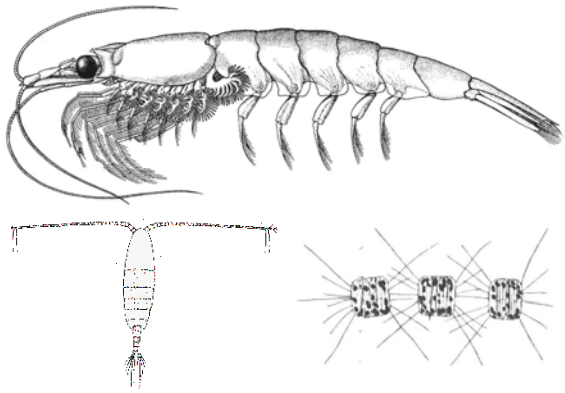
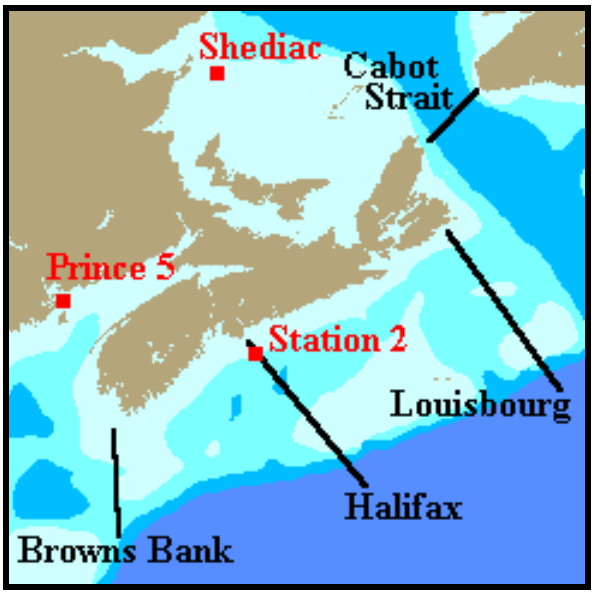
Fisheries and Oceans / Pêches et Océans
Maritimes Region

DFO Science
Stock Status Report G3-03 (2001)



Chemical and Biological Oceanographic Conditions in 2000 – Maritimes Region



Background

The Atlantic Zonal Monitoring Program (AZMP) was implemented in 1998 with the aim of: (1) increasing DFO's capacity to understand, describe, and forecast the state of the marine ecosystem and (2) quantifying the changes in ocean physical, chemical and biological properties and the predator-prey relationships of marine resources. A critical element in the observational program of AZMP is an annual assessment of the distribution and variability of nutrients and the plankton they support.

A description of the distribution in time and space of nutrients dissolved in seawater (nitrate, silicate, phosphate, oxygen) provides important information on the water-mass movements and on the locations, timing and magnitude of biological production cycles. A description of the distribution of phytoplankton and zooplankton provides important information on the organisms forming the base of the marine food-web. An understanding of the production cycles of plankton is an essential part of an ecosystems approach to fisheries management.

Summary

- Nutrient concentrations on the Scotian Shelf and Gulf of Maine in spring and summer 2000 were similar to levels observed in 1999 but higher in the Southern Gulf of St Lawrence in fall than in the previous year.

- The seasonal phytoplankton cycles on the Scotian Shelf, the Southern Gulf and the Bay of Fundy in 2000 were similar to 1999 and characterized by a large spring or early summer "bloom" and smaller fall peak in biomass. Biomass was highest and the blooms lasted longest in the Bay of Fundy.

- Phytoplankton biomass observed along the Scotian Shelf sections was higher in spring and lower in the fall in 2000 than in 1999.

- The phytoplankton community was composed predominantly of diatoms during the blooms but their relative contribution to the community decreased

through the summer/fall period as flagellates increased in abundance.

- Satellite ocean colour data indicated that the spring phytoplankton blooms in the Maritimes region occurred later in 2000 than in 1999 but were similar to the historical timing for the bloom.

- Continuous Plankton Recorder (CPR) colour index and species counts from the Scotian Shelf show phytoplankton abundance has been above the historical mean for the entire decade of the 90s.

- CPR numbers for the zooplankton species *Calanus finmarchicus* indicate abundances have been lower than the historical mean since the mid 90s but levels seem to have shown some recovery in the past few years.

- Zooplankton biomass levels observed along the Scotian Shelf sections and at fixed stations in 2000 were similar to 1999 levels.

- *C. finmarchicus* abundance was lower in spring and higher in fall in 2000 than in 1999 along the Scotian Shelf sections. Its abundance peaked in spring and dominated the zooplankton biomass at that time. Reproduction started later in 2000 than in 1999, by about a month. *C. finmarchicus* was a relatively less important component of the zooplankton in the Southern Gulf of St. Lawrence and in the Bay of Fundy.

Introduction

The production cycle of plankton is largely under the control of physical processes. Specifically, light and a source of nutrient salts (e.g. nitrate, phosphate, silicate) are required for the growth of marine microscopic plants (phytoplankton). Of the major available nutrients, nitrogen is generally in shortest supply in coastal waters and is thought to limit the growth of phytoplankton, particularly in summer. A description of the cycle of nutrients on the continental shelf will aid in understanding and predicting the spatial and temporal variability in plankton populations.

The phytoplankton constitute the base of the marine food-web and are the primary food source for the animal component of the plankton, i.e. the zooplankton. Both phytoplankton and zooplankton, in turn, are food for larval fish and invertebrates and influence their survival rate. An understanding of plankton cycles will aid in assessing the state of the marine ecosystem and its capacity to sustain harvestable fisheries.

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, groundfish surveys, satellite remote-sensing) in each region (Laurentian, Maritimes, Newfoundland) sampled at a frequency of bi-weekly to once annually. Information on the relative abundance and community structure of plankton is also collected on long survey lines from Iceland to the coast of Newfoundland and Newfoundland to the Gulf of Maine from commercial ship traffic instrumented with the Continuous Plankton Recorder (CPR).

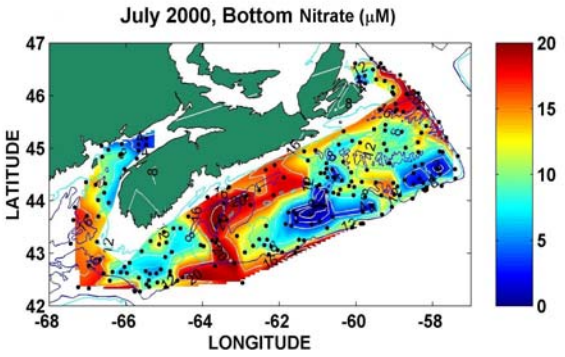
The AZMP sampling design provides for basic information on the natural variability in physical, chemical and biological properties of the Northwest Atlantic continental shelf. Groundfish surveys and cross-shelf sections provide detailed regional geographic information but are limited in their seasonal coverage. Critically placed fixed stations (in the Maritimes region: the Shediac Valley station in the Southern Gulf of St. Lawrence, Station 2

along the Halifax Line on the Scotian Shelf and the Prince 5 station in the Bay of Fundy) complement the geography-based sampling by providing more detailed information on temporal (seasonal) changes in ecosystem properties. Satellite remote-sensing of sea-surface temperature (SST) and phytoplankton biomass (chlorophyll) provide the large scale (zonal) perspective on important environmental and ecosystem variability. The CPR lines provide information on large scale (inter-regional) and long-term (yearly to decadal) variability in plankton abundance and community structure.

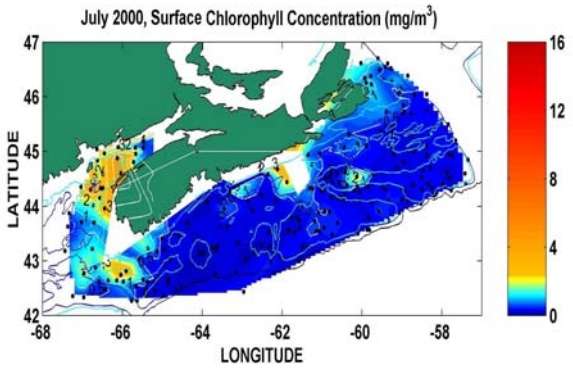
Summer and Fall Groundfish Surveys

July Survey - Scotian Shelf/Gulf of Maine

Near surface nutrient concentrations were uniformly low over the entire shelf and eastern Gulf of Maine (not shown) as in the previous year, a result of consumption by phytoplankton earlier in the year. Concentrations increased with water depth such that highest concentrations were observed in the deep basins on the shelf (e.g. Emerald Basin) and in slope waters at the shelf edge. Overall, bottom water nutrient concentrations in 2000 were similar to those observed in 1999 although concentrations were slightly higher in the east and lower in the west, compared with the long-term mean.

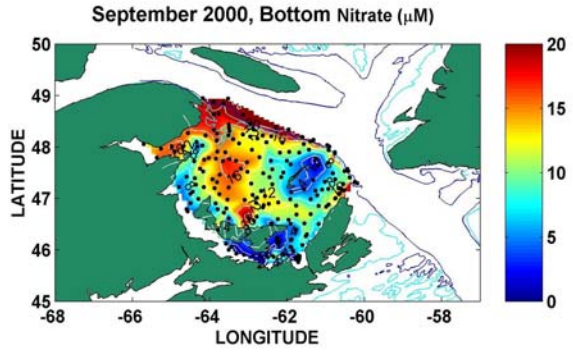


Near surface chlorophyll levels in 2000 were low; no distinct distribution pattern was observed except for a few isolated "hot spots" near the coast of central and SW Nova Scotia and the approaches to the Bay of Fundy where vertical mixing is strong. Concentrations were slightly lower overall than in the previous year but similar to the long-term mean.



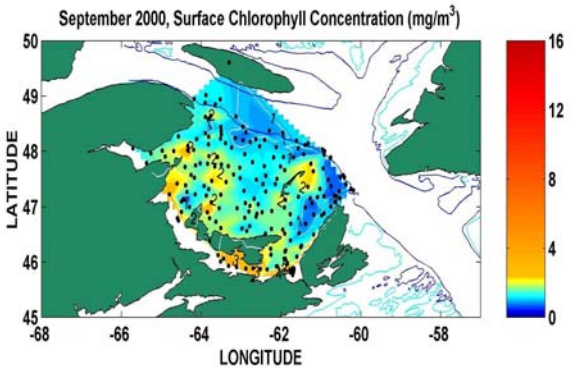
September Survey - Southern Gulf of St. Lawrence

Surface concentrations in fall were uniformly low in 2000 as in the previous year. Bottom water concentrations were higher than in 1999.



Chlorophyll "hot spots" were observed in the Shediac Valley region, in the eastern Northumberland Strait and off the Magdalen Islands, as seen in 1999. Levels were somewhat lower in 2000, overall, than those observed in 1999. Similar patterns of surface phytoplankton distribution were

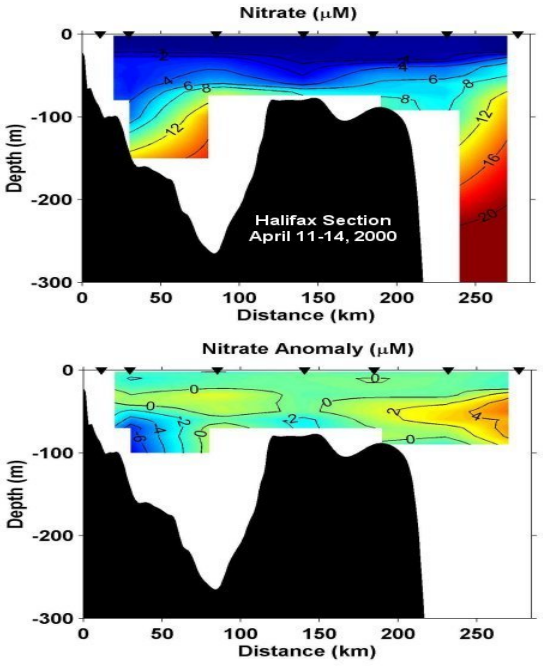
revealed in satellite ocean colour imagery (not shown), particularly the elevated levels off SW Nova Scotia, the Bay of Fundy and in the Northumberland Strait.

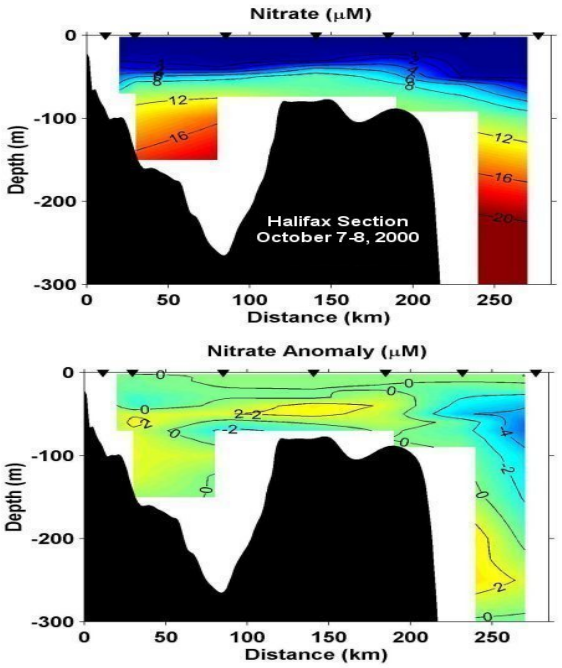


Spring and Fall Sections

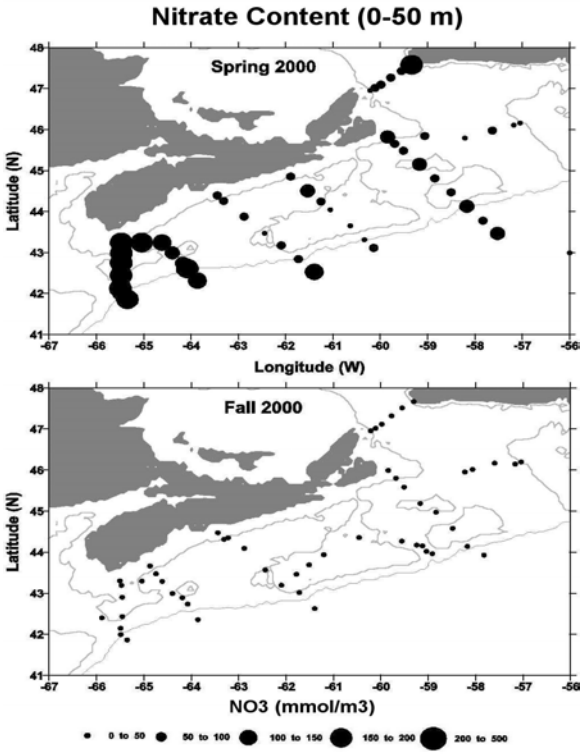
Nutrients

Distributional patterns were similar to those seen in 1999 and anomaly maps (i.e. year 2000 minus the long-term mean) for the Halifax section suggested that concentrations were somewhat higher shelf-wide in spring and lower offshore in fall than usual.



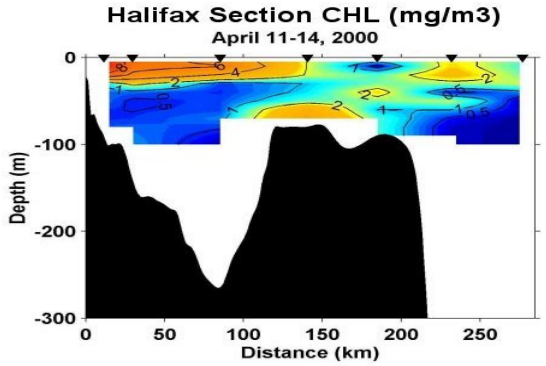


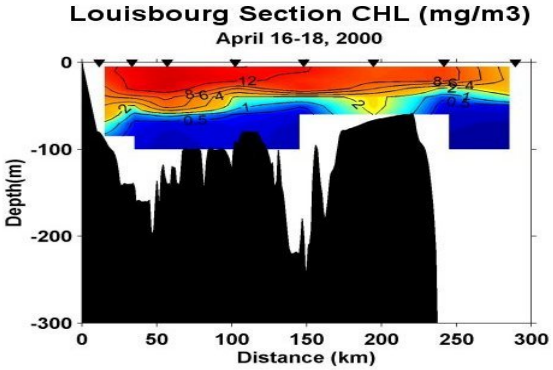
Nutrient content in the upper 50m was significantly higher in the spring than in fall 2000 and in spring, was higher on the western shelf than to the east. Nutrient levels in 2000, however, were not significantly different from levels in those seasons in 1999.



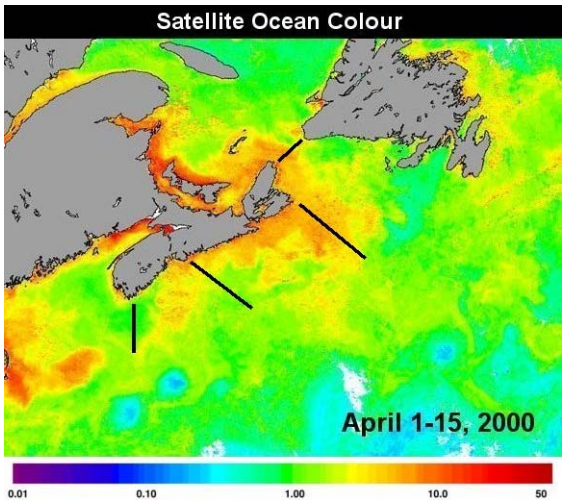
Phytoplankton

Phytoplankton biomass (chlorophyll concentration) was higher in spring than in fall along all sections in 2000. This was particularly evident in the extremely high surface concentrations (>10 mg m^{-3}) along the Louisbourg and Cabot Strait lines. Springtime chlorophyll concentrations shelf-wide were higher in 2000 than in 1999, whereas concentrations were lower in fall 2000 than in 1999. Concentrations were highest on the eastern half of the shelf in spring but similar shelf-wide in fall.





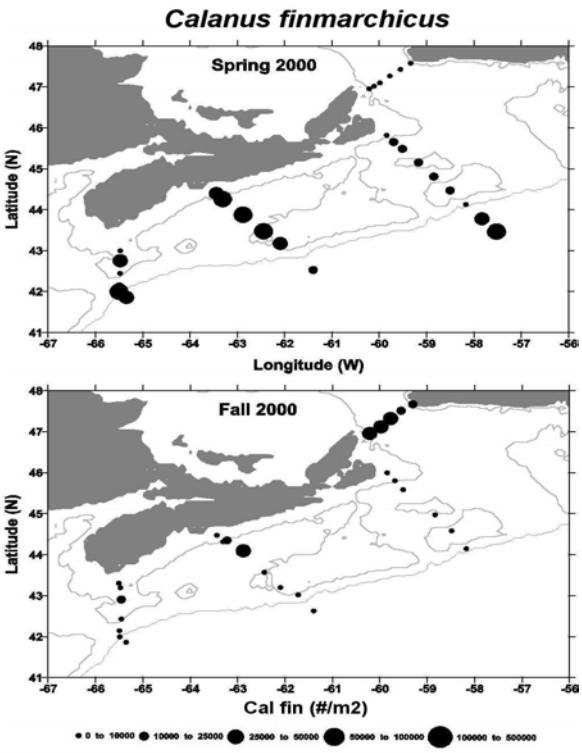
Satellite ocean colour images for early April clearly show the enhanced phytoplankton biomass was widespread on the eastern shelf and Cabot Strait.



Zooplankton

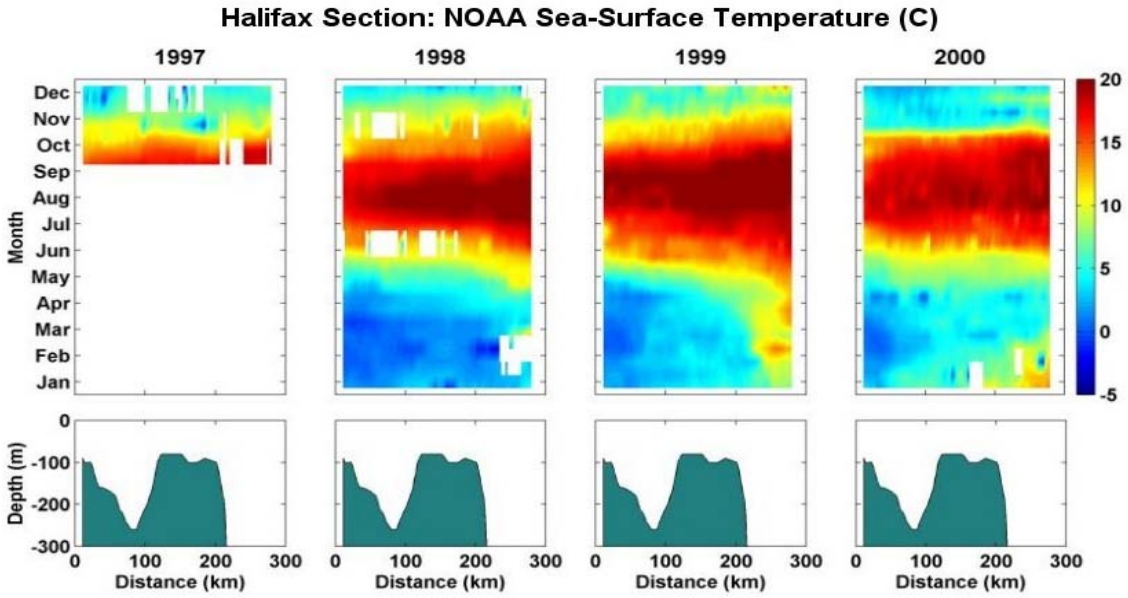
Zooplankton biomass distribution on the shelf (not shown) was highly variable both geographically and with season; no clear patterns were evident, although biomass appeared to be persistently high in the deep basin (Emerald Basin) and Cabot Strait in spring and fall. This high biomass represented predominantly over-wintering populations residing at depth. Levels in 2000 were similar to those in 1999.

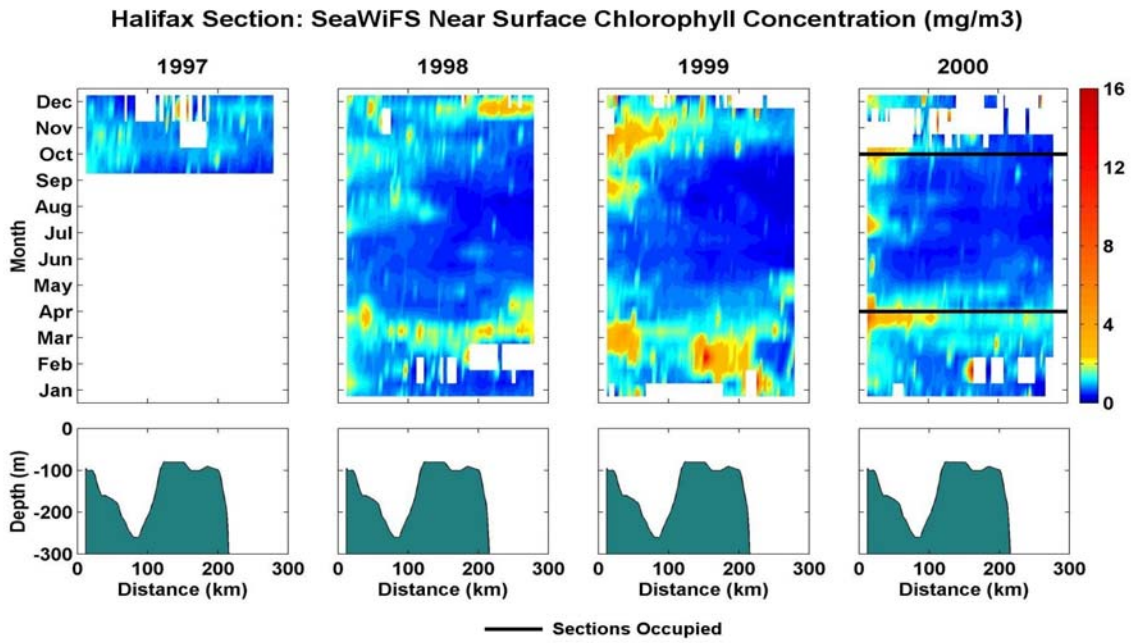
The abundance of one of the most common zooplankton species in North Atlantic waters, *Calanus finmarchicus*, on the other hand, showed a clear seasonal and geographic distribution pattern. Numbers were significantly higher in spring 2000 than in fall and higher on the western shelf (spring) than the east. Notably high numbers in Cabot Strait in fall were likely over-wintering populations of late-stage adults. Abundances shelf-wide were somewhat lower in 2000 than in 1999 in spring but similar between the two years in fall.



Satellite remote-sensing

Satellite remote sensing places the field measurements in the broader geographical and temporal context. The seasonal sea-surface temperature cycle along the Halifax section in 2000 revealed a "cooler" year (lower seasonal maximum, shorter warm period) than in 1998 and 1999. The spring phytoplankton bloom was later in 2000 than in 1998 and 1999 and largely confined to the inner shelf. A similar pattern was observed along the other sections (not shown) except that no spring bloom was detected along the Browns Bank section in 2000. The fall phytoplankton biomass peaks along all sections were variable and less temporally distinct than the spring peaks.

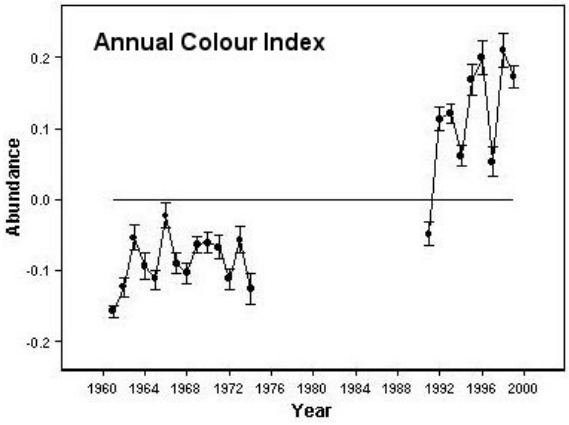




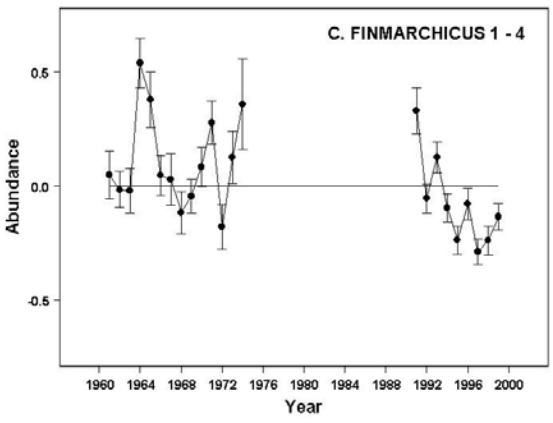
Continuous Plankton Recorder

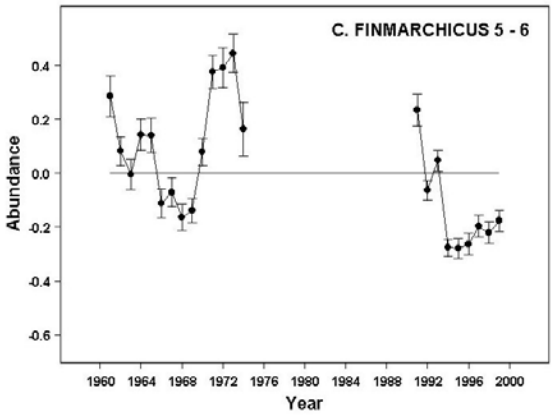
The Continuous Plankton Recorder (CPR) is an instrument that collects phytoplankton and zooplankton on a long continuous ribbon of silk while towed from commercial ships at a depth of about 7m. The position on the silk corresponds to location of the different sampling stations. Historical CPR data were analyzed to detect differences in the indices of phytoplankton and zooplankton abundance for different years on the Scotian Shelf. The indices are measures of numbers of plankton collected in CPR samples and represent relative changes in concentrations from year to year. Due to time-consuming sample processing, CPR data are generally not available until almost a year after collection and therefore results through 1999 are reported.

Large changes have occurred since the start of the time series in 1961. The phytoplankton colour index was much higher in the 1990s than in the 1960s and early 1970s, reflecting large increases in both diatoms and dinoflagellates.



In contrast, indices of an important zooplankton species (*C. finmarchicus*) declined to low values in the mid-1990s compared to the 60s, 70s and early 90s. Abundance levels have remained below the long-term annual mean although there appears to have been a slight increase in abundance of all growth stages in recent years.

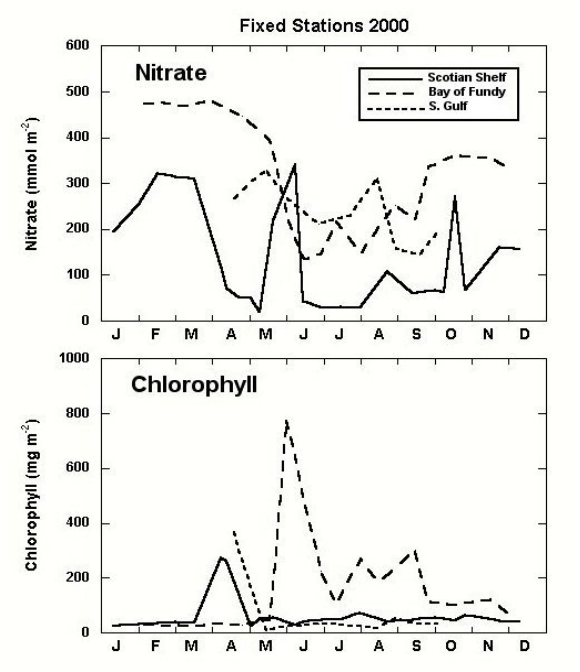




Fixed Stations

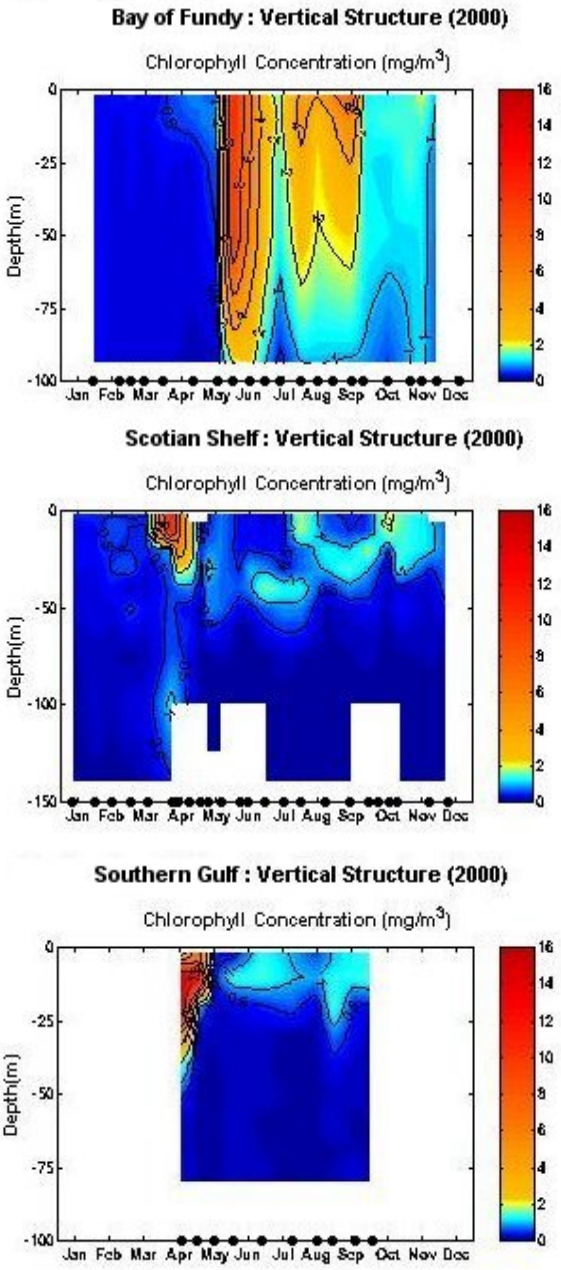
Nutrient content in the upper 50 m followed a similar seasonal pattern at all three locations; content was high in late fall/winter and low in spring/summer as a result of biological consumption.

Typically, nutrients were higher in the Bay of Fundy and in the Southern Gulf than on the Scotian Shelf, by about a factor of two when averaged over the year. Nutrient levels were not significantly different from the long-term mean levels where they exist, i.e. the Scotian Shelf and Bay of Fundy. Seasonal patterns and nutrient content were similar to those observed in 1999 in the Bay of Fundy and the Southern Gulf; levels on the Scotian Shelf were somewhat higher in 2000 than in 1999.



A spring phytoplankton "bloom" was observed on the Scotian Shelf and the Southern Gulf in April (apparently, only the end of the bloom was caught at the latter site). The elevated nutrient content in the Scotian Shelf in 2000 (compared with 1999) was not matched by higher phytoplankton biomass. The bloom in the Bay of Fundy was later (July) and much larger in magnitude than at the other fixed stations. The delay in timing of the Bay of Fundy bloom may be associated with more turbid waters there than on the Scotian Shelf and in the Southern Gulf (water transparency in the Bay of Fundy was half that at the other two stations), resulting in less favorable underwater light conditions for growth in spring. The magnitude of the bloom in the Bay of Fundy, on the other hand, was likely linked to the larger reservoir of winter-time nutrients compared with the other fixed stations. Biomass was also elevated in late summer / early fall in the Bay of Fundy; no late summer/early fall bloom was observed on the Scotian Shelf or in the Southern Gulf. Biomass in 2000 was not significantly different from historical mean values on the

Scotian Shelf. Seasonal patterns and biomass was similar to those observed in 1999.



Phytoplankton species counts indicated that total species abundance matched chlorophyll biomass distributions reasonably well and that diatoms dominated during blooms. There was a general trend of decreasing abundance of diatoms and increasing abundance of flagellates from spring to late fall on the Scotian Shelf and in the Southern Gulf; diatoms dominated year-round in the Bay of Fundy.

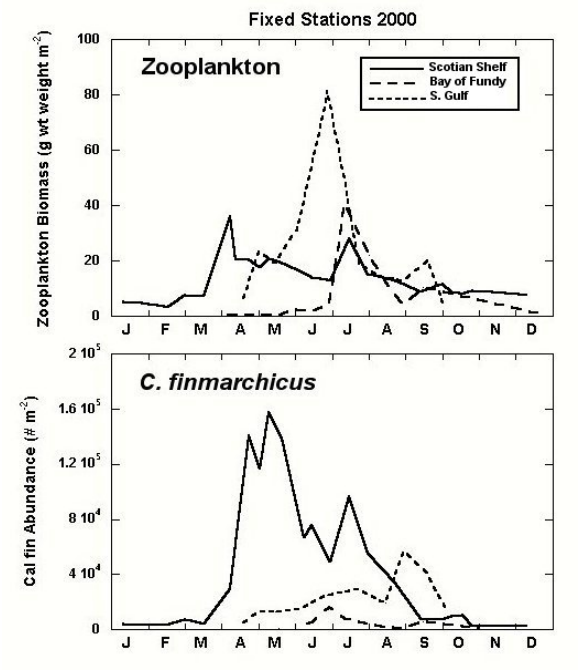
Zooplankton biomass peaked in summer in the Southern Gulf, late summer/fall in the Bay of Fundy and was distributed broadly over the entire summer on the Scotian Shelf. Biomass was highest in the Southern Gulf, probably associated with the relatively higher abundance of the large cold-water copepod species *C. hyperboreus* and to a lesser extent *C. glacialis*. On the whole, biomass seasonal patterns and levels were similar to those observed in 1999.

C. finmarchicus abundance peaked in the spring on the Scotian Shelf and later in the Bay of Fundy and the Southern Gulf; levels were very low at the latter two stations compared to the Scotian Shelf. Adundances at all stations were similar to those observed in 1999.

Analysis of the developmental stage distributions showed that *C. finmarchicus* reproduction was confined to the spring on the Scotian Shelf but continued throughout the year in the southern Gulf. In the latter case, the young stages observed are likely produced for the most part in the St. Lawrence Estuary (where reproduction occurs through out the summer) and are tranported to the Southern Gulf in the Gaspé Current. *C. finmarchicus* reproduction started on the Scotian Shelf earlier in 1999 (by about a month) than in 2000; the timing of the reproductive cycle in 2000 was closer to the long-term norm.

C. finmarchicus was a relatively less important component of the zooplankton at the Southern Gulf and Bay of Fundy fixed stations than on the Scotian Shelf. In the Bay of Fundy in partucilar, smaller and

more temperate water species (*Acartia spp*., *Centropages*, *Oithona* and *Pseudo/Paracalanus spp*.) were dominant. Overall, relative zooplankton abundance and community composition were markedly different among the three fixed stations; the station-to-station differences seen in 2000 were also observed in 1999.



2000 Highlights

Seasonal patterns and regional differences were observed in chemical and biological variables in the Maritimes Region in 2000. Noteworthy among the differences in conditions between 2000 and the previous year were:

(1) near surface nutrients were somewhat higher at the Scotian Shelf fixed station in 2000 than in 1999 but no corresponding increase in phytoplankton biomass was detected,

(2) both surface and bottom nutrient concentrations were higher in the Southern Gulf during the fall 2000 groundfish survey than in 1999,

(3) phytoplankton biomass levels observed along the cross-shelf sections were higher in spring and lower in fall 2000 than in 1999; levels were generally highest on the eastern shelf,

(4) *C. finmarchicus* abundance, in contrast to phytoplankton, was lower on the shelf in spring 2000 and higher in fall than in 1999,

(5) satellite data showed that surface temperatures in the Maritimes region were lower in 2000 than in 1999,

(6) the timing of the spring phytoplankton bloom was later in the Maritimes region in 2000 than in 1999 based on satellite ocean colour data,

(7) CPR data showed that phytoplankton abundance indices have been higher and zooplankton indices lower in the mid-late 90s than in the 60s, 70s and early 90s.

References

DFO. 2000a. State of the Phytoplankton, Zooplankton and Krill on the Scotian Shelf in 1998. DFO Science Stock Status Report G3-02 (2000).

DFO. 2000b. Chemical and biological oceanographic conditions 1998 and 1999 – Maritimes region. DFO Science Stock Status Report G3-03 (2000).

Petrie, B., P. Yeats and P. Strain. 1999. Development of a Sea Surface Temperature Index for the Canadian East Coast; Nutrient and Dissolved Oxygen Variability on the Scotian Shelf: a Preliminary Report from the Zonal Monitoring Program. Can. Stock Assessment Secretariat Res. Doc. 99/57, 16p.

Plourde, S. and J.A. Runge. 1993. Reporduction of the planktonic copepod *Calanus finmarchicus* in the Lower St. Lawrence Estuary: relation to the cycle of phytoplankton production and evidence for a *Calanus* pump. Mar. Ecol. Prog. Ser. 102: 217-227.

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