2006 STATE OF THE OCEAN: CHEMICAL AND BIOLOGICAL OCEANOGRAPHIC CONDITIONS IN THE NEWFOUNDLAND AND LABRADOR REGION

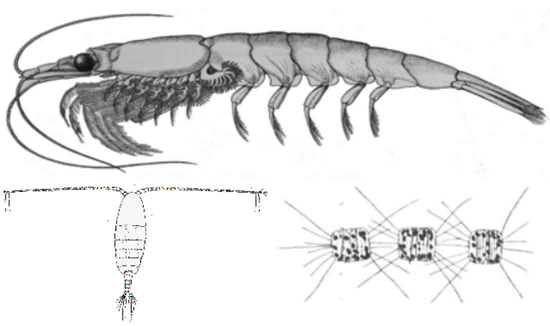

Figure 1: Map of survey region showing AZMP oceanographic transects (in black) and location of fixed station (in red).

Context

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

- The inventories of nitrate, the principal limiting nutrient, have remained relatively stable throughout the time series although there appears to be a decline in near-surface levels and an overall reduction in the magnitude of the seasonal cycle in recent years compared to earlier observations.

- Indications of a decrease in phytoplankton abundance at Station 27 since 2002 were reversed in 2006 but the magnitude of the change is not statistically significant nor was it reflected along the oceanographic transects.

- In 2006, the overall abundance of zooplankton at Station 27 was low relative to the long term average in 6 of the 12 dominant species groups, including *C. glacialis* and *C. hyperboreus*.

- In contrast, the abundance of *Calanus finmarchicus* at Station 27 rebounded substantially from its lowest level in the previous year, as did the abundance of euphausiids and *Metridia* spp.

- The abundance of the dominant copepod species was at near record high levels on both the Newfoundland shelf as well as off the coast of Labrador. The abundance on the northern and southern Grand Banks was generally at or near the lowest levels observed since 2000.

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

Nutrient concentrations and phytoplankton biomass

During 2006, 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 recovered from a declining trend observed since 2002.

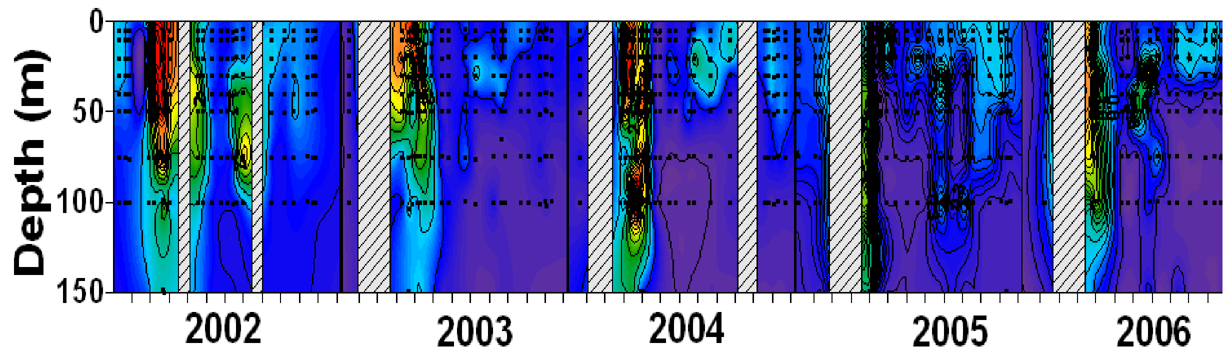

Figure 2: Seasonal vertical distribution of phytoplankton at Station 27 for 2002-2006. White areas represent time periods when samples were unavailable. The color bar provides a measure of phytoplankton abundance.

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 2000-2006. Furthermore, we have not detected a prominent 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, has increased in recent years reversing a trend observed in earlier years at the fixed station near St. John's (Figure 3). Both silicate and nitrate inventories in the surface layer (0-50 m) at Station 27 appear to show a gradual reduction in levels since the start of monitoring. The most notable change was in the concentration of nitrate, an essential element in the growth of all phytoplankton species, although this pattern did not appear to prevail across the Newfoundland Shelf.

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. Data were not available in 2006.

The pattern in phytoplankton biomass observed during the spring oceanographic survey showed an increase over previous years. 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 earlier from 2003 to 2006, with a marked return to an April bloom in 2004. In 2006, the spring phytoplankton bloom was generally dispersed throughout the water column, as in previous years.

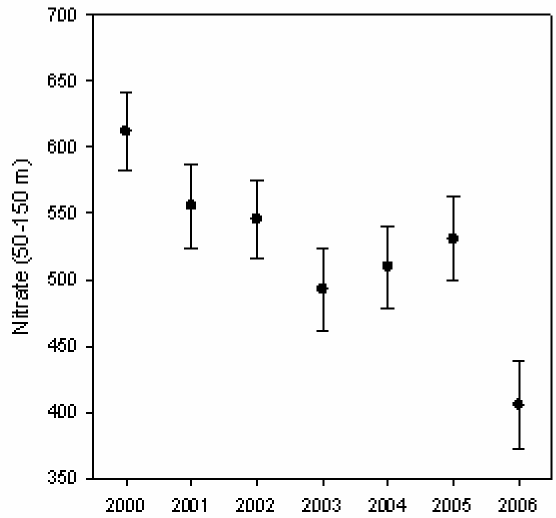

Figure 3. Seasonally-adjusted average deep-water nitrate inventory at Station 27.

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 2006, the overall abundance of zooplankton at Station 27 was generally low, relative to the long term average, in 6 of the 12 dominant taxa collected at Station 27. These taxa included *C. glacialis* and *C. hyperboreus*. In contrast, the abundance of *Calanus finmarchicus* at Station 27 rebounded substantially from its lowest level in the previous year, as did the abundance of euphausiids and *Metridia* spp. Most of these differences were not statistically significant but the indication of a decreasing trend in abundance since 1999 for many species was mirrored on the southeastern Grand Banks.

The overall abundance of *C. finmarchicus* at Station 27 was similar to its peak abundance in 2000 (Figure 4). There was a strong peak in abundance at the start of the summer, which is in contrast with the pattern in 2004/05, when peak abundance was less pronounced and only achieved in early fall. Peak occurrence of CI stages occurred in late May/early June, as in previous years. As in most years, early stage copepodites were present in the zooplankton community throughout the fall. As in 2000-03, there appeared to be a greater relative abundance of late stage copepodites well into the fall of 2006.

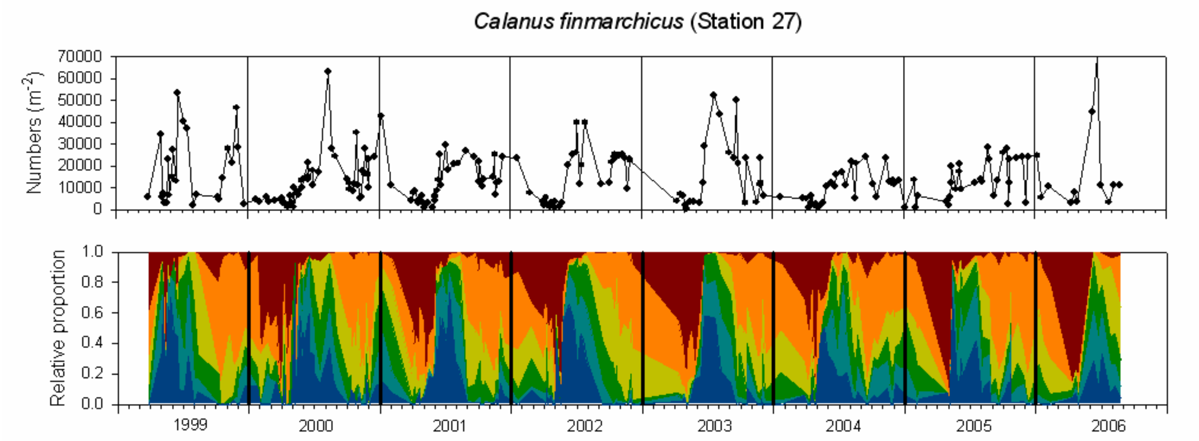

Figure 4: Seasonal abundance and relative stage distribution of copepodites of C. finmarchicus at Station 27 for 1999 to 2006. The youngest stages are indicated as CI (dark blue) and the oldest stages (C VI) represent the adults capable of reproduction (dark brown).

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 well above the long-term average. The only exception to this overall pattern was in the abundance of *Metridia* spp. and *Pseudocalanus* spp. on the Newfoundland shelf, which have been decreasing in abundance since 2003. In the case of *C. finmarchicus*, a dominant species in the region, there has been a 15-20 fold increase in summer abundance off Labrador since 2000.

On the northern Grand Banks (Flemish Cap transect), abundance levels for most copepod species in 2006 were generally higher than in the previous years. 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 (e.g. transport, local production, predation pressure), 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, the overall abundance in 2006 was generally low.

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 have increased since 2003 reversing a downward trend at the start of the monitoring program. Nitrate inventories in the upper layer continue to show a gradual reduction consistent with the decline observed since 2000. The cause for the decline in shallow inventories of nitrate remains unknown, but may be linked to changes in productivity, water column structure, and influence of volume transport of the inshore branch of the Labrador Current. The decreasing trend in the average integrated biomass of phytoplankton since 2002 appears to have been reversed as has the general decrease in the abundance of some large calanoid copepods (*C. finmarchicus*, *Metridia* spp.) along with euphausiids. Although we have observed annual changes in nutrient inventories and biological variables since 2000, they are not statistically significant. 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.

Other oceanographic variables showed fluctuations from year to year, but 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 at above average abundance levels, and most inter-annual variations 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. In contrast, the abundance of most of the dominant copepod species on the southern Grand Banks is below the long-term average.

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