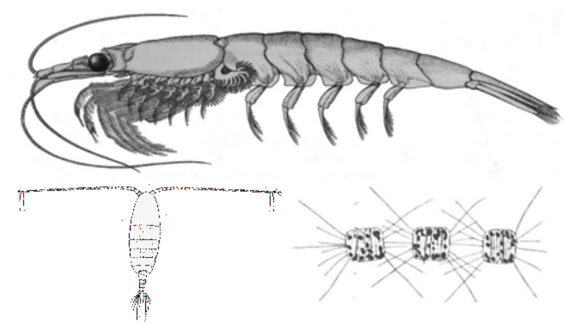
2005 STATE OF THE OCEAN: CHEMICAL AND BIOLOGICAL OCEANOGRAPHIC CONDITIONS IN THE NEWFOUNDLAND AND LABRADOR REGION



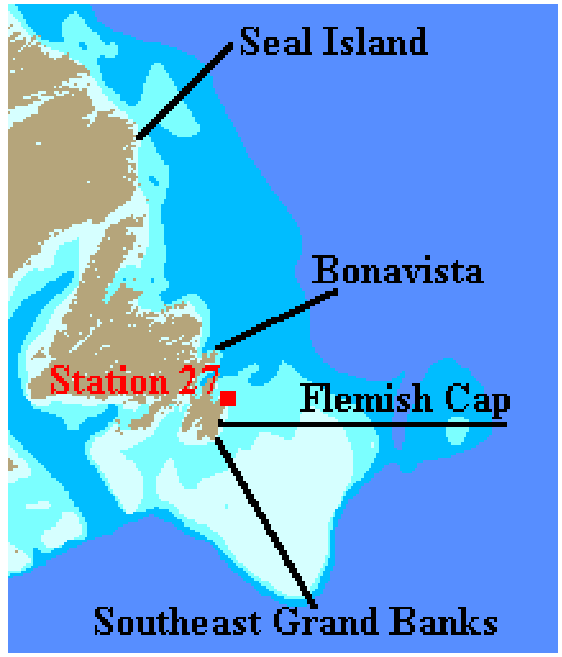


Figure 1: Map of survey region showing AZMP oceanographic transects (in black) and location of fixed station (in red).

Background

The Atlantic 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's physical, chemical and biological properties. A critical element of the AZMP involves an observation program aimed at assessing the variability in nutrients, phytoplankton and zooplankton.

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 (Quebec, Gulf, Maritimes, Newfoundland) sampled at a frequency of bi-weekly to once annually.

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.

SUMMARY

- Near bottom nutrient inventories at Station 27 remain low relative to values observed in 2000 but this pattern is not observed along the major oceanographic transects.

- There are some indications of a decrease in phytoplankton abundance at Station 27 since 2002 but the magnitude of the change is not statistically significant nor was it reflected along the oceanographic transects.

- In 2005, the overall abundance of zooplankton at Station 27 was low relative to the long term average in 5 of the 12 dominant species groups.

- The abundance of *Calanus finmarchicus* and its sister species at Station 27 was at the lowest level since 1999, as was the abundance of euphausiids and larvaceans.

- The abundance of the dominant copepod species was at near record levels on both the Newfoundland shelf as well as off the coast of Labrador. The abundance on the northern and southern Grand Banks were generally comparable to the long-term average for these parts of the region.

INTRODUCTION

Phytoplankton are microscopic plants that form the base of the aquatic food web, occupying a position similar to that of plants on land. There is a wide variation in the size of phytoplankton, with the largest species being members of a group called diatoms while smaller species are members of a group called flagellates. They use light to produce organic matter from nutrients dissolved in marine waters. The growth rate at which new organic matter is produced depends on temperature and the abundance of light and nutrients. The phytoplankton constitute the primary food source of the animal component of the plankton, zooplankton. In most marine waters, phytoplankton undergo a spring-summer explosion in abundance called a bloom.

The dominant zooplankton in Newfoundland waters are copepods. They represent the critical link between phytoplankton and larger organisms. Young copepods (nauplii) are the principal prey of young fish while the older stages (copepodites) are eaten by larger fish, such as juvenile and adult capelin.

A description of the cycle of nutrients on the continental shelf aids in understanding and predicting the variability of plankton populations in space and time. An understanding of the plankton cycles will, in turn, aid in assessing the health of the marine ecosystem and its capacity to sustain fisheries. The data for this report are derived from approximately bi-monthly observations at Station 27, located 5 km from the mouth of St. John’s Harbour, and from oceanographic surveys conducted along 3 to 4 cross-shelf transects in the spring, summer and fall. At each sampling site, physical (temperature, salinity, density), chemical (oxygen, nutrients), and biological (phytoplankton, zooplankton) variables are collected.

ANALYSIS

<u>Nutrient concentrations and phytoplankton biomass</u>

During 2005, the seasonal cycle of nitrate (a source of nitrogen) and silicate (a source of silica which is critical for some dominant species of phytoplankton) showed the typical pattern of depletion in surface waters following the spring phytoplankton bloom. We were unable to determine the time of the onset and duration of the spring phytoplankton bloom because of a gap in observations (Figure 2). However, the average seasonally-adjusted biomass of phytoplankton at Station 27 was at the lowest level observed since 1999. This may have been due to warmer surface temperatures and more intense stratification during the summer productive period.

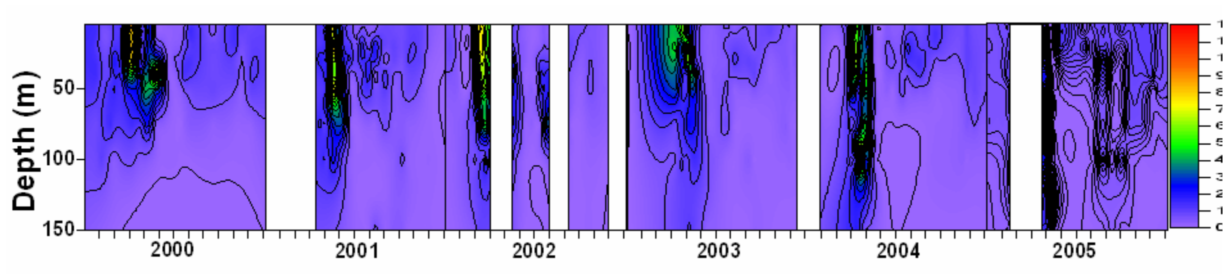


Figure 2: Seasonal vertical distribution of phytoplankton at Station 27 for 2000-2005. White areas represent time periods when samples were unavailable. The color bar provides a measure of phytoplankton abundance.

Following the spring bloom, there were small amounts of phytoplankton below the surface which persisted throughout the summer and fall. This is in contrast with observations in 1999 when the levels of phytoplankton below the surface showed substantial changes in abundance throughout the summer and fall, reaching concentrations that were approximately 2-3 times higher than what was observed in 2000-2005. Furthermore, we have not detected a fall phytoplankton bloom at Station 27 since 2000, although satellite derived observations of surface concentrations of phytoplankton across a broader area of the Avalon Channel and other regions of the Shelf indicate an increase in phytoplankton abundance when mixing of the water column increases in the fall.

Nutrient concentrations near the bottom (50-150 m), which provides a measure of the amount of material that will be available once the fall and winter mixing of the water column takes place, was similar to levels observed in 2001-2004 but about half the levels found in 1999-2000 at the fixed station near St. John's (Figure 3). On the other hand, both silicate and nitrate inventories in the surface layer (0-50 m) at Station 27 appeared to show limited overall variability since the inception of the monitoring program. The most notable change was in the concentration of nitrate, an essential element in the growth of all phytoplankton species. Although near bottom nutrient concentrations at Station 27 were still low relative to observations from 2000, this pattern did not appear to prevail across the Newfoundland Shelf where nutrient inventories were generally at comparable levels to the start of the program, with some instances showing a slight increase since the start of the century while others showed a slight decrease (Figure 4).

Seasonal fluctuations in phytoplankton biomass in the Newfoundland region are dominated by changes in the abundance of diatoms. Information from 1999 to 2004 shows that the spring phytoplankton bloom is a time of the year diatoms dominate during the spring while in the fall it is primarily flagellates and dinoflagellates which dominate. In 2004 the numerical abundance of most phytoplankton groups was lower than in previous years, following a trend which started in 2000. This was also apparent during the regional oceanographic surveys. Although this did not appear to affect the overall biomass of phytoplankton available to zooplankton, the lower numbers may affect other elements of the pelagic ecosystem on the Newfoundland Shelf.

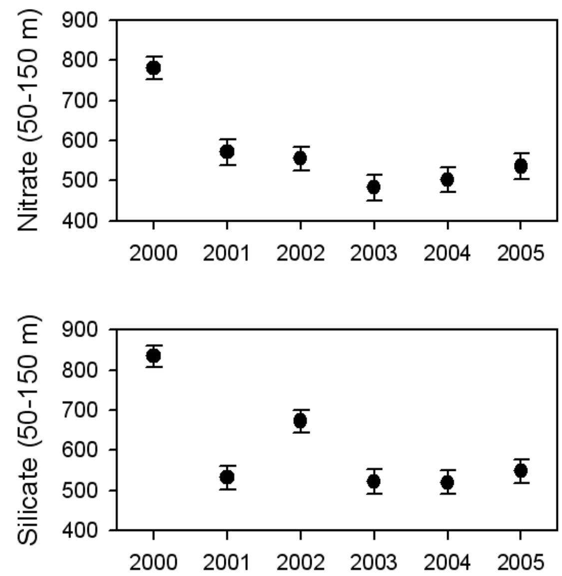


Figure 3. Seasonally-adjusted average deep-water nutrient inventories at Station 27.

The pattern in phytoplankton biomass observed during the spring oceanographic survey showed an increase over 2003 but levels were similar to those observed in 2004. The differences among years were largely due to differences in the timing of the spring phytoplankton bloom relative to that of the survey. Satellite observations reveal that over much of the mid-shelf region off Newfoundland, the spring phytoplankton bloom had occurred progressively later from 2000 to 2003, with a marked return to an April bloom in 2004. In 2005, the spring phytoplankton bloom was not dispersed throughout the water column, as in previous years, but was found in the form of a sub-surface chlorophyll maximum across much of the shelf.

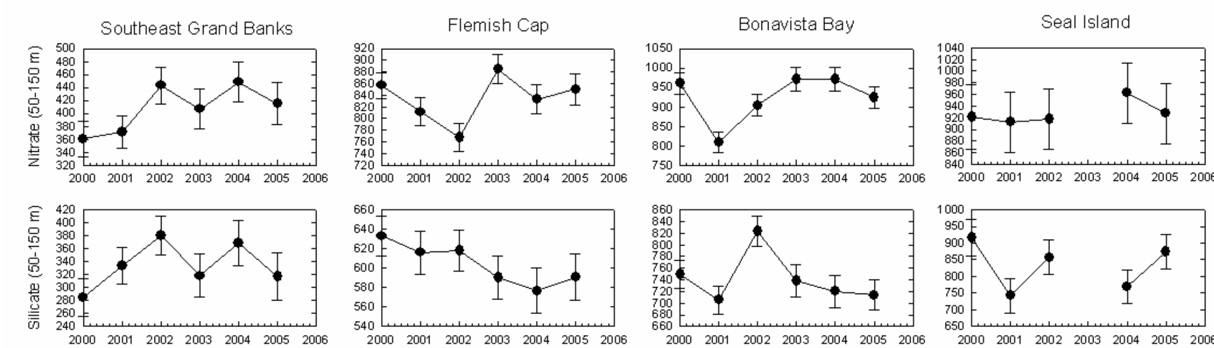


Figure 4. Seasonally-adjusted mean integrated nutrient inventories along the major oceanographic transects.

Zooplankton abundance

Zooplankton abundance shows a distinct seasonal cycle, with a gradual increase throughout the year until late fall when there is a substantial decrease following a reduction in phytoplankton production. This seasonal pattern reflects the increased production of copepod nauplii and copepodites, as well as larvaceans (the organisms associated with the occurrence of slub) and blackberries (pelagic gastropods). Species of small copepods (*Pseudocalanus* sp., *Oithona* sp., *Centropages* sp., *Acartia* sp.) dominate in the spring and fall, whereas larger species of the genus *Calanus* (*C. finmarchicus*, *C. glacialis*, *C. hyperboreus*) reach similar levels of numerical abundance by early to mid-summer.

In 2005, the overall abundance of zooplankton at Station 27 was generally low relative to the long term average. In 5 of the 12 dominant taxa collected at Station 27, the overall seasonally average abundance was either the lowest since 1999, or the second lowest. In 2005, the abundance of *Metridia* spp. and *Pseudocalanus* spp. recovered from the lowest levels recorded in 2004. The overall abundance of *C. finmarchicus* reached its lowest level since the start of the series in 1999 as did the abundance of *C. glacialis* and *C. hyperboreus*. These differences were not statistically significant but there is an indication of a decreasing trend in abundance since 1999 for these three species. The abundance and occurrence of copepod species normally associated with cold (*Calanus glacialis, Calanus hyperboreus*, and *Microcalanus* sp.) and warm waters (*Temora longicornis*), which had shown a gradual shift toward cold water species since 1999 shifted back toward warm water species in 2003, a pattern which continued in 2005.

The overall abundance of *C. finmarchicus* at Station 27 was approximately 35% of its peak abundance in 2000 (Figure 5). In contrast to previous years, there was no strong peak abundance in early summer, with abundance peaking on in September. Peak occurrence of CI stages occurred in late May/early June, as in previous years. The overall pattern of abundance showed a much weaker seasonality than in previous years with the peak abundance being ~50% lower than in 2002-2003. As in most years, early stage copepodites were present in the zooplankton community throughout the fall. As in 2004, there appeared to be a greater relative abundance of early stage copepodites well into the fall of 2005, when CIV and CV had generally dominated during 2000-2003 (Figure 5).

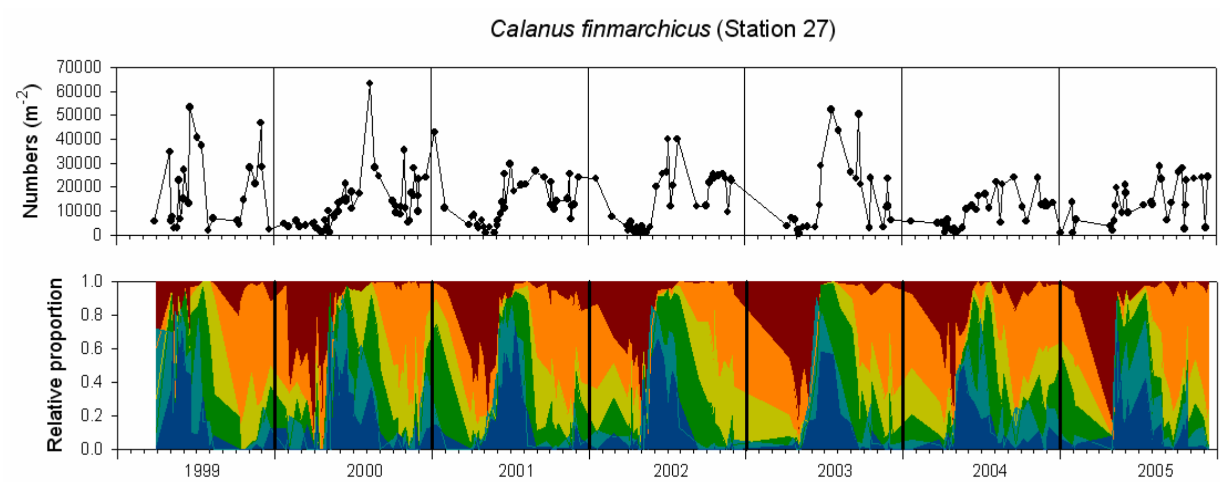


Figure 5: Seasonal abundance and relative stage distribution of copepodites of C. finmarchicus at Station 27 for 1999 to 2005. The youngest stages are indicated as CI and the oldest stages (C VI) represent the adults capable of reproduction.

The general distribution of copepod species across the Newfoundland Shelf was generally consistent with previous observations, with most small species occurring closer to shore, and larger species being distributed further offshore.

The pattern of copepod abundance on the Newfoundland and Labrador Shelf differed somewhat from the long term trends observed at Station 27. Off the coast of Labrador (Seal Island transect), as well as on the Newfoundland shelf (Bonavista Bay transect), the seasonally-adjusted estimates of abundance for the dominant copepod species (*C. finmarchicus*, *C. glacialis*, *C. hyperboreus*, *Pseudocalanus* spp., *Oithona* spp., *Metridia* spp., and copepod nauplii) were either at or near the highest levels recorded since 2000 and reflect a long term trend of increasing abundance. The only exception to this overall pattern was in the abundance of *Metridia* spp. on the Newfoundland shelf, which has been decreasing in abundance since 2003. In the case of *C. finmarchicus*, a dominant species in the region, there has been a 19-fold increase in summer abundance off Labrador since 2000.

On the northern Grand Banks (Flemish Cap transect), abundance levels for most copepod species in 2005 were generally higher than in the previous year. In many instances, the abundance was at or near the highest levels encountered since the start of the monitoring program. However, the inter-annual fluctuations in copepod abundance on the northern Grand Banks do not all show long-term trends. In several cases, persistent patterns of increase or decrease may persist for three years in a row only to be followed by a sharp change in abundance, such as occurred for *C. hyperboreus* and *Pseudocalanus* spp. from 2002 to 2003. The lack of long-term trends in this area may indicate that the pelagic ecosystem is influenced by a number of factors, the balance of which may change abruptly.

There are no consistent patterns of change in the abundance of different copepod species on the southern Grand Banks. Although there have been year-to-year fluctuations in seasonally-adjusted estimates of abundance, few species have shown variations that are considered statistically significant. For most species, there has been approximately a 2-fold variation in overall abundance since 2000.

Sources of Uncertainty

The general patterns in the spatial distribution of physical, chemical and biological oceanographic variables in the Northwest Atlantic zone monitored by AZMP have remained relatively constant during the period 1999-2005. Although there are seasonal variations in the distribution of water masses, plants and animals, these variations show generally predictable patterns. However, there is considerable uncertainty in estimates of overall abundance of phytoplankton and zooplankton. This uncertainty is caused in part by the life cycle of the animals, their patchy distribution in space, and by the limited coverage of the region by the monitoring program.

Physical (temperature, salinity) and chemical (nutrients) oceanographic variables are effectively sampled because they exhibit fairly conservative properties that are unlikely to show precipitous changes from year-to-year. Also, measurements of these variables are made with a good degree of precision. The only exception occurs in surface waters where rapid changes in the abundance of phytoplankton, particularly during the spring bloom, can cause rapid depletion of nutrients. In an attempt to be conservative in our description of the long-term changes in chemical variables, we restrict our conclusions to deep water inventories of nutrients.

The greatest source of uncertainty comes in our estimates of phytoplankton abundance because of the difficulties in describing the inter-annual variations in the timing, magnitude and duration of the spring phytoplankton bloom. Phytoplankton may undergo rapid changes in abundance, on time scales of days to weeks. Because our sampling is limited in time, and occasionally suffers from gaps in temporal coverage due to vessel unavailability or weather, which often occurs in the sampling at our fixed stations during the winter months, we may not sample the spring phytoplankton and other important variables adequately. Also, variations in the timing of the spring phytoplankton bloom across the region and in relation to our spring oceanographic surveys may limit our ability to determine inter-annual variations in maximum phytoplankton abundance. In contrast, we are better capable of describing inter-annual variations in the abundance of dominant zooplankton species because their seasonal cycle occurs at time scales of weeks to months because of their longer generation times. However, zooplankton show greater variability in their spatial distribution. Although inter-annual variations in the abundance of dominant groups, such as copepods, can be adequately assessed, variations in the abundance of rare, patchily distributed or ephemeral species cannot be reliably estimated at this time.

In the Newfoundland region, occupation of Station 27 during the winter and early spring are particularly limited, causing us to sometimes miss the onset of the spring phytoplankton bloom. Also, reductions in vessel scheduling within the region are also reducing the number of full observations at this fixed site. Loss of time during the spring oceanographic survey severely limited the number of stations sampled in offshore areas, leading to a loss of information. The losses were most acute for the zooplankton, which are most abundant in offshore areas.

CONCLUSIONS

There are some consistent trends in some chemical and biological oceanographic conditions at Station 27. Deep water nutrient inventories dropped dramatically from 2000 to 2002 and conditions have remained unchanged since then. There has also been a decrease in the average integrated biomass of phytoplankton since 2002 and there has been a general decrease in the abundance of large calanoid copepods (*C. finmarchicus*, *C. glacialis*, *C. hyperboreus*) along with euphausiids and larvaceans. Although the changes in nutrient inventories are statistically significant, changes in the biological variables are not. The trends are likely indicative of changes taking place in coastal areas, from Bonavista to the southern Avalon, because the patterns do not match the trends observed further offshore.

There are no major trends in integrated nutrient or chlorophyll inventories on the Labrador or Newfoundland shelves as well as on the Grand Banks, Although there are fluctuations from year to year, we have not been able to detect consistent trends in these variables in either region. This pattern is in contrast with the general trends in the abundance of the dominant copepod species on the Labrador and Newfoundland shelves. Nearly all of the seven dominant species are either at or near the highest densities observed since 2000, and most trends are statistically significant. Although the abundance of most copepods is generally high on the northern Grand Banks, many species do not show clear long-term trends, and only approximately half are statistically significant. In contrast, the abundance of most of the dominant copepod species on the southern Grand Banks is near the long-term average.

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