*Phocoena phonoeca*)	Threatened (Campbell 1997)

[1] Estimate given by: J. Lien, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999.

Table 10 gives the most recent International Whaling Commission (IWC) world population estimates for a number of selected species.

Table 10: World population estimates for selected whale species (Taken from http://whales.Magna.com.au/home.html).

Species	Original Population	Established Population	Year Protected
Blue	228,000	11,700	1967
Bowhead	30,000	7,800	1935
Fin	548,000	110,000	1986
Gray	+20,000	18,000	1935
Humpback	115,000	10,000	1955
Minke	+490,000	880,000	1986
Right	+100,000	3,200	1935
Sei	256,000	54,000	1986
Sperm	2,400,000	1,950,000	1985

Established population refers to April 1994 estimates. + denotes larger than.

6.3 Summary

There are a large number of marine mammals that utilize the Hamilton Bank-Hawke Channel area seasonally. Harp and hooded seals form large whelping concentrations on the "Front" which occurs in this region but varies in exact location with ice conditions. This "Front" is the source of 77% of all commercial seal landings and most of the personal use hunt in 1998. Cetaceans such as the Fin, Humpback, Blue, Minke, Killer, Sei whales, etc. also frequent these waters, likely to feed on capelin. Some of these whale species have very low population sizes in the north Atlantic and some are protected (Table 9, 10) by regulations of the International Whaling Commission (IWC). Further scientific research is needed to determine cetacean populations and migration routes in the Hamilton Bank-Hawke Channel region.

Chapter VII: Seabirds

7. 0 Introduction

Seabirds are an important biotic component of the environment of the Labrador coast and the Labrador Sea. Twenty species of seabirds and 15 species of marine waterfoul and shorebirds regularly breed in this region. Labrador is at the southern limit of breeding rage of Arctic species such as Red-necked Phalaropes, Parasitic Jaegers (*Stercorarius parasiticus*) and Glaucous Gulls (*Larus hyperboreus*). Labrador is also the northern breeding limit for Leach's Storm-petrels (*Oceanodroma leucorhoa*), Caspian Terns (*Sterna caspia*), Common Terns (*Sterna hirundo*), Atlantic Puffins (*Fratercula arctica*), Razorbills (*Alca torda*), Common Murres (*Uria aalge*), Surf Scoters and Common Goldeneyes. Common Eiders (*Somateria mollissima*) breed along the entire coast and the many rivers provide breeding habitat for almost half of the eastern North American population of Harlequin Ducks (Lock *et al.* 1994).

In addition to the aforementioned breeding species there are 12 species that occur as non-breeders in the Labrador Sea. The continental shelf and slope offshore are important as feeding areas for these migrant species that occur in larger numbers than the coastal breeding species. From June to September there are several million wintering Greater and Sooty Shearwaters (*Puffinus* spp.), post-breeding visitors from colonies in the Southern Hemisphere. From July-August, large, but undetermined, numbers of Red Phalaropes, migrating from the Arctic feed along the continental slope and the various banks, including the Hamilton Bank. Immature Fulmars (*Fulmarus glacialis*) and Great Skuas are present offshore in all seasons where there is open water (Lock *et al.* 1994).

The Hamilton Bank-Hawke Channel area is probably beyond the foraging ranges of birds that are breeding inshore. However, in addition to the previously mentioned species, Kittiwakes (*Rissa* spp.) are present in this area and other areas of the Labrador Sea, perhaps attracted to waste produced by fishing vessels. In late summer, Thick-Billed Murres (*Uria lomvia*) undertake a swimming migration in the Labrador Current to the Grand Banks. They are joined by Razorbills and both murre species from colonies in Labrador. About 3.8 million birds are involved in this migration but the route along the Labrador shelf is not well defined. The majority of the world population of Dovekies (*Alle alle*), at least 10 million birds, from northern Baffin Bay, winters off Labrador or crosses it on the way south to the Grand Banks. The Dovekies, and other Auks wintering on the Labrador Banks, are eventually pushed south by the advance of pack ice (Lock *et al.* 1994; Lock 1978).

7.1 Distribution

The seasonal distribution of members of the Auks is shown in Figure 37. These animals are primarily present in the Hamilton Bank-Hawke Channel (see Figure 2 for reference location) region is in the fall of the year. During the fall there are 10-100 birds/km^2 in the northeast area on the bank and 3-10 birds /km^2 in other areas (Petro-Canada 1982; Lock 1978). The seasonal distribution of pelagic seabirds is shown in Figure 38. Pelagic seabirds also have their greatest concentration in the Hamilton Bank-Hawke Channel area in the fall of the year having concentrations of greater than 100 birds /km^2. However, both in summer and winter concentrations vary from 10-100 birds/km^2 too greater than 100 birds /km^2 (Petro-Canada 1982).

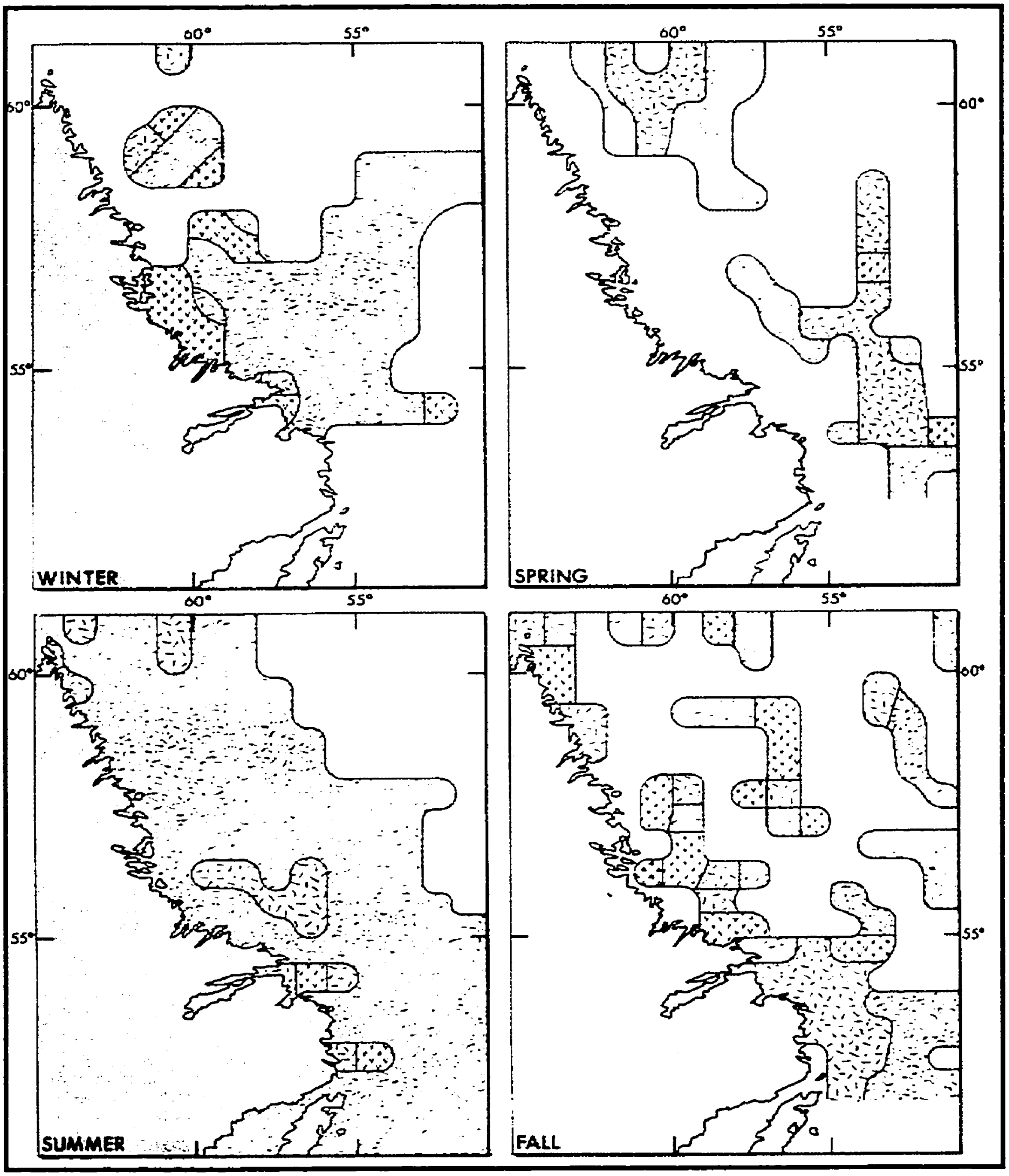


Figure 37: Seasonal distribution of auks in the Labrador Sea. Species included are the Razorbill, Common Murre, Thick-billed Murre, Dovekie, Black Guillemot (*Cepphus grylle*), and the Atlantic Puffin (after Petro-Canada 1982). The key to bird distributions are found in Figure 39.

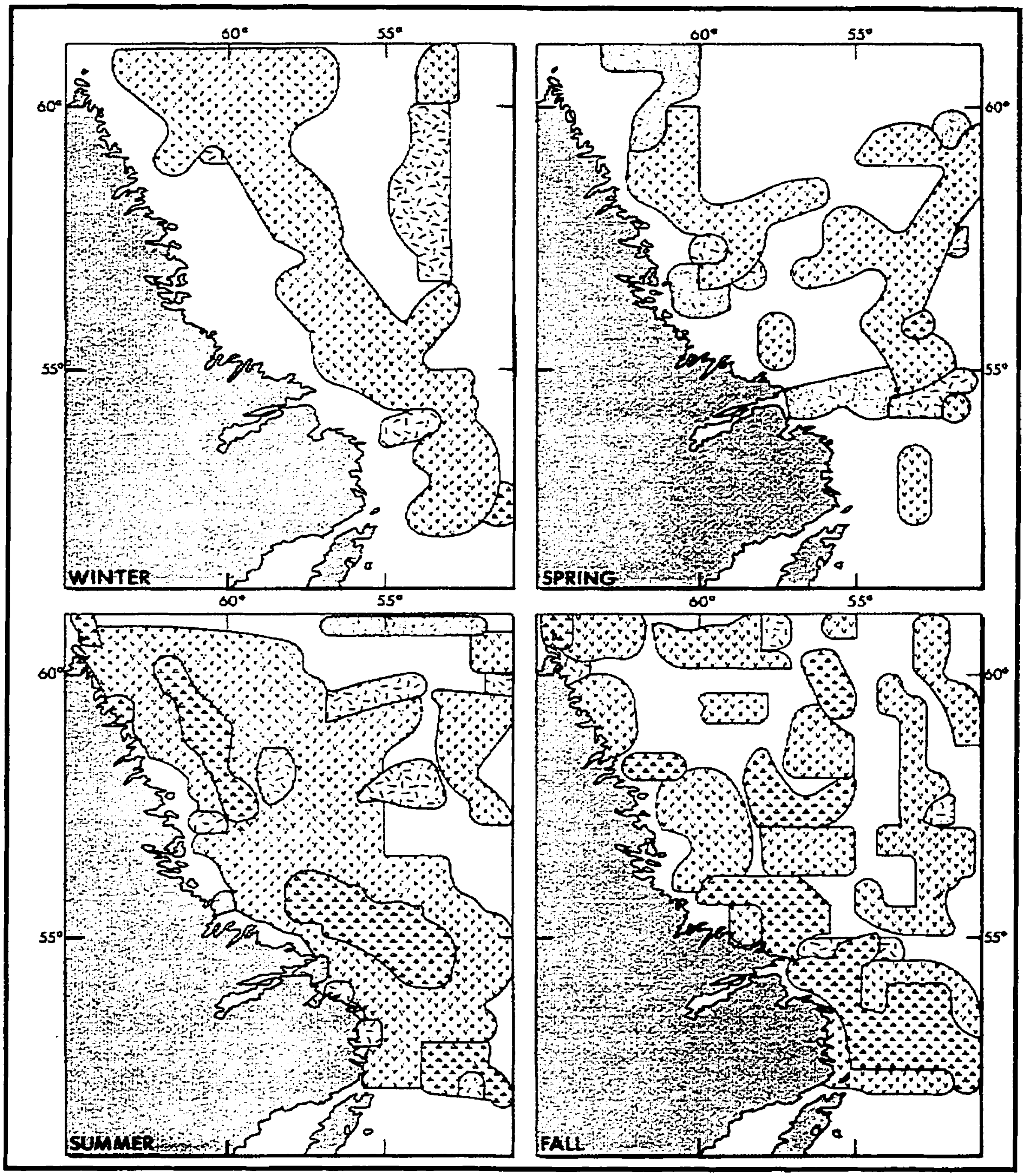
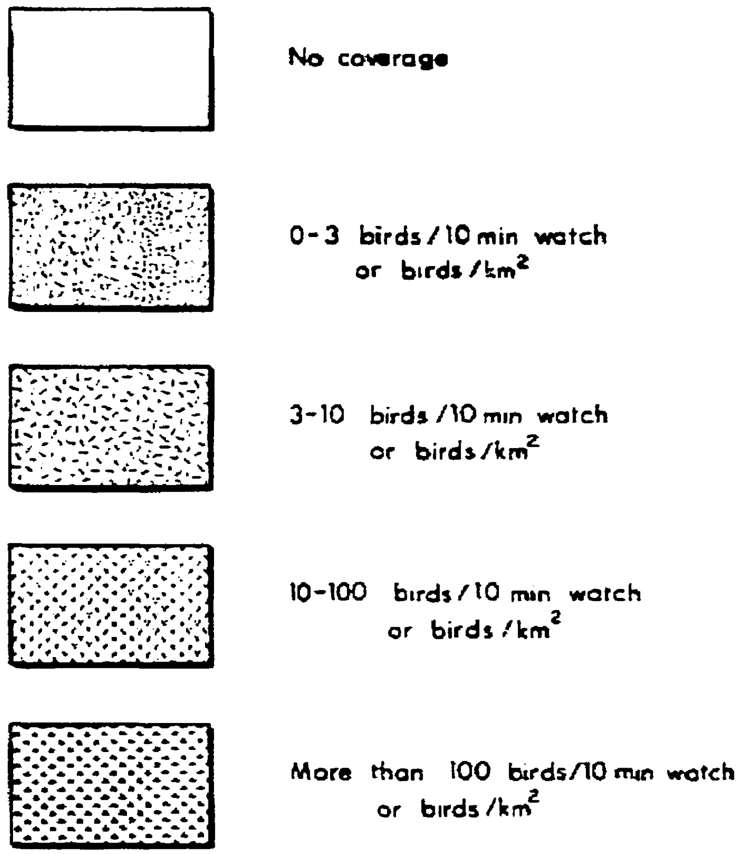


Figure 38: Seasonal distribution of pelagic seabirds in the Labrador Sea. Species included are: Northern Fulmar, Greater Shearwater (*Puffinus* spp.), Blacklegged Kittiwake, Northern and Red Phalarope (after Petro-Canada 1982). The key to bird distributions are found in Figure 39.



<u>Figure 39</u>: Key to bird distributions for Figures 36 & 37. Observations are based on shipboard PIROP (birds/min watch) and aerial surveys (birds/km^2) (after Petro-Canada 1982).

7. 2 Summary

Seabirds are an important part of the overall marine ecosystem. However, the role that seabirds play in the marine ecosystem of the Hamilton Bank- Hawke Channel region is largely unknown. Further study would be required to update the distributions and concentrations of these species and to accurately determine their trophic role. The information used in this section was originally documented in the mid-late 1970s and may be inaccurate at this time.

Chapter VIII: Fishing Methods

8.0 Introduction

There is very much concern in Newfoundland about the effects of overfishing on the populations of target species such as shrimp, crab, and Atlantic cod. Little concern is given to the effects of fishing practices on other ecosystem components. This chapter will examine the fishing gear types used in today's major fisheries in the Hamilton Bank-Hawke Channel area and examine how these gear types may effect non-target marine species and the local environment.

8.1 The Shrimp Fishery

Both fleet components (>65, <65ft) of the shrimp fishing vessels in the Northwest Atlantic use small mesh otter trawls as their primary gear. The minimum mesh size for these trawls, which is set by the Department of Fisheries and Oceans is 40 mm (ICES 1994). In addition, all shrimp fishing gear must have a Nordmore Grate (Figure 40) to prevent bycatch of non-target species (Hickey *et al.* 1993).

There have been various studies on the Nordmore Grate (mandatory use was implemented in 1994 (Kulka 1995)) and it is believed to be the best means of preventing bycatch in the shrimp fishery. However, the Nordmore grate is not perfect and bycatch issues still arise (D. Parsons, Department of Fisheries and Oceans, St. John's, NF, personal communication, 1999; Skuladottir 1998; Kulka 1995). Recent data presented by Skuladottir (1998) demonstrates that bycatch levels at the Flemish cap in 1997 were 1.8% of the total catch/tow. The majority of the bycatch was small redfish, Greenland halibut and wolffish. Redfish bycatch in the north is also a concern since the Nordmore grate is not an effective excluder of small (10-20 cm) fish (Kulka 1995). Information on bycatch rates for the Hamilton Bank-Hawke Channel region is limited to periods before the implementation of the Nordmore grate and is not relevant to this discussion.

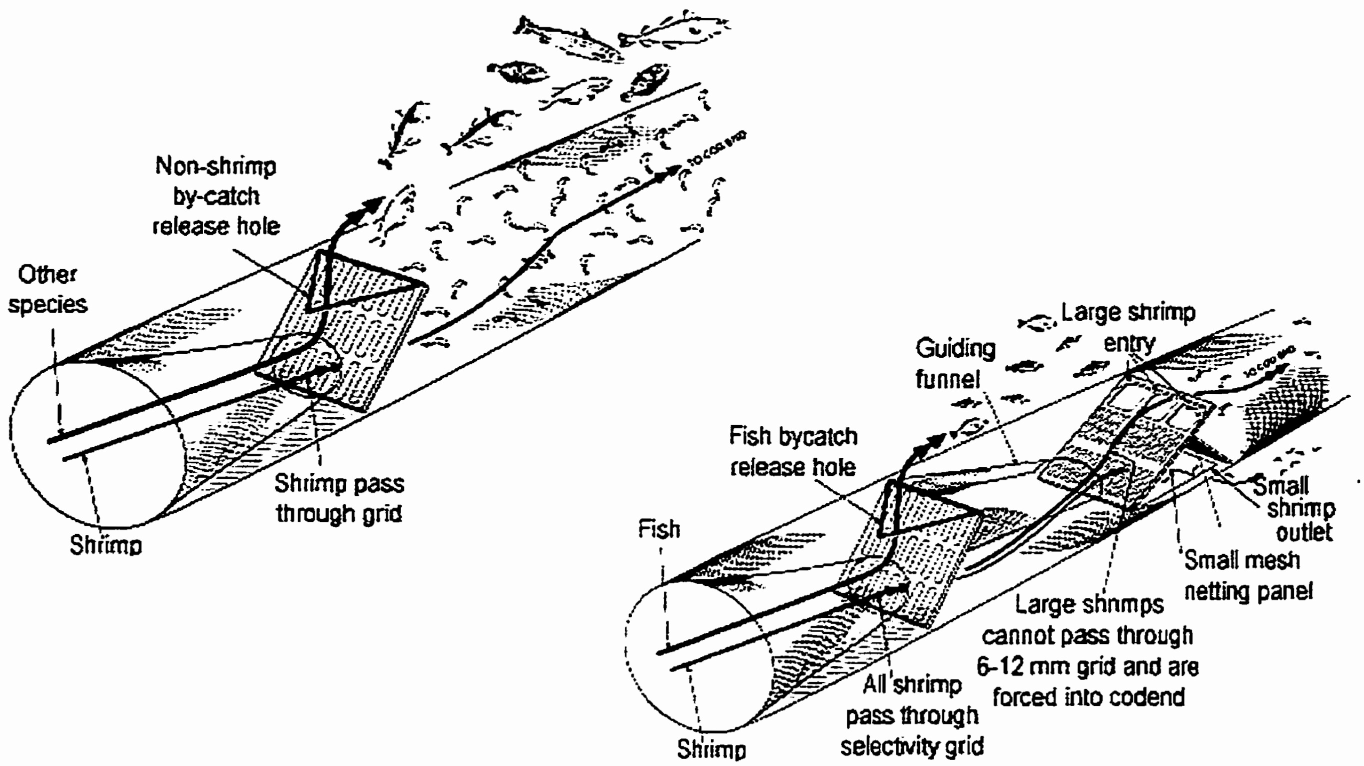


Figure 40: The Nordmore Grate: its setup and operation in an otter trawl (Taken from: http://www.ncr.dfo/frcc). Top: this set-up is not size specific for shrimp, consequently, small and large shrimp, along with bycatch of similar size organisms are directed to the codend. Bottom: a second grate has been added, this allows small shrimp and similar size organisms to be removed from the otter trawl, reducing discard of small shrimp and bycatch.

The otter boards or doors present on the otter trawl, due to their weight and size, cause damage to the infauna of the benthic environment. However, the damage caused by otter trawl doors is at least one order of magnitude lower than those caused by beam trawls (Dayton *et al.* 1995). The ground ropes of this particular fishing gear may also cause damage to epifauna present in the benthic zone. In addition to direct impacts, there are many indirect impacts caused by trawling resulting in increased turbidity which is likely to reduce or eliminate sea grass habitats, which are critical to many invertebrates and to juvenile fish species (FRCC 1997a; Dayton *et al.* 1995).

Otter trawling may also have an important impact on non-target commercial species (Skuladottir 1998; FRCC 1997a; ICES 1995; Kulka 1995). The Hawke Channel is one of the most important areas in the northwest Atlantic for the offshore commercial shrimp fishery. This area presently has the only known offshore spawning concentration of northern cod (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999). Experiments by Morgan *et al.* (1997) demonstrate the effects of otter trawls on a spawning shoal of cod. They observed that following the passage of the trawl, a 300m wide hole appeared in the cod aggregation. This disturbance was detected for 77 min after the passage of the trawl. Disruptions of this type in the spawning shoal could have a negative effect on spawning if time and energy are wasted in re-establishing shoal structure. In addition, survival rates of cod and other fish species (turbot, redfish, American plaice, winter flounder) after impact with the Nordmore grate are unknown. Further research is needed to determine the effects of the Nordmore grate on non-target species after they are directed from the otter trawl.

8.2 The Crab Fishery

The snow crab fishery uses cone shaped traps with mesh size no less than 65mm and does not exceed $2.1m^3$ when measured on the exterior (Figure 41) (Department of Fisheries and Oceans 1999). There is very little bycatch of non-target species such as groundfish and other benthic invertebrates. However there is a significant amount of female crab bycatch and small crab discard that presents some problems. Most fishers tend to hi-grade their trip catches, consequently most of the small crab is kept on board until larger crab is caught and then the smaller crab is discarded. High grading may have major repercussions on the size at age distribution of the crab population (size at terminal molt will be smaller) and cannibalism of smaller crab may occur (D. Taylor, Department of Fisheries and Oceans, St. John's, NF, personal communication, 1999.)

However, in comparison to most fisheries the snow crab pot fishery is in general "environmentally friendly", and because mostly males are harvested, more easily sustained with the limits imposed by natural fluctuations, than other fisheries.

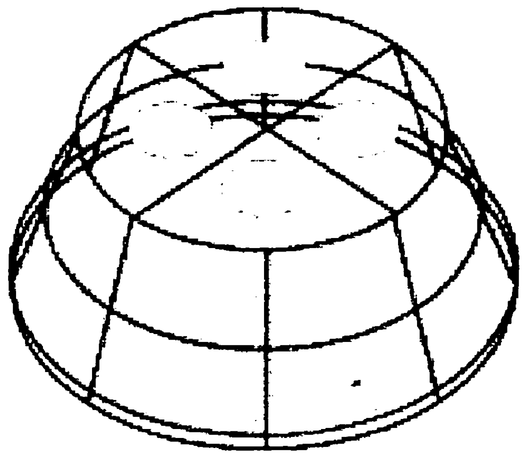


Figure 41: Diagram of crab pot. Taken from: www.imft.nf.ca/mi-net/fishdeve.

8.3 Miscellaneous Fisheries

Gillnet fisheries, longline fisheries, and scallop drag fisheries will not be discussed in great detail in this chapter since there are very few fisheries in the Hamilton

Bank-Hawke Channel area that uses these types of gear. It is however, important to realize the destructive nature of some of these methods.

Gillnets

Gillnets are used on the Atlantic coast to catch many species of fish, especially groundfish and pelagics and such anadromous species as salmon and smelt. Gillnets are constructed principally of monofilament netting and can be either secured to the bottom of the sea with the use of weights or left to drift. Fish are caught as they attempt to swim through the webbing, entangling their gills or bodies. Nets that are anchored to the seabed to keep the gear stationary have buoys on each end, which float on the surface. Buoys indicate the location and ownership of the gear and provide a line from which the gear can be raised to the surface to harvest the catch. The nets may be positioned in varying water depths, depending on the location of the species. The size of the mesh used in gillnets can differ, depending on the species and size of the fish sought (http://www.ifmt.nf.ca/mi-net/fishdeve/methods.htm).

There are serious bycatch concerns when fishing with gillnets. Gillnets can be very size selective, however, their ability to be species selective is very poor. There are problems of marine mammals such as whales and seals becoming entangled along with large catches of non-target species (FRCC 1997a) such as crab. The bycatch of crab in Division 3Ps is a developing problem (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999). Similar problems may arise or could now be occurring in the Hamilton Bank-Hawke Channel area.

A second problem with gillnets occurs when they become lost, and consequently 'ghost fish' (FRCC 1997a). Monofilament netting takes a very long time to breakdown in salt water. Consequently, gillnets may continue to fish unchecked for many years. The gillnet, once lost, may remain fishing (due to the attached floatation) until the net becomes too heavy and sinks. Once sunk, the captured fish first decompose and then fall clear of the net. The gillnet then refloats and the process begins anew. There is no way to quantify the amount of gillnets lost over the years, nor the amount of fish that have been caught by ghost nets. This issue should be of major concern and prohibiting the current expansion of gill net fisheries should be considered.

Scallop Drags

Scallops can be harvested in both inshore and offshore areas. While methods of fishing are quite similar in both areas, the offshore fishery is larger, both in terms of the volume of the landings and the size of the gear used. The drag consists of a large metal frame with teeth on which a type of chain-mesh bag is attached. The drag is hauled along the ocean bottom and the catch is raked into the mesh bag. The vessel tows the gear for a duration of time and then winches it onboard (http://www.ifmt.nf.ca/mi-net/fish deve/methods.htm).

Scallop dragging is one of the most destructive types of fishing with respect to the benthic zone. This method of fishing has been implicated in reducing species abundance in dragging areas, especially sessile organisms (ICES 1995). It is also quite common that various species (target or non-target) that come in contact with the drag become injured and are left on the seabed or have to be discarded once on deck. There is also a lot of sediment disruption that occurs when using scallop drags that may be detrimental to the benthic environment (ICES 1995). In addition, scallop drags have a tendency to remove large rocks creating a homogeneous sediment distribution of only sand and small pebbles. This may effect the types of organisms that re-colonize the area effecting the natural ecosystem (Collie *et al.* 1996).

There is no current scallop fishery in the Hamilton Bank-Hawke Channel region . However, any future, experimental, or full time fisheries that may be planned for in this area must first be evaluated carefully due to the destructive nature of this fishery.

Longlining

Longlining involves the use of a 'long line' with a series of baited hooks spread along the ocean floor. Initially manually retrieved, this system has now become mechanized and uses automatic hauling, baiting and shooting machines. Because of these technological improvements fishermen are able to fish more gear, and in many other ways can compete with other forms of fishing. They can be more selective, landing a much higher quality of fish, and also require less fuel for the operation. Longlining is used primarily in the Atlantic Provinces to catch groundfish such as cod, hake, haddock, turbot and halibut (http://www.ifmt.nf.ca/mi-net/fishdeve/methods.htm).

A longline type of fishery is much more "conservation friendly" than most other fishing methods that have been discussed (excluding the snow crab fishery). More juveniles are caught with trawls than with longlines and discards are much higher in the trawl catch than the longline catch. Longline fisheries may remove older more piscivorous fish from the population and may be beneficial to recruitment (Bjordal and Laevastu 1990). Undersized and non-target fish species may be returned less damaged than in trawl fisheries, resulting in less serious bycatch problems. Unfortunately, a comparison of released fish survival rates for trawl verses longline fisheries are unavailable at this time.

8.4 Summary

There are two main types of fishing gear used in current fisheries in the Hamilton Bank-Hawke Channel region. They are: the otter trawl and the crab pot. As discussed in section 8.2 the crab fishery is a well-designed and "environmentally friendly" fishery that does little to disrupt the local ecosystem. The otter trawl, (section 8.1) on the other hand, is indirectly more destructive and results in disruption of bottom sediments and bycatch problems could arise. Although the use of the Nordmore grate has undoubtedly helped reduce bycatch, significant catches of juvenile groundfish species still occurs. Caution should be taken in any fishery that uses otter trawls as the primary fishing gear because the effects on the overall ecosystem from these fishing practices is not well established. In addition, further research is needed on the effectiveness of the Nordmore grate and the survival rates of fish and other organisms (i.e. smaller shrimp) that come into contact with the grate and are removed from the trawl.

Gillnets, longlines, and scallop drags are not being used in the current fisheries in the Hamilton Bank-Hawke Channel area. This will benefit the area. Gillnets and scallop drags are very destructive in different ways. Gillnets become major ecosystem threats when lost, and consequently become 'ghost nets' (FRCC 1997). Scallop drags are destructive to the sea floor and organisms that cannot escape the rake. On the other hand, longline fisheries can be very conservation minded. If hauled regularly, a higher quality fish product will be produced and discards and bycatch are likely to be reduced.

Chapter IX: Consultations with Industry

9.0 Introduction

In this chapter, the views and concerns of members of industry will be explored in regard to the Hamilton Bank-Hawke Channel region. In addition, opinions of industry will be presented to whether or not this area is deserving of protection under the Marine Protected Areas program of the Department of Fisheries and Oceans. Interviews were carried out in late July-early August with Fishery Products International (FPI), Fisheries Association of Newfoundland and Labrador (FANL), St. Anthony Basin Resources (SABRI), Daley Brothers Inc., and the Provincial Government.

9.1 Fishery Products International (FPI)

Fishery Products International (FPI) readily promotes its commitment to environmental leadership as an integral part of their corporate philosophy. FPI is also committed to sustainable harvesting practices in all of their groundfish and shellfish harvesting activities. They currently are using larger than regulation mesh sizes to reduce catch of juvenile fish, grates are used in offshore shrimp fisheries, and they have developed new technology to reduce the catch of small crab (Fishery Products International 1999).

FPI is currently conducting experiments on fishing gear to reduce the catch of juvenile turbot and to enhance separation of yellowtail flounder from American plaice. Research is being carried out to develop cod traps for use in an offshore deep sea cod fishery and to reduce finfish bycatch in the scallop fishery (Fishery Products International 1999).

FPI is not currently directly involved in scientific research in the Hamilton Bank-Hawke Channel area. They are however, funding projects with Memorial University and the Fisheries Conservation Chair (Gabe Gregory, Fishery Products International, St. John's, NF, personal communication, 1999)

In terms of fishing activity, FPI currently has only one vessel that is fishing in the Hamilton Bank-Hawke Channel Area, the Newfoundland Otter, a >65 ft shrimp trawler. However, FPI is also involved in the purchasing and processing of raw materials harvested by other vessels >65ft in the area (both crab and shrimp). When asked if a value could be put on these fisheries to FPI, Mr. Gregory could only speculate, but noted that the shrimp fishery itself in SFA 6 was worth well over $100 million to vessels and processors.

When asked if he felt that the Hamilton Bank-Hawke Channel area deserved protection, Mr. Gregory replied that he could not make any judgements of that nature until detailed information (publications, or other relevant literature) became available. However, Mr. Gregory, when told that the Hawke Channel has the only current offshore spawning biomass of cod, suggested that this aspect would be important to industry. But, Mr. Gregory did add that the spawning area should be defined as the Hamilton Bank-Hawke Channel is a very large area and closing the entire area for a biomass of cod that may inhabit only a small zone, may not be that practical. Mr. Gregory also added a that a primary concern would be if the cod in the area could be protected without seriously disrupting the current shrimp fishery.

Mr. Gregory also believes that there would be opposition, from both big and small processors and harvesters, to the idea of an MPA in this area.

9.2 Fisheries Association of Newfoundland and Labrador (FANL)

Mr. Alistair O'Reilly, a representative of FANL was interviewed on August 6, 1999. Mr. O'Reilly, when asked if FANL would support an MPA in the Hamilton Bank-Hawke Channel area he replied " in absence of what an MPA is defined as, it is very hard to support or non-support" (A. O'Reilly, FANL, St. John's, NF, Personal Communication, 1999). Mr. O'Reilly also suggested that the Bonavista NMCA (National Marine Conservation Area) was not satisfactory for similar reasons, however FANL abstained from involvement in this venture by Parks Canada.

Mr. O'Reilly also posed concerns to what are we trying to accomplish with an MPA, and where does normal DFO fisheries management end and MPAs begin. He believes that if it is fisheries conservation that we are trying to achieve, than it should be possible to achieve it with existing legislation (A. O'Reilly, FANL, St. John's, NF, Personal Communication, 1999)

Mr. O'Reilly also commented on the idea of the type of MPA that may be applicable. He believes that no MPA in the area should be a no fish zone. He referred to such ideas as reduced quotas, higher observer coverage, and a greater emphasis on conservation and reduction of bycatch as long as no commercial fisheries stop. He also suggested that the Nose and Tail of the Grand Banks might be a better area for an MPA. However, these areas are outside Canadian jurisdiction.

9.3 St. Anthony Basin Resources (SABRI)

St. Anthony Basin Resources (SABRI) is the company that represents the town of St. Anthony, NF to allocate an offshore shrimp community quota of 3,000 tonnes. SABRI is also involved, in conjunction with Clearwater, a shrimp processing and harvesting company, in operating a shrimp processing plant in the St. Anthony area.

In an interview with Dennis Coates of SABRI on July 8, 1999, he expressed his views on the Hamilton Bank-Hawke Channel area. Mr. Coates had several concerns with a protected area in the region. If a protected area was created in the area, Mr. Coates was against any no-fish zones but establishment of zones or temporal closures may be acceptable. Mr. Coates also mentioned that if the recovery and continued success of certain stocks could be enhanced by an MPA then it would be a worthwhile venture. He also expressed concerns about the decreased budgets and research and felt that if an MPA in the area would increase scientific coverage, focused on the ecosystem, it would be acceptable.

9.4 Daley Brothers Fisheries

An interview with Mrs. Rose Mary Buckingham, a representative of Daley Brothers Inc., was carried out on August 26, 1999. When asked about Daley Brothers Inc. position on the idea of a marine protected area in the Hamilton Bank-Hawke Channel region Mrs. Buckingham's response was that more information was needed. Mrs. Buckingham also commented on the current fisheries in the area and described their value to fishers and to the residence of Newfoundland and Labrador. Her final comment was that in order for her organization to support such a venture it would have to be feasible and viable to fishers and processors and supported by science. There seemed to be a noticeable lack of knowledge, or lack of interest, presented by Mrs. Buckingham about this project and the MPA program as a whole.

9.5 Department of Fisheries and Aquaculture (DFA)

Mr. Robert Coombs, of the Department of Fisheries and Aquaculture (from this point referred to as DFA) was interviewed on September 6, 1999. Mr. Coombs, as a representative of the Province, stated that DFA supports the concept of MPAs as fisheries management tools. When asked about the Hamilton Bank-Hawke Channel area, Mr. Coombs replied that it is one of the most important areas in the North Atlantic in terms of species richness and productivity and is a great location for an MPA. But, Mr. Coombs then posed the question of how can this be made feasible? There would be opposition by fishers and processing firms to an MPA in this area if it in any way disrupted their lives and the lives of the people in their communities. Mr. Coombs then inferred that the politics of the situation may also play a role in decisions made by the Province on the Hamilton Bank-Hawke Channel area as an MPA.

Mr. Coombs also added that the mechanics of such a project would have to be further explored. He suggested that the opportune time to implement such a project may have been in 1995-96, before new fisheries (shrimp, etc.) took off in the area, it now may be too late. He also suggested that an MPA in this region must start with a small study area and progress, with time, to a larger size. During this growth period, scientific research must increase so that better, more accurate information becomes available. In a final comment Mr. Coombs suggested that a better time to look at this area as an MPA may occur when the ITQ (Individual Transferable Quotas) system becomes implemented in Newfoundland. Mr. Coombs believes that the ITQ program will be reality in the near future and may be one of the only ways to get fishers to become conservation minded, as he feels that fishers are not ready for conservation at this time.

To date, various attempts have been made to consult with other organizations such as Quinlan Fisheries and the FFAW. Unfortunately, individuals at these organizations were not available for interviews.

Chapter X: Conclusions and Recommendations

10.0 Conclusions

The Hamilton Bank-Hawke Channel area is a significant, highly important, yet representative region of the northeast Newfoundland and Labrador shelf region. The region has specific attributes in terms of its oceanographic conditions, primary production characteristics, past and present commercial fisheries, marine mammal concentrations, and marine sea bird distributions. It is a crucial area for fisheries production, particularly for Atlantic cod, capelin and northern shrimp. The Hamilton Bank-Hawke Channel area has a wide diversity of fish fauna, including both commercial and non-commercial species, and has the sole extant offshore spawning biomass of northern cod known to exist on the Newfoundland -Labrador Shelf.

Oceanographic conditions in the Hamilton Bank-Hawke Channel region, in particular, the combination of localized upwelling and nutrient transport via the Labrador Current enhances nutrient availability (Chapter II). Nutrient availability in association with adequate temperature and salinity characteristics, results in elevated primary production in the area when compared to the rest of the Newfoundland-Labrador shelf (Figure 11) (exceeding 10mg/m^3 for several months of the year (Chapter 3)). In addition, zooplankton production has been shown to be in excess of 500mg/ m^3/year. This production rate is similar to other offshore banks such as the Belle Isle Bank and the Funk Island Bank, but exceeds the averages for other offshore regions.

A key reason for protecting this area is its potential importance to the productivity of the northern cod. The oceanographic patterns in the Newfoundland region make the

Hamilton Bank-Hawke Channel area a key potential source of cod eggs and larvae for areas to the south. Egg and larval drift patterns demonstrate that eggs and larvae released on the Hamilton Bank or the Hawke Channel are likely to be carried by currents along the northeast coast of Newfoundland (Figure 21) and onto the northern Grand Banks, seeding a broad band of potential nursery zones along the way. As a consequence, this area has been considered the "engine that drives the northern cod" (deYoung and Rose 1993).

Several important commercial species of invertebrates also occur in the Hamilton Bank-Hawke Channel area. These include the northern shrimp (*P. borealis)* and snow crab (*C. opilio*). The northern shrimp fishery in SFA 6 is worth hundreds of millions of dollars to harvesters, processors and communities in Newfoundland and Labrador. The Hawke Channel is one of the most important areas in SFA 6 and in the entire north Atlantic for shrimp. Eighty-eight percent of all catches by vessels over 65ft in 1998 were taken in this area and the majority of the 29,834 tonnes taken by <65ft vessels was also caught in the Hawke Channel (Chapter IV). The high abundance levels of this species in this area is further evidence of the productivity of this region. Spawning products of shrimp in this region could also seed areas to the south.

The snow crab fishery in the Hamilton Bank-Hawke Channel area is one of the most important in Division 2J. However it is not as important as in other Divisions such as 3K and 3L. This fishery was worth approximately $24 million to harvesters and processors in 1998. The crab resource in Division 2J is believed to be increasing.

In the past, the Hamilton Bank-Hawke Channel area has been a very important fishing area for species such as cod, redfish and capelin. Millions of tonnes of these fish species were taken from area 2J from the late 1950s to the time of the groundfish moratorium and closures in 1992. When examining the Hamilton Bank-Hawke Channel area at present, the large concentrations of cod, redfish and capelin are much diminished the result of several factors, with the most important being overfishing, fishing during spawning periods and changes in ocean conditions.

There is however, some promise for the future. As mentioned before, recent surveys carried out in the Hawke Channel have shown that the area contains not only an abundance of shrimp, but, the only remaining significant spawning biomass of cod present on the Newfoundland-Labrador shelf. Hence, this region may be crucial to the rebuilding of the northern cod and may offer a rationale for protection under an MPA. Spawning concentrations of cod on or near the Hamilton Bank or Hawke Channel could produce billions of eggs which would be carried by the Labrador current southward to stock the nursery grounds of the Newfoundland shelf, the northeast coast of Newfoundland and the northern Grand Banks.

The COSEWIC status Atlantic cod is described as unknown at this time (Campbell 1998), however, recent genetic studies have shown that coastal cod, which are currently more abundant, may differ from offshore cod (FRCC 1999). This 'difference' may promote more investigation into the cod of the Hawke Channel. Because of their low abundance, and possible genetic differences, this stock may be designated as threatened, or endangered in the future. Redfish in the Hamilton Bank-Hawke Channel area may also be subject to such designation.

In addition to the presence of cod in the Hawke Channel, there has been an increasing biomass of capelin in the Hamilton bank-Hawke Channel area. Historically, this region was very important to capelin and was a major center for fishing activity.

Surveys have shown that over the last two years capelin numbers have been increasing. The origin of these capelin is unknown, however due to their large size, it is speculated that they may have migrated from the Gulf of St. Lawrence, or from White Bay (R. O'Driscoll, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999). In a recent survey of the Hawke Channel (June 99) these capelin were mature and should have spawned sometime in late June or early July. However, the location of spawning is unknown (R. O'Driscoll, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999). Capelin are the major prey of various fish, mammals and seabirds (Scott and Scott 1988), consequently ecosystem health may improve with increased capelin abundance and special consideration should be given to the importance of this region to capelin.

There is a vast diversity of marine mammals that inhabit and/or have migration patterns over the Hamilton Bank-Hawke Channel area. Large whelping concentrations of harp and hooded seals form on the 'Front' (Chapter VI) which occurs in this region but exact location varies yearly with ice conditions. These animals surely take advantage of the high productivity in the region and feed on Atlantic cod, capelin and shrimp populations before and after whelping. Economically, this 'Front' is the source of 77% of all commercial seal hunt landings and consequently provides much needed money to Newfoundland and Labrador's local economies.

Cetaceans such as the Humpback, Blue, Fin, Sei, Minke and Killer whales also frequent the waters of the Hamilton Bank-Hawke Channel region. The specific migration routes of these species have not been clearly defined and further research to determine the importance of the Hamilton Bank-Hawke Channel region to cetaceans in the area is needed. A concentration of cetaceans in the Hamilton Bank-Hawke Channel region may spur public support for a Marine Protected Area.

Social characteristics of this area are directly related to the economic characteristics. Fisheries for crab, and especially shrimp in the Hawke Channel are very important to many communities in Newfoundland and Labrador. These fisheries provide income to families once dependent on the northern cod. Closures of fisheries in some areas could have short-term detrimental economic impacts on Newfoundland communities such as St. Anthony, Black Duck Cove, Jackson's Arm, and Black Tickle, Labrador. However, in the long-term, an enhanced fishery would be a goal of such closures within an MPA. Further studies on socioeconomic and social impacts on such aforementioned communities would be required prior to implementation of an MPA.

10.1 Potential as an Offshore Marine Protected Area?

The information presented in this report on the Hamilton Bank-Hawke Channel area forms a basis for considering a portion of this region for protection under the legislation of the *Oceans Act* (Section 35 (1)). In the following section each purpose stated in Section 35 (1) will be examined and related to information presented in this report on the Hamilton Bank-Hawke Channel region.

Section 35 (1) states (Fisheries and Oceans Canada 1997; Fisheries and Oceans Canada 1999): "...for special protection for one or more of the following purposes:

1) "conservation and protection of commercial and non-commercial fisheries resources, including marine mammals and their habitats;"

The Hamilton Bank-Hawke Channel region is likely to be the most crucial offshore habitat to fisheries production on the Newfoundland Labrador shelf. The area is important as an historical and current breeding ground whose effects are likely to spill out over a very broad area to the south across the Newfoundland Shelf, the northeast coast and to the northern Grand Banks. Because of this, the Hamilton Bank-Hawke Channel area may be of extraordinary importance to the productivity of the northern cod. At present the underlying productivity of the area is evident in the shrimp and crab fisheries. The Hamilton Bank-Hawke Channel region also supports a wide diversity of non-commercial fish species (see section 5.1) and is the location (Hawke Channel) of the only known offshore spawning biomass of northern cod on the Newfoundland-Labrador Shelf. These fish may be critical to the rebuilding of the offshore northern (2J3KL) cod stock. The area is also significant historically for redfish, capelin, and now for turbot. There have been reports of capelin returning to the area in the last several years. It is clear that capelin play a critical role as a forage species in our northern ecosystems and their conservation is vital to many other species. The Hamilton Bank-Hawke Channel also has a large number of marine mammals (both pinnipeds and cetaceans) that also frequent the area.

2) "conservation and protection of endangered or threatened marine species, and their habitats;"

There are currently 2 endangered, 1 threatened and 5 vulnerable species of cetaceans that frequent the Hamilton Bank-Hawke Channel area (Table 9). There are also numerous species of fish and other marine mammals that are given"unknown" COSEWIC status. In addition, although the sub-stock structure of the northern cod and redfish stocks are unclear, recent evidence suggests that Hamilton Bank-Hawke Channel cod may differ from coastal and Grand Bank cod (Ruzzante *et al.* 1997). Protection of this area would enhance the likelihood that these components of the northern ecosystem can be conserved.

3) "conservation and protection of unique habitats"

The Hamilton Bank-Hawke Channel area is not a unique habitat in terms of the majority of its physical and bathymetric characteristics, since there are several other offshore banks (Belle Isle Bank, Funk Island Bank and the 3Ps shelf system), and deep channel areas with similar attributes. However, the Labrador Current creates a somewhat unique habitat. The Labrador Current (Section 2.1) flows directly over the Hamilton Bank and the Hawke Channel and south to the Grand Banks. These are very nutrient rich waters made up by the West Greenland Current and polar water with additions of fresh-water from land runoff in Hudson Bay, Ungava Bay and along the Labrador coast. This current plays an important role, along with local upwelling events, in the high productivity (nutrient availability, temperature, salinity characteristics) of the study area. The dominant flows may also be important in terms of seeding downstream areas with egg and larval fish of species such as northern cod. Study of these processes would benefit greatly from the establishment of a protected area in the region.

4) "conservation and protection of marine areas of high biodiversity or biological productivity";

The Hamilton Bank-Hawke Channel area is an area of high biodiversity and primary productivity. There are at least 50 species of fish, and up to 17 species of marine mammals (Chapter VI) and large quantities of shrimp, snow crab and other crustaceans. Primary productivity of the area is equal to or higher than most other offshore areas (Figure 11). Zooplankton production is also very high and exceeds the averages for most offshore areas. In addition, productivity is readily transported from this area (i.e. spawning products of cod/redfish) to more southern locations as a result of the flows of the Labrador Current.

5) "conservation and protection of any other marine resource or habitat as is necessary to fulfill the mandate of the Minister of Fisheries and Oceans."

The mandate of the Department of Fisheries and Oceans is as follows:

" The Department of Fisheries and Oceans (DFO), on behalf of the Government of Canada, is responsible for policies and programs in support of Canada's economic, ecological and scientific interests in the oceans and freshwater fish habitat; for the conservation and sustained utilization of Canada's fisheries resources in marine and inland waters, and for safe, effective and environmentally sound marine services responsive to the needs of Canadians in a global economy." (Taken from http://www.dfo-mpo.gc.ca/dfo_mpo/mandat_e.htm).

The long-term priorities of this mandate include:

"**Manage and Protect the Fisheries Resource**: To maintain a biologically sustainable resource supporting self-reliant fisheries by conserving Canada's fishery resources and ensuring sustainable utilization.

Manage and Protect the Marine and Freshwater Environment: To achieve an integrated, cohesive approach to the management of the marine and freshwater environment through stewardship and protection of productive fish habitat and reduction in the risks and impacts of oil and chemical spills in the sea.

Understand the Oceans and Aquatic Resources: To acquire, apply and communicate knowledge on Canada's oceans, as well as on marine and freshwater resources, to support the activities of clients, partners and the operational branches of DFO." (Taken from http://www.dfo-mpo.gc.ca/dfo_mpo/mandat_e.htm).

The combination of high productivity, plankton, crustaceans, fishes, pinnipeds, cetaceans and marine birds in the Hamilton Bank-Hawke Channel area provides an unique opportunity for scientific study to better understand ocean dynamics.

The conservation of northern cod is thought to be a unique and extraordinary conservation issue that falls directly under the mandate of the Minister of Fisheries and Oceans.

10.2 What could an MPA in the Hamilton Bank-Hawke Channel area accomplish?

The establishment of an MPA in the Hamilton Bank-Hawke Channel region has the potential to protect key marine resources, enhance fisheries production, and provide a central area for research on fisheries and marine ecology. It may be unrealistic, however, to promote the entire Hamilton Bank-Hawke Channel area as an MPA. There is likely to be immense opposition from industry and other interest groups (i.e. FFAW, FANL) and such a large area would not be practical to manage, regulate and enforce. It is however, practical to consider a portion of this region for protection. This zone should be representative of the area and have biological and physical characteristics that would benefit the marine ecosystem and fisheries production now, and in the future.

A Marine Protected Area in the Hamilton Bank-Hawke Channel area could enhance the preservation of many marine species. Most importantly, an MPA could serve to protect a key portion of the historic spawning grounds of the northern cod, and protect the only known spawning concentration on the Newfoundland-Labrador shelf. This population may be genetically distinct and at risk. In addition, an MPA would provide a safe haven from fishing pressure for species such as capelin, shrimp, crab, turbot, redfish, other non-commercial species, and marine mammals. There are currently 2 endangered, 1 threatened, and 5 vulnerable species of cetaceans that frequent the area to feed. An MPA in the area may increase the success of these species since food sources would not be disrupted by commercial fishing practices. An MPA in the area could also be used to implement seasonal closures of existing fisheries to allow protection of over-wintering or spawning aggregations for other species (i.e. capelin, redfish, shrimp, non-commercial species).

The implementation of an MPA in the Hamilton Bank-Hawke Channel region could also enhance fisheries production in the Hamilton Bank-Hawke Channel region and over a much broader area downstream. Physical and oceanographic features of the area allow for southern transport of pelagic eggs and larvae. This may have strong implications to shrimp populations in Divisions 3KL and to the resurgence of cod stocks on the northeast coast and the northern Grand Banks. An MPA serving as a no fish zone may increase, or at least maintain high shrimp and cod biomass within the MPA and in the surrounding areas. Also, a refuge for snow crab from the effects of bottom trawling in the shrimp directed fishery might increase recruitment within the MPA and in the surrounding area. These possibilities could form the basis for research into fisheries production on the Labrador and northeast Newfoundland Shelf. .

An MPA in the Hamilton Bank-Hawke Channel would be an ideal site for scientific research on the fishery and marine ecology of the Labrador and Newfoundland Shelf ecosystem. Historical fisheries data from this area exist as far back as the 1950s and the area has been under scientific study since 1994, with particular emphasis on northern cod, capelin and shrimp (G. Rose, Fisheries Conservation Chair, Memorial University of Newfoundland, St. John's, NF, personal communication, 1999). An enhanced study could draw on these results.

In closing, an ecosystem approach to fisheries management is needed. Research within an MPA in the Hamilton Bank-Hawke Channel area, because of the biodiversity that it exhibits, could give a better understanding of long-term ecosystem dynamics. In addition, information could be collected on species of sea birds, whales, primary and secondary production, and benthic organisms. One of the major benefits of protected areas is to provide 'benchmark' areas for monitoring and research.

The removal of a relatively small area from commercial fishing activity is thought to be a small price to pay for the benefits that could accrue.

10. 3 Recommendations

Recommendation 1:

A portion of the Hamilton Bank-Hawke Channel area should be considered for protection under the Marine Protected Areas Program of the Department of Fisheries and Oceans. From the information presented in this paper, it is clear that the aforementioned area meets the requirements stated in Section 35(1) of the *Oceans Act* (Fisheries and Oceans Canada 1997; Fisheries and Oceans Canada 1999) (see section 10.1)

Recommendation 2:

Further scientific research is needed in the Hamilton Bank-Hawke Channel area to better define the boundaries of a proposed MPA. The most important areas are primary and secondary productivity, fish abundance and seasonal use, commercial and non-commercial fishing activity, and marine mammal and seabird distributions. However, the lack of specific knowledge should not be a rationale for stalling implementation of an MPA in this region.

Recommendation 3:

An MPA in this region should not be exclusively a no-fish zone. The value of the commercial fisheries in the Hamilton Bank, and especially the Hawke Channel is very high and very important to Newfoundland and Labrador. Industry opposition to no-fish zones may be high. The MPA concept should be put forth as a means to better understand and potentially enhance production, both of commercial and non-commercial species, and hence benefit future fisheries. There may be advantages to both the commercial fisheries and to research in having zones of restricted fishing adjacent to areas that would be fished An MPA in this area could use zones defining levels of protection to be established.

Presumably such zones could be representative of a cross-section of the bank, channel, and shelf break, which characterize the region. Only specified activities would be allowed within each zone. In most of the MPA management could enforce quota reductions, gear restrictions, and temporal and seasonal closures (i.e. during cod spawning seasons). In some areas all commercial fisheries could be prohibited. The effects of such restrictions would form a basis for research and adaptive management.

Recommendation 4 :

A more detailed study of the long-term social and economic impacts and opinions about the establishment of this MPA is necessary. This may be facilitated through a survey, possibly in conjunction with the education coordinator of the Professional Fish Harvesters Board.

Recommendation 5:

Involving stakeholders in this project is essential to success. Obtaining information from harvesters and processors should be a priority. Harvesters could play a key role in the enforcement measures of the MPA, and should be involved in the decision making process. They must be made aware of their importance in the process and be acknowledged and benefit from their contributions. Without the support of industry, an MPA in this region is unlikely to be accomplished.

Recommendation 6:

Education about Marine Protected Areas is essential. The public and industry must be made aware of the potential benefits of the MPA. There is at present, a great deal of speculation and mistrust about MPAs. The benefits of protecting marine resources will not be realized without longer-term thinking and actions on the part of all involved.

Although there is growing support for protection and conservation, there is also uncertainty and misunderstanding that MPAs would be used solely to restrict historical access without benefits to local communities. New methods for public discourse on these matters should be examined.

References Cited

Agardy, T. S. 1997. Marine protected areas and ocean conservation. Austin, Texas: R. G. Landes Company.

Anonymous. 1999. 1999 Atlantic seal hunt management plan. Resource Management – Atlantic Fisheries and Oceans. Canada. Ottawa, Ontario DFO/5832.

Anonymous. 1999a. Capelin in Subarea 2 + Div. 3KL. Department of Fisheries and Oceans. Stock Status Report B2-02.

Anonymous. 1999b. Northern shrimp (*Pandalus borealis*) resources from Division OB to 3K-an interim review. Stock Status Report C2-05.

Anonymous. 1997. Northern shrimp off Newfoundland and Labrador. Fisheries and Oceans. Newfoundland Region. DFO Science Stock Status Report #C2-05.

Anonymous. 1997a. Capelin in Subarea 2 + Div. 3KL. Department of Fisheries and Oceans. Stock Status Report B2-02.

Anonymous. 1995. Report on the status of Canadian managed groundfish stocks of the Newfoundland region. DFO Atlantic Fisheries Stock Status Report 95/4E.

Apollonio, S. (1969). The Northern Shrimp, Pandalus Borealis in the Gulf of Maine. (Report No. 3-12-R). Bureau of Commercial Fisheries. Boothbay Harbour, Maine.

Billard, G. L. 1998. Marine conservation areas in the Newfoundland context: The proposed Bonavista and Notre Dame Bay initiative. Master of Marine Studies Report. Memorial University of Newfoundland.

Bjordal, A., and T. Laevastu. 1990. Effects of trawling and longlining on the yield and biomass of cod stocks-numerically simulated. ICES. C.M. 1990/G32.

Buchanan, R. A., and S. M. Brown. 1981. Zooplankton of the Labrador coast and shelf during summer, 1979. LGL limited for Petro-Canada Explorations Limited.

Campbell, R. R. 1998. Rare and endangered fishes and marine mammals of Canada: COSEWIC fish and marine mammal subcommittee status reports: XI. Canadian Field-Naturalist 112 (1): 94-97.

Campbell, R. R. 1997. Rare and endangered fishes and marine mammals of Canada: COSEWIC fish and marine mammal subcommittee status reports: XI. Canadian Field-Naturalist 111 (2): 249-257.

Carscadden, J., and B. S. Nakashima. 1997. Abundance and changes in distribution, biology, and behaviour of capelin in response to cooler waters of the 1990's. Proceedings, Forage Fishes in Marine Ecosystems. p. 459-468.

Colbourne, E., B. de Young, S. Narayanan and J. Helbig. 1997. Comparison of hydrography and circulation on the Newfoundland Shelf during 1990-1993 with the long term means. Can. J. Fish. Aquat. Sci., Vol. 54(Supp. 1): 68-80.

Collie, J. S., G. A. Escanero and L. Hunke. 1996. Scallop dredging on Georges Bank: Photographic evaluation of effects on benthic epifauna. ICES C. M. 1996/Mini: 9.

Dawe, D. E., and D. M. Taylor. 1997. Stock status report Newfoundland and Labrador snow crab. DFO Science Stock Status Report C2: 01.

Dawe, D. E., D. W. Kulka, H. J. Drew, P. C. Beck, and P. J. Veitch. 1998. An assessment of Newfoundland and Labrador snow crab in 1997. Canadian Stock Assessment Secretariat. Research Document 98/137.

Dayton, P. K., S. F. Thrush, M. T. Agardy, and R. J. Hofman. 1995. Viewpoint: environmental effects of marine fishing. Aquatic Conservation: Marine and Freshwater Ecosystems, Vol. 5, 205-232.

Department of Fisheries and Oceans. 1999. Integrated management plan. Snow crab Newfoundland Region 1999-2000. Fisheries Management Branch. St. John's, Newfoundland

Department of Fisheries and Oceans.1984. Underwater World. Turbot (Greenland Halibut). Communications Directorate, Ottawa.

deYoung, B., and G. A. Rose. 1993. On recruitment and distribution of Atlantic cod (*Gadus morhua*) off Newfoundland. Can. J. Fish. Aquat. Sci., Vol. 50, 1993.

Dore, I. & Frimodt, C. (1987). An illustrated guide to shrimp of the World. New York: Osprey.

Drinkwater, K. F., R. G. Pettipas and W. M. Petrie. 1999. Overview of Meteorological and sea ice conditions off Eastern Canada during 1998. Canadian Stock Assessment Secretariat. Research Document 99/51.

Drinkwater, K. F., and G. C. Harding. 1995. The effects of the Hudson Strait outflow on the biology of the Labrador shelf. ICES. CM 1995/C: 14 Ref L.

Drinkwater, K. F. 1994. Environmental changes in the Labrador Sea and some effects on fish stocks. ICES C. M. 1994/Mini: 4.

Fisheries and Oceans Canada. 1999. Marine protected areas policy. Marine Ecosystems Conservation Branch. Oceans Directorate. Ottawa, Ontario.

Fisheries and Oceans Canada. 1998. Marine protected areas program. Ottawa: Communications Directorate. Fisheries and Oceans Canada. 27 pp.

Fisheries and Oceans Canada. 1997. An approach to the establishment and management of marine protected areas under the Oceans Act. *A discussion paper*. Ottawa: Communications Directorate. Fisheries and Oceans Canada. 47 pp.

Fishery Products International. 1999. Company profile. St. John's, Newfoundland.

Fisheries Resource Council of Canada (FRCC). 1999. 1999 conservation requirements for 2J3KL cod. Report to the Minister of Fisheries and Oceans. FRCC 99. R3. Found at http://www.ncr.dfo/frcc.

Fisheries Resource Council of Canada (FRCC). 1998. 1999 conservation requirements for groundfish other than cod in Sub Area 0 and Area 2 + 3 (except 3Ps). Report to the Minister of Fisheries and Oceans. Found at http://www.ncr.dfo/frcc.

Fisheries Resource Council of Canada (FRCC). 1997. 1998 Conservation Requirements for Grand Banks, Labrador Shelf and Davis Strait Groundfish Stocks. Report to the Minister of Fisheries and Oceans. Found at http://www.ncr.dfo/frcc.

Fisheries Resource Council of Canada (FRCC). 1997a. A report on gear technology in eastern Canada. Report of the Gear Technology Subcommittee, March 1997. Found at http://www.ncr.dfo/frcc

Fitzpatrick, C., and R. J. Miller. 1979. Review of spawning times and locations for some commercial finfish on the Newfoundland and Labrador coasts. Fisheries and Marine Service. Technical Report 905.

Frank, K. T., J. E. Carscadden, and J. E. Simon. 1996. Recent excursions of capelin (*Mallotus villosus*) to the Scotian Shelf and Flemish Cap during anomalous hydrographic conditions. Can. J. Fish. Aquat. Sci. 53: 1437-1486.

Hannesson, R. 1997. Fishing as a supergame. Journal of Environmental Economics and Management. Vol. 32: is. 3, pp. 309-322

Harper, J. R., J. Christian, W. E. Cross, R. Firth, G. Searing, and D. Thompson. 1993. Coastal & Ocean Resources. Sydney, B.C. 71 pp.

Hickey, W. M., G. Brothers, and D. L. Boulos. 1993. By-catch reduction in the northern shrimp fishery. Canadian Technical Report of Fisheries and Aquatic Sciences. No. 1964.

Hutchings, J. A., R. A. Myers and G. R. Lilly. 1993. Graphic variation in the spawning of Atlantic cod, *Gadus morhua*, in the northwest Atlantic. NAFO SCR Doc. 93/42.

ICES. 1995. Report on the study group on ecosystem effects of fishing activities. ICES Cooperative Research Report NO. 200. Copenhagen, Denmark.

ICES. 1994. Report on the study group on life histories and assessment of *Pandalus* stocks in the north Atlantic. C. M. 1994/K8.

Kelleher, G. and R. A. Kenchington. 1992. Guidelines for establishing marine protected areas. A maritime conservation and developmental report. Gland, Switzerland: ICUN.

Kulka, D. W. 1997. Discarding of cod (*Gadus morhua*) in the northern cod and northern shrimp directed trawl fisheries, 1980-94. NAFO Sci. Coun. Studies, 29: 67-79.

Kulka, D. W. 1995. Bycatch of commercial groundfish species in the northern shrimp fisheries. Department of Fisheries and Oceans Atlantic Fisheries Research Document; 95/48.

Lilly, G. R. 1994. Predation by Atlantic cod on capelin on the southern Labrador and northeast Newfoundland shelves during a period of changing spatial distributions. –ICES mar. Sci. Symp., 198: 600-611.

Lilly, G. R., P. A. Shelton, J. Brattey, N. Cadigan, E. F. Murphy, and D. E. Stansbury. 1999. An assessment of the cod stock in NAFO Divisions 2J+3Kl. Department of Fisheries and Oceans. Canadian Stock Assessment Secretariat. Research Document 99/42.

Lilly, G. R., P. A. Shelton, J. Brattey, N. Cadigan, E. F. Murphy, D. E. Stansbury, M. B. Davis, and M. J. Morgan. 1998. An assessment of the cod stock in NAFO Divisions 2J+3Kl. Department of Fisheries and Oceans. Canadian Stock Assessment Secretariat. Research Document 98/15.

Lock, A. R., R. G. B. Brown, and S. H. Gerriets. 1994. Gazetteer of marine birds in Atlantic Canada: an atlas of seabird vulnerability to oil pollution. Canadian Wildlife Service. Environmental Conservation Branch. Environment Canada-Atlantic Region

Lock, A. R. 1978. Offshore Labrador biological studies (OLABS): Report on 1978 Surveys of Seabirds in Labrador. Canadian Wildlife Service, Atlantic Region.

Morgan, M. J., E. M. DeBlois, and G. A. Rose. 1997. An observation on the reaction of Atlantic cod (*Gadus morhua*) in a spawning shoal to bottom trawling. Can. J. Fish. Aquat. Sci. 54(Suppl. 1): 217-223.

NAFO. 1998. Greenland halibut (*Reinhardtius hippoglossoides*) in Subarea 2 and Divisions 3KLMNO. Found at http://www.nafo.ca/

NAFO. 1998a. Scientific Council Reports 1998. Dartmouth, Nova Scotia.

NAFO. 1995.. Fishery statistics for 1960-90. Statistical Bulletin. Supplementary Issue Dartmouth, Nova Scotia.

Parsons, D. G., P. J. Veitch and G. T. Evans. 1999. Resource status of Northern Shrimp (*Pandalus borealis*) off Baffin Island, Labrador, and northeastern Newfoundland: second interim review. Canadian Stock Assessment Secretariat Research Document 99/112.

Parsons, D. G., and P. J. Veitch. 1998. Status of Northern Shrimp (*Pandalus borealis*) resources in areas off Baffin Island, Labrador and Northeastern Newfoundland-interim review. Canadian Stock Assessment Secretariat Research Document 98/72.

Parsons, D.G. (1984). The Northern Shrimp. Underwater World. Communications Directorate, DFO.

Pepin, P., and J. A. Helbig. 1997. Distribution and drift of Atlantic cod (*Gadus morhua*) Eggs and larvae on the northeast Newfoundland Shelf. Can. J. Fish. Aquat. Sci. 54: 670-685.

Petro-Canada. 1982. Offshore Labrador biological studies (OLABS). Offshore Labrador Initial Environmental Assessment.

Rose, G. A. 1993. Cod spawning on a migration highway in the north-west Atlantic. Nature (Lond.), 366: 458-461.

Rose, G. A. and W. Hiscock. 1999. Trends in spring and winterresearch CPUE of shrimp on Hawke Channel, 1994-1999. Canadian Stock Assessment Secretariat Research Document 99/154.

Rose, G. A. 1996. Cross-shelf distributions of cod in NAFO Divisions 2J3KL in May and June 1995: some preliminary findings of a longer term study. Can. Stock Assess. Secr. WP 96/10.

Ruzzante, D. E., C. T. Taggert, D. Cook, and S. V. Goddard. 1997. Genetic differentation betwen inshore and offshore Atlantic cod (*Gadus morhua*) off Newfoundland: a test and evidence of temporal stability. Can. J. Fish. Aquat. Sci. 54:2700-2708.

Savenkoff, C., Saint-Amand, L., Ouellet, P., and Packard, T.T.(1995). An index of respiratory efficiency in the shrimp *Pandalus Borealis* Larvae. Canadian Technical Report of Fisheries and Aquatic Science. (Report No. 2072). Division of Ocean productivity, Maurice Lamontagne Institute, Mont Joli, Quebec.

Scott, W. B. and M. G. Scott. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219:731 p.

Skinner, B.J., and S. C. Porter. 1995. The Blue Planet. An Introduction to Earth System Science. Canada: John Wiley and Sons, Inc.

Skuladottir, U. 1998. The bycatch in the shrimp fishery of Iceland at Flemish Cap in 1997 and 1998. NAFO SCR document; 98/29.

Stenson G. B., R. A. Myers, I-H. Ni, and W. G. Warren. 1997. Pup production and population growth of hooded seals (*Cystophora cristata*) near Newfoundland, Canada. Can. J. Fish. Aquat. Sci. 54 (Suppl. 1): 209-216.

Stenson G. B., R. A. Myers, M. O. Hammill, I-H. Ni, W. G. Warren and M. C. S. Kingsley. 1993. Pup production of harp seals *Phoca groenlandica,* in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 50:2429-2439.

Stenson, G. B., and B. Sjare. 1997. Seasonal distributions of harp seals, *Phoca groenlandica*, in the Northwest Atlantic. ICES C. M. 1997/CC:10. Biology and Behaviour II.

Taylor, D. M. and P. G. O'Keefe. 1998. An assessment of the 1997 Newfoundland and Labrador snow crab fishery. Canadian Stock Assessment Secretariat. Research Document 98/140.

Travin, V. I., and C. N. Pechenik. 1963. Soviet fishery investigations and fishing northwest Atlantic. B. Hershkovitz (Translator), Soviet Fisheries Investigations in the Northwest Atlantic (pp. 4-55). Washington: U. S. Department of the Interior and the National Science Foundation.

van der Linden, W. J., R. H. Fillon and D. Monahan. 1976. Hamilton Bank, Labrador margin: origin and evolution of a glaciated shelf. Marine Sciences Paper 14. Ottawa. Canada.