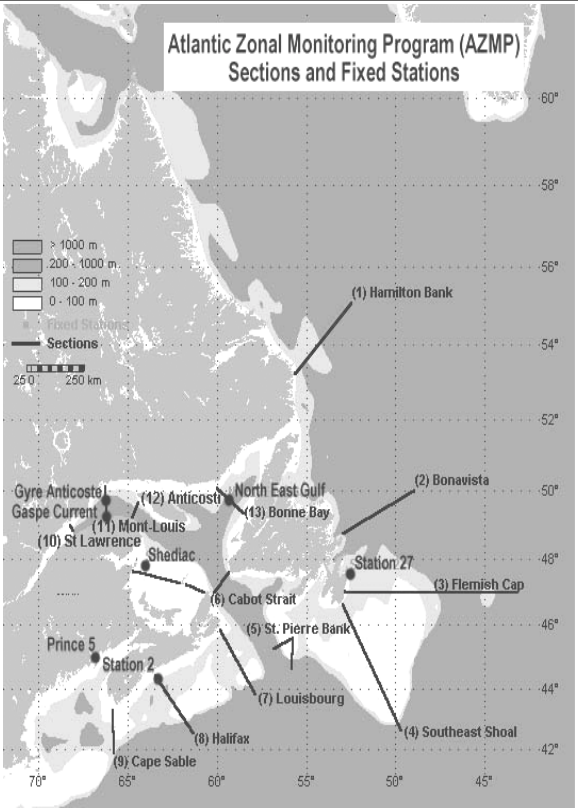
Fisheries and Oceans Pêches et Océans

Newfoundland Region

DFO Science

Stock Status Report G2-02(2000)



Chemical and Biological Oceanographic Conditions 1998 and 1999 Newfoundland Region

Background

The Altantic Zone Monitoring Program (AZMP) was implemented in 1998 with the aim of increasing DFO's capacity to understand, describe, and forecast the state of the marine ecosystem and to quantify the changes in the ocean physical, chemical and biological properties (Therriault et al. 1998). A critical element of the AZMP involves an observation program aimed at assessing the variability in nutrients, phytoplankton and zooplankton that is supplemented by annual surveys of the nekton in the Newfoundland Region.The AZMP derives its information on the state of the marine ecosystem from data collected at a network of sampling locations (fixed point stations, cross-shelf sections, and groundfish surveys) in each region (Laurentian, Maritimes, Newfoundland) sampled at a frequency of bi-weekly to once annually. This provides a good view of the state of the pelagic ecosystem.

A description of the seasonal patterns in the distribution of phytoplankton (microscopic plants) and zooplankton (microscopic animals) provides important information about organisms that form the base of the marine foodweb. An understanding of the production cycles of plankton, and their interannual variability, is an essential part of an ecosystem approach to fisheries management.

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Summary

- Peak phytoplankton abundance in both the spring and fall of 1999 appear to have been greater than in 1998 for most areas on the Newfoundland Shelf whereas concentrations during the summer months appear to have been close to normal. Phytoplankton concentrations were substantially higher in the fall of 1999 than had been previously observed. The increased abundance from summer levels appears to be the result of an increase in the abundance of diatoms.

- Zooplankton abundance has increased steadily during the latter part of the 1990s.

Much of the increase appears to have started in small species (e.g. *Oithona* sp., *Pseudocalanus* sp.) but in 1998 and 1999, there was a notable increase in the abundance of larger species such as *Calanus finmarchicus*.

- There has been a steady increase in the abundance of nekton (small pelagic fish and macrozooplankton) since the mid 1990s. Although the composition has changed somewhat from year to year, the young pelagic stages of redfish, sand lance, Atlantic cod and American plaice were more abundant in 1999 that has been observed since 1994. There have been fluctuations in the abundance of capelin but their abundance is at levels comparable to peak observations since 1994. The combined abundance of several northern taxa (e.g. sea snails, pelagic squid) has decreased steadily since the mid 1990s.

Nutrient concentrations and chytoplankton biomass

The Bonavista Bay transect represents one of the key areas that has been sampled since before the inception of the monitoring program in the Newfoundland region. As a result, it has the greatest base of information from which we can assess variations from the average seasonal cycle in biological and chemical oceanographic conditions.

During the spring of 1998, chlorophyll concentrations indicated that the spring phytoplankton bloom had already peaked by late April-early May and that concentrations were beginning to decrease in offshore regions, past the shelf break, but there appeared to be sufficient nutrients in surface waters to maintain high chlorophyll concentrations over most of the continental shelf. By the end of July, chlorophyll concentrations had decreased to levels slightly above the 1993-97 average. Summer conditions were characterized by a strong subsurface chlorophyll maximum, as is typical for conditions throughout most of the eastern Newfoundland shelf during this time of year. Sum-

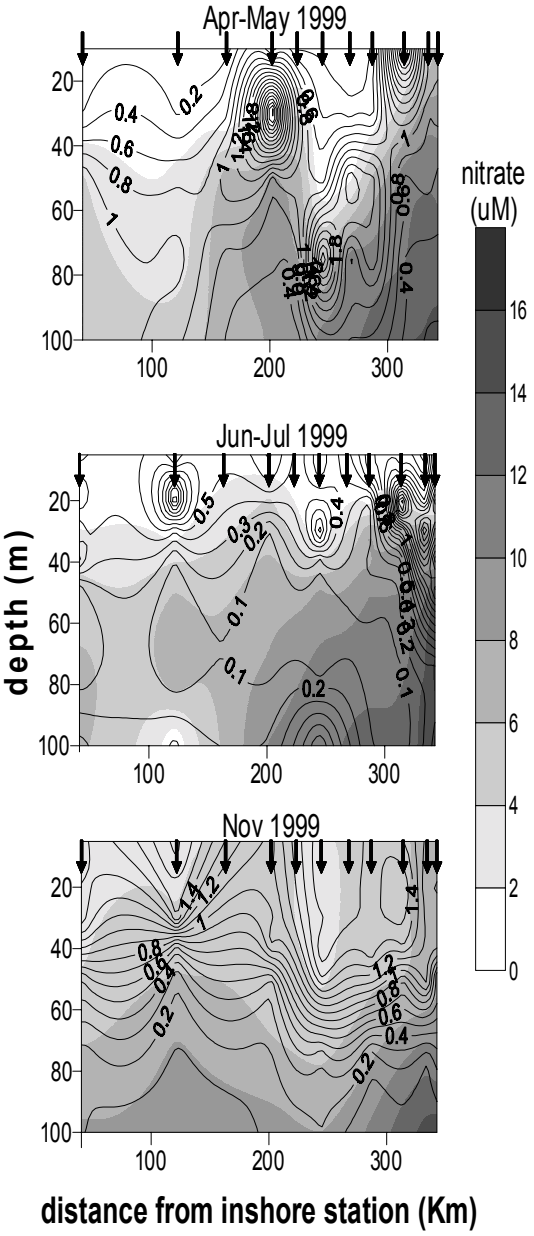

Figure 1. Overlay of chlorophyll 'a' contours on nitrate color intensity. Bonavista Bay transect.

mer nitrate concentrations throughout the water column appeared to be below the 1993-97 average.

In 1999, the Bonavista transect was sampled on three occasions: April-May, July-August and November. By late April-early May, chlorophyll concentrations indicated that the spring phytoplankton bloom had occurred prior to our sampling, with levels approaching near summer conditions and nitrate concentrations depleted across most of the shelf in that area. In July, chlorophyll concentrations were slighly below the long term (1993-97) average and nitrate levels were slightly above normal. By November, mixing of the water column had begun but there was evidence of a fall phytoplankton bloom consisting primarily of diatoms (other phytoplankton groups had shown little evidence of seasonal variation in abundance) (Pepin and Maillet 2000). Bottom nitrate concentrations were slightly lower than previous observations.

Apart from collections on Bonavista transect, observations on the Grand Banks suggest that phytoplankton biomass levels in this region of the shelf were elevated in 1999. Phytoplankton concentrations were elevated during the July-August survey and there is good evidence that a strong fall phytoplankton bloom occurred. Diatoms were substantially more abundant in the fall than in the summer. The high biomass of phytoplankton was associated with a warm water lens which was found atop the southeast Shoal and extended over a wide region of the Grand Banks.

Satellite derived estimates of surface chlorophyll

Biological conditions derived from ocean colour data collected by the Sea-viewing Wide Field of View (SeaWiFS) satellite sensor can be found at the BIO Ocean Sciences Division website (http://www.mar.dfo-mpo.gc.ca /science/ocean/ias/seawifs_1.html). Although these data do not provide information on vertical structure of phytoplankton in the water column, they do provide highly resolved (~1km) data on their geographic distribution in surface waters. The data are provided as composite images over two week intervals for the northwest Atlantic.

The seasonal cycle of phytoplankton throughout most Newfoundland waters is characterized by two peaks, one in the spring (April-May) and another smaller peak in the late fall or early winter (October-January). The satellite information is consistent with observations from Station 27 and from transects across the shelf. Peak phytoplankton abundance in both the spring and fall of 1999 appear to have been greater than in 1998 for most areas on the Newfoundland Shelf whereas concentrations during the summer months appear to have been close to normal (0.5-1 mg m^{-3}).

Zooplankton abundance

Total copepod abundance was highest in 1998, relative to levels observed from 1993-97. Species of small copepods (*Pseudocalanus* spp., *Oithona* spp., *Centropages* spp., *Acartia* spp.) dominate in the spring whereas larger species of the genus *Calanus* (*C. finmarchicus*, *C. glacialis*, *C. hyperboreus*) reach similar levels of numerical abundance by mid-summer. In 1999, total copepod abundance was somewhat less than in the previous year, but the abundance of species of *Calanus* was higher than in 1998, which resulted in an increase in the overall zooplankton biomass relative to previous observations.

The general spatial distribution of copepod species was consistent with previous observations. In the spring, overall copepod abundance appears to be relatively uniform across the shelf. However, during summer months, species show

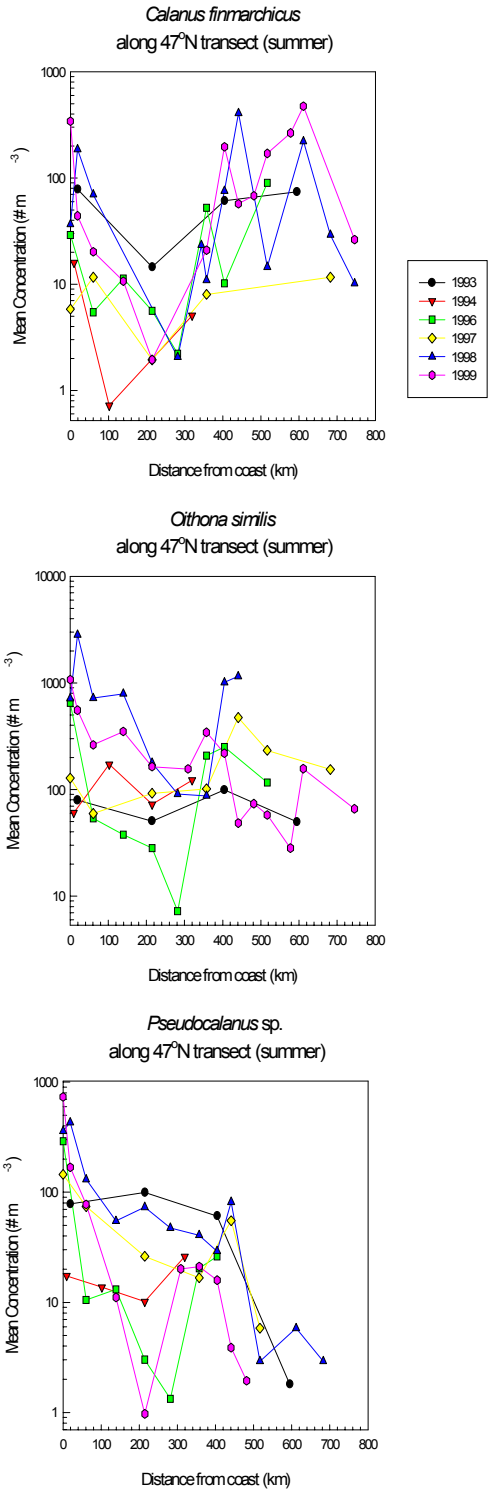

Figure 2. Zooplankton Abundance

a greater degree of spatial structure in their distributions. *Pseudocalanus* spp. is most abundant in coastal areas and decreases in numbers as one moves further offshore.*Oithona* spp. is ubiquitous over the entire shelf but is relatively more abundant on the Grand Banks. Similarly, species of *Calanus*, dominated by *C. finmarchicus*, occur over the entire shelf but their greatest numbers are generally associated with the inshore and offshore branches of the Labrador current where large numbers of immature adults are found.

During the period from 1993-1999, there have been major shifts in the summer (July-August) distribution of copepods on the Newfoundland Shelf. During the early part of this period, the community was dominated by *Calanus* spp. and *Pseudocalanus* spp., which were widely distributed. From 1994 until 1998, the relative abundance of *Oithona* spp. increased across the entire shelf all the way to Labrador. This was the result of a substantial (2 to 10-fold) increase in the absolute abundance of this species during this period while there was relatively less change in the abundance of other species. In 1999, the community distribution appears to have returned to that observed in the early part of the 90s (93-94). This is the result of a slight decrease in the abundance of *Oithona* spp. coupled with an increase in the abundance of *Calanus* spp.

Continuous Plankton Recorder

The Continuous Plankton Recorder (CPR) collections along the Z-line (Iceland to St. John's), which crosses the northern edge of the Grand Banks, has been ongoing between the years 1959-1986 and 1991-present (Sameoto 2000). The collections show that during the period after 1991, the abundance of all stages of *Calanus finmarchicus* as well as that of total euphausiids has been lower than during the earlier period whereas the color index, a measure of phy-

toplankton abundance, has been substantially higher. However since 1997, the abundance of *C. finmarchicus* appears to have been increasing (Sameoto 2000), which is consistent with the observations from the net plankton sampled along the standard oceanographic transects.

Total size fractionated plankton biomass

From 1994 to 1999 late summer surveys (late August-early September) of plankton and nekton have been carried out in Newfoundland waters (NAFO Divisions 2J3KLNO). Total zooplankton biomass including 3 size fractions (>2mm, 1-2mm and <1mm) has been greater on the Northeast Newfoundland Shelf than in the inshore, which has been greater than on the Grand Banks. Total zooplankton biomass remained relatively high in 1999 following a trend of increasing biomass during the first 4 years. Biomass of the largest size fraction has decreased slightly; following initial increases between 1994 and 1995, and 1999 was not significantly less than any year, except 1995. Biomass of the mid-size zooplankton has shown a steady increase over the study period with peak catches in 1999. Biomass of the smallest size fraction remained relatively low in 1999 after peak biomass levels were obtained in 1997.

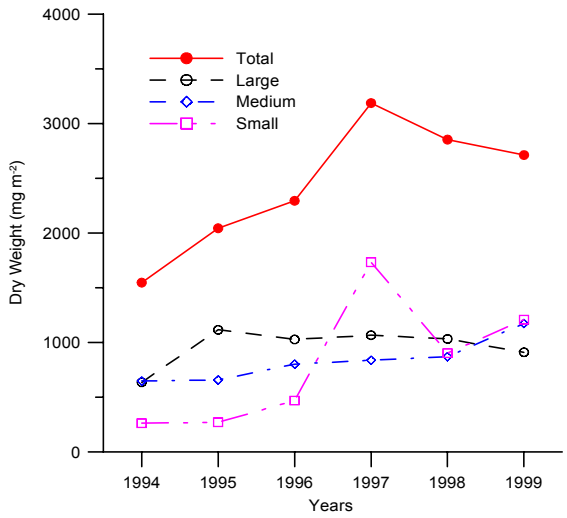

Figure 3. Size Fractionated Plankton Biomass

Nekton

Mean nekton biomass (with or without jellyfish) has increased steadily since 1995. In 1999, total nekton biomass, with jellyfish, was significantly greater than any previous year. Highest biomass of jellyfish occurred inshore and on the northern Grand Bank. Without jellyfish, which were particularly abundant in the two most recent years, nekton biomass in 1999 was significantly greater than all other years, except 1998.

Nekton was dominated by capelin and sand lance, both of which were relatively abundant in 1999. Capelin, in contrast to sand lance, was relatively low in abundance in 1998. Highest catch rates of capelin occurred inshore and on the Northern Grand Bank, although in 1999 relatively high catch was also taken on Funk Isle Bank. Highest catch rates of sand lance, over all years, occurred on the southern Grand Bank but in 1999 the centre of distribution shifted to the Northern Grand Bank.

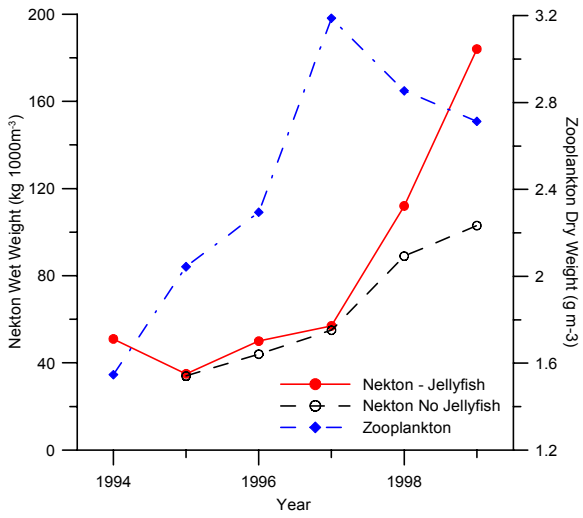

Figure 4. Mean Nekton Biomass

Mean catch rate of pelagic 0-group Arctic cod decreased after the first year of the survey. In 1999 mean catch rate ranked significantly lower than in 1994 but was not significantly different from any other year, indicating a fairly stable abundance in recent years.

Mean catch rate of pelagic 0-group Atlantic cod increased for the third year in succession following extremely low catches in 1996. Increase in 1998 over 1997 resulted from higher catches on the Grand Bank, particularly the southern portion. Highest increases in 1999 occurred in the inshore. Abundance of cod on the southern Grand Bank decreased relative to 1998 whereas abundance on the Northern Grand Bank increased compared to 1998. Over the period of the surveys the only year that significant catches were taken in the offshore portion of the NE

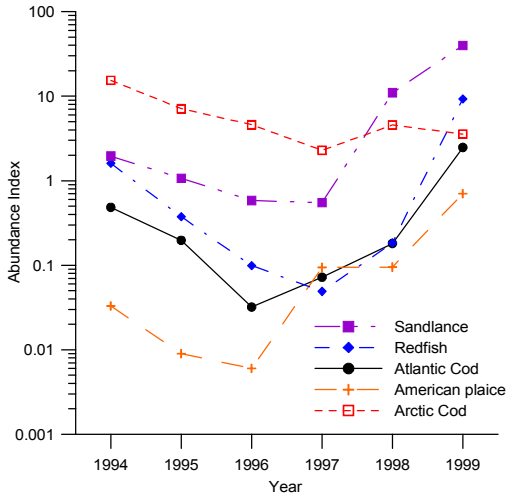

Figure 5. Pelagic O-Group Abunance Indices

Newfoundland Shelf was 1994. Relatively low abundance of several Grand Bank species (e.g. sand lance, haddock and hake) were noted in 1997, but abundance increased again in 1998 (Dalley et al. 2000). In addition to sand lance; hake, which are mainly restricted to the southern Grand Bank, were significantly more abundant in 1999 than any previous year. Redfish, which increased in distribution and abundance in 1999, had highest catch rates on the southern Grand Bank. Pelagic 0-group American plaice, which have been observed in low abundance on the Grand Bank in previous years, were more abundant in 1999 than in any previous year. There was a substantial increase in their abundance in coastal areas.

Pelagic 0-group haddock, which were observed for the first time in the survey in 1998, were present in 1999 but in lower numbers than in the previous year and their distribution was restricted to the southern Grand Banks.

With the exception of Arctic cod and haddock, all indices of nekton abundance ranked higher in 1999 than 1998. In 1998 overall abundance of six northern taxa decreased sharply compared to 1997. In 1999 abundance of all six again was slightly higher than their 1998 levels but well below a level that was observed during the first four years of the surveys.

Conclusions

The sampling design of the AZMP provides basic information on the natural variability in physical, chemical and biological properties of the Northwest Atlantic continental shelf. Cross-shelf sections provide detailed geographic information but are limited in their seasonal coverage. Critically placed fixed stations complement the geography-based sampling by providing more detailed information on temporal (seasonal) changes in ecosystem properties.

Seasonal patterns and regional differences were observed in chemical and biological variables in the Newfoundland region in 1998 and 1999. Noteworthy among the differences between years was the higher concentration of chlorophyll in both the spring and the fall of 1999. Differences observed in the hydrographic and chemical conditions between the two years were not as apparent in biological properties but this

may be partially a result of the high inherent spatial and temporal variability in phytoplankton and zooplankton.

There appear to have been substantial increases in the abundance of zooplankton and nekton during the latter part of the 1990s. It is still unclear whether these changes are associated with fluctuations in the physical or biological components of the Newfoundland Shelf ecosystem.

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ISSN: 1480-4913

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