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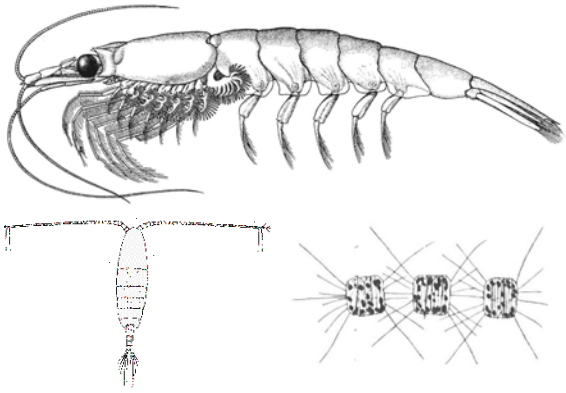
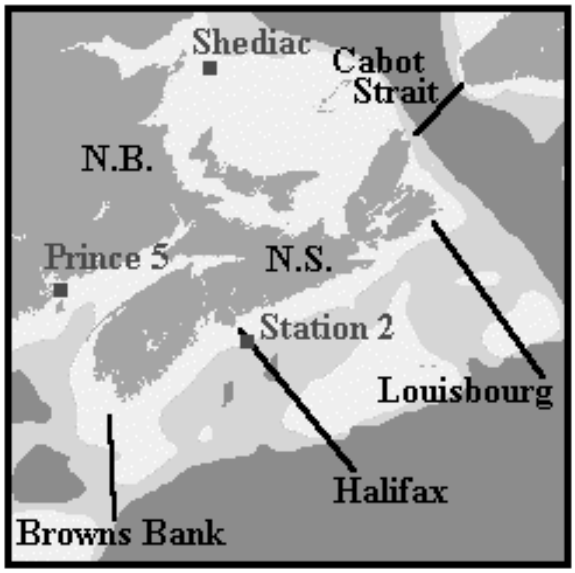
Maritimes Region **Stock Status Report G3-03(2002)**





Chemical and Biological Oceanographic Conditions in 2001 – Gulf of Maine, Bay of Fundy, Scotian Shelf and the Southern Gulf of St. Lawrence

Background

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

The AZMP uses data collected through a network of sampling locations (fixed point stations, cross-shelf sections, groundfish surveys, satellite remote-sensing) in Quebec, Maritimes, Southern Gulf, and Newfoundland sampled from bi-weekly to annually. Information on the relative abundance and community structure of plankton is also collected from Iceland to the coast of Newfoundland and Newfoundland to the Gulf of Maine through commercial ship traffic instrumented with a Continuous Plankton Recorder (CPR).

A description of the distribution in time and space of nutrients dissolved in seawater (nitrate, silicate, phosphate, oxygen) provides important information on the water 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 in 2001 were generally similar to levels observed in 2000.
- Phytoplankton biomass in 2001 was similar to levels observed in 2000. The spring bloom occurred at approximately the same time in 2001 as in 2000.
- Phytoplankton species composition in 2001 was similar to that observed in 2000.
- Continuous Plankton Recorder (CPR) colour index and species counts showed that phytoplankton abundance continues to be well above levels observed in the 1960s and 1970s.
- Zooplankton biomass in 2001 was higher than levels observed in 2000.

- *Calanus finmarchicus* abundance was higher in 2001 than in 2000. The species' reproductive cycle, however, was similar in both 2000 and 2001.

- CPR species counts show that zooplankton abundance continues to be well below levels observed in the 1960s and 1970s although trends for the past few years indicate that populations may be recovering.

Introduction

The production cycle of plankton is largely under the control of physical processes. Specifically, light and nutrients (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.

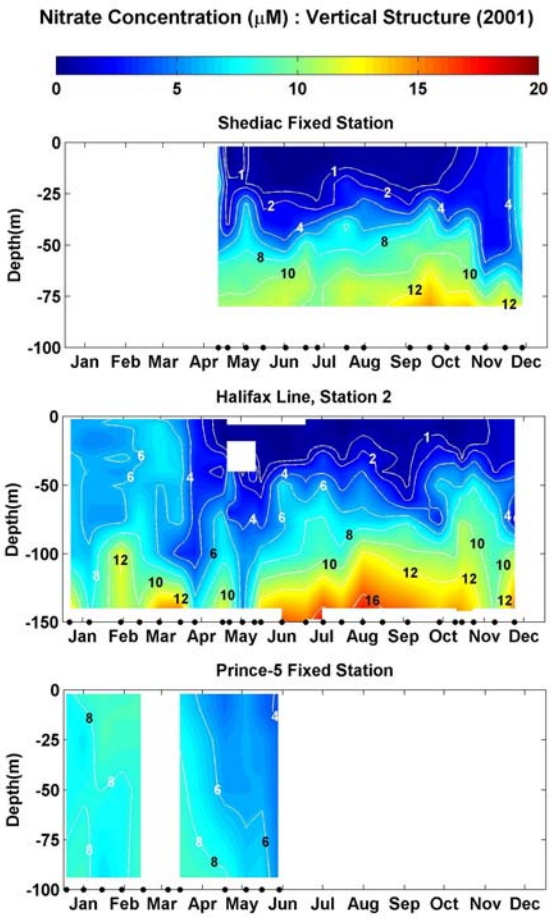
Phytoplankton constitute the base of the marine food-web and are the primary food source for the animal component of the plankton (zooplankton). Both phytoplankton and zooplankton, in turn, are food for larval fish and invertebrates and influence their survival rate. An understanding of plankton cycles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

The AZMP provides basic information on the natural variability of 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 (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 seasonal changes in ecosystem properties. Satellite remote-sensing of sea-surface phytoplankton biomass (chlorophyll) provides a 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.

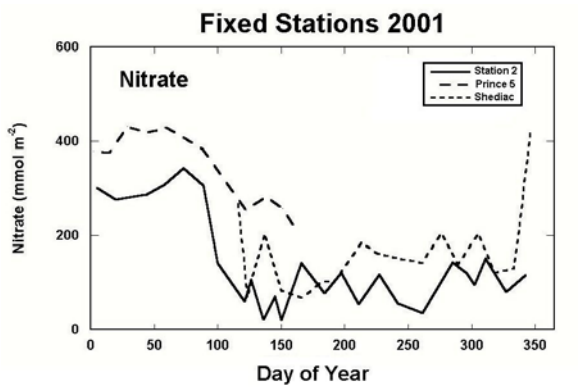
Nutrients

Fixed Stations. Rapid reduction in near surface nitrate concentrations was seen at all fixed stations in spring 2001. Low surface values persisted throughout the summer at Shediac and Station 2; concentrations did not increase at the surface again until late fall. The zone of nitrate depletion (defined as depths where concentrations were equal to or less than 1 μM) in summer was greater at Station 2 than at Shediac, by approximately 5-10 m. Data for the latter half of 2001 at Prince 5 are unavailable but based on observations made during the first half of 2001 and in previous years, nitrate concentrations were never reduced to the 1 μM level. Seasonal changes in nitrate concentrations at the fixed stations in 2001 were similar to those seen in 2000 except that reduced surface

concentrations appeared to occur somewhat earlier at Prince 5 in 2001 than in 2000. Nitrate concentrations in the upper water column (0-50 m) at Station 2 was similar to the long-term mean for the central Scotian Shelf, however, concentrations in the 50-150 m depth range were considerably lower (by 6-10 μM) than normal. The reason for the nutrient "deficit" is unclear.

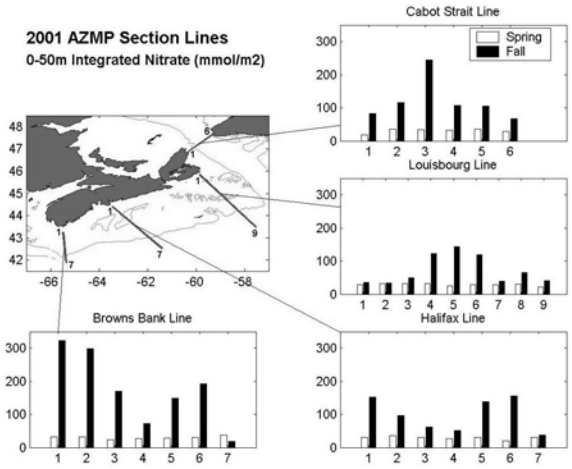


Nitrate inventories in the upper 50 m (depth zone over which nutrient dynamics are strongly influenced by biological processes) in 2001 followed similar seasonal patterns at all stations; levels were high in late fall/winter and low in spring/summer as a result of biological consumption. Averaged over the year, inventories were significantly higher at Prince 5 than at Station 2 and Shediac due to strong tidal mixing. Seasonal patterns and levels were similar to those observed in 2000 at Prince 5 and Station 2 while levels were slightly lower at Shediac in 2001 than during the previous year. Nitrate inventories at Station 2 in 2001 were considerably lower in winter (by a factor of 2) than the long-term mean levels on the central Scotian Shelf but similar to the historical average during other seasons. Synopsis: nutrient concentrations and seasonal cycles at the fixed stations were similar in 2001 to those observed in 2000.



Seasonal Sections. Nitrate inventories in the upper 50 m were low in spring 2001 along all sections; levels were substantially higher in fall. In 2000, the opposite was observed, i.e. spring nitrate inventories were substantially higher than in the fall. Shelf-wide, spring 2001 levels were one quarter of 2000 levels while fall 2001 levels were four times 2000 levels. The fact that both the spring and fall surveys were later (by as much as a month) in 2001 than in 2000 may help explain this reversal in pattern. The extent of near surface nitrate depletion (and thus lower nitrate inventories) would be expected to be more pronounced in May (2001) than in April (2000) due to biological

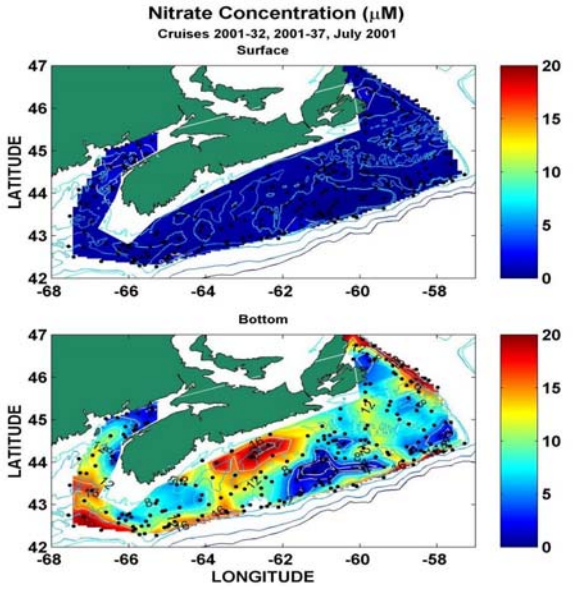
consumption. On the other hand, higher nitrate levels in fall 2001 may have indicated earlier onset of the fall mixing (and surface nutrient replenishment) than in 2000. Synopsis: adjusting for survey timing, nutrient concentrations on the Scotian Shelf in spring and fall 2001 were similar to levels observed in 2000.



Groundfish Surveys. Near surface nitrate concentrations during the summer groundfish survey were uniformly low over the Scotian shelf and eastern Gulf of Maine, similar to long-term mean concentrations. Bottom water concentrations were substantially higher than near surface concentrations but somewhat lower than bottom water concentrations observed in 2000. Concentrations increased with water depth such that the highest concentrations were observed in the deep basins on the shelf (e.g. Emerald Basin) and in slope waters at the shelf edge. Bottom water nutrient concentrations in 2001 were higher off the edges of the shelf and in deep waters of the eastern Gulf of Maine and lower on the inner shelf, compared with the long-term mean; surface concentrations shelf-wide were similar to the historical average.

Near surface nitrate concentrations during the fall groundfish survey in the Southern Gulf of St. Lawrence were likewise uniformly low. Bottom water concentrations were elevated compared to surface concentrations and depth dependent, i.e. highest concentrations were seen in the western Gulf and deep waters of the Laurentian Channel. Surface and bottom water nitrate concentrations in the Southern Gulf were lower in 2001 than in 2000.

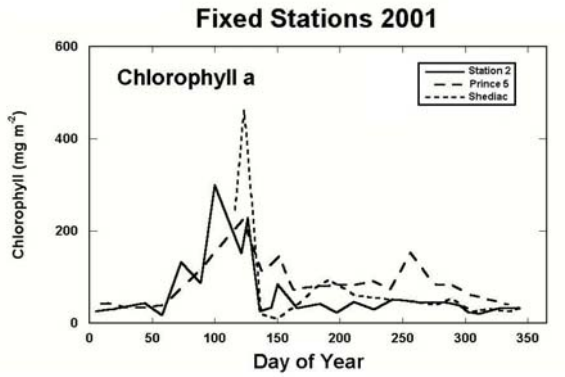
Synopsis: nutrients concentrations observed during the summer Scotian Shelf groundfish survey in 2001 were similar to 2000 levels, however, concentrations observed during the fall Southern Gulf survey were lower in 2001 than in 2000.

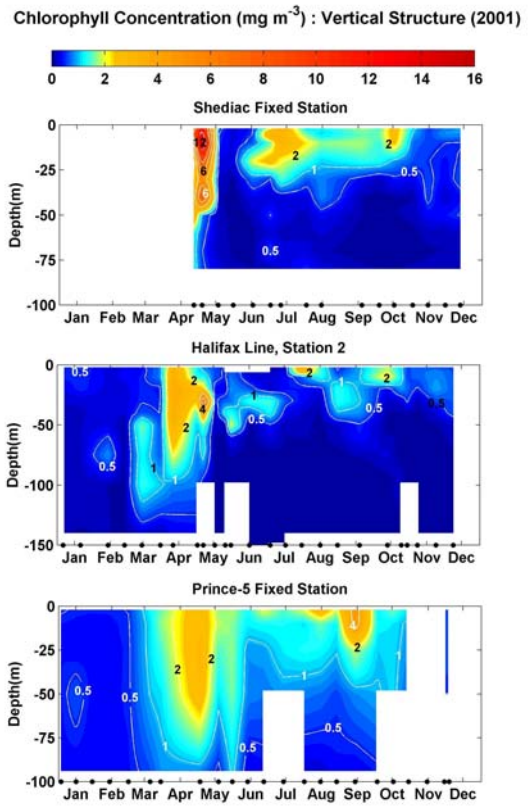


Phytoplankton

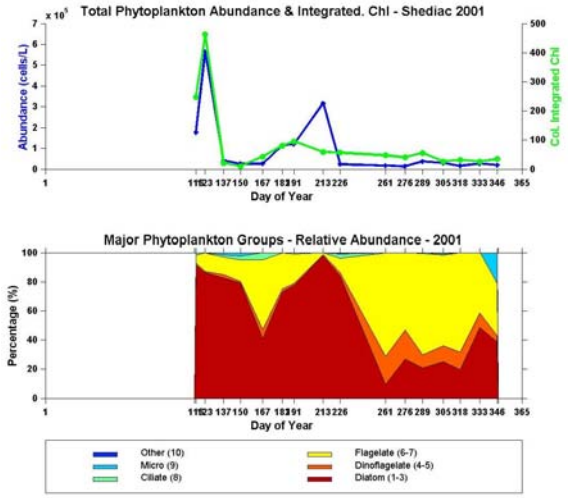
Fixed Stations. A spring phytoplankton "bloom" was evident from the seasonal changes in the vertical chlorophyll distribution and column-integrated chlorophyll peaks at all of the fixed stations in April/May, 2001. A less

conspicuous, broader fall bloom was also evident at all stations. Chlorophyll levels in 2001 were similar to those observed in 2000 at Station 2 and Shediac but were significantly lower in 2001 at Prince 5. Additionally, the Prince 5 spring peak occurred earlier in 2001 (April/May) than in 2000 (May/June). The seasonal chlorophyll cycle at Station 2 was similar to that seen generally on the central Scotian Shelf



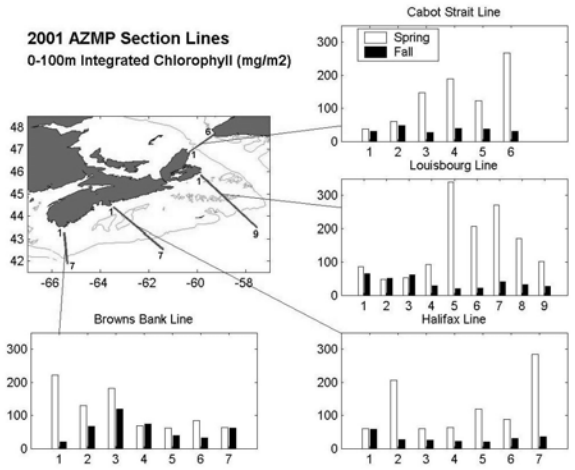


Phytoplankton species counts indicated that total species abundance matched chlorophyll biomass distributions reasonably well at the fixed stations in 2001. Diatoms dominated during blooms at all stations. There was a general trend of decreasing relative abundance of diatoms and increasing relative abundance of flagellates/dinoflagellates from spring to late fall at Shediac and Station 2; diatoms dominated year-round at Prince 5. Seasonal changes in phytoplankton community composition at all fixed stations were remarkably similar to those observed for the in 1999-2000. Synopsis: phytoplankton biomass and species composition at the fixed stations were similar in 2001 to levels and composition observed in 2000. The onset of the spring bloom at Prince 5 in 2001 may have been earlier than in 2000, however.

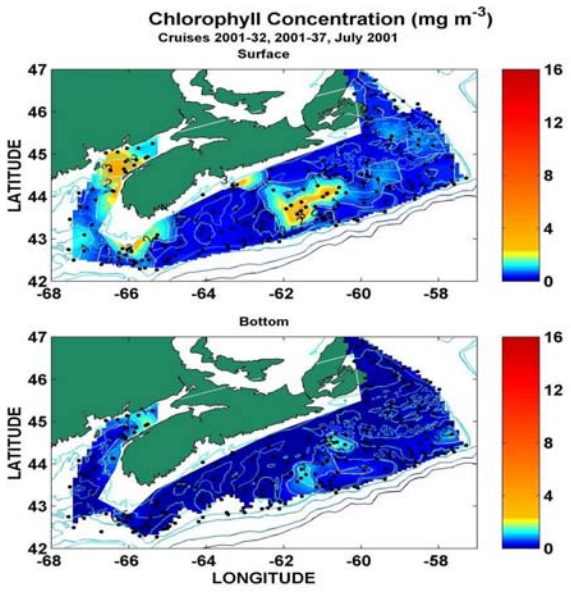


Seasonal Sections. Shelf-wide, chlorophyll levels in spring 2001 were only about half of the levels observed in 2000, however, the 2001 survey occurred later in the year than the 2000 survey and well after the major spring bloom period in April. High subsurface chlorophyll concentrations, as seen

along the sections in 2001, are also indicative of post-bloom conditions. Chlorophyll levels in fall 2001 were similar to 2000 levels. Synopsis: adjusting for survey timing, chlorophyll concentrations on the Scotian Shelf in spring and fall 2001 were similar to levels observed in 2000.



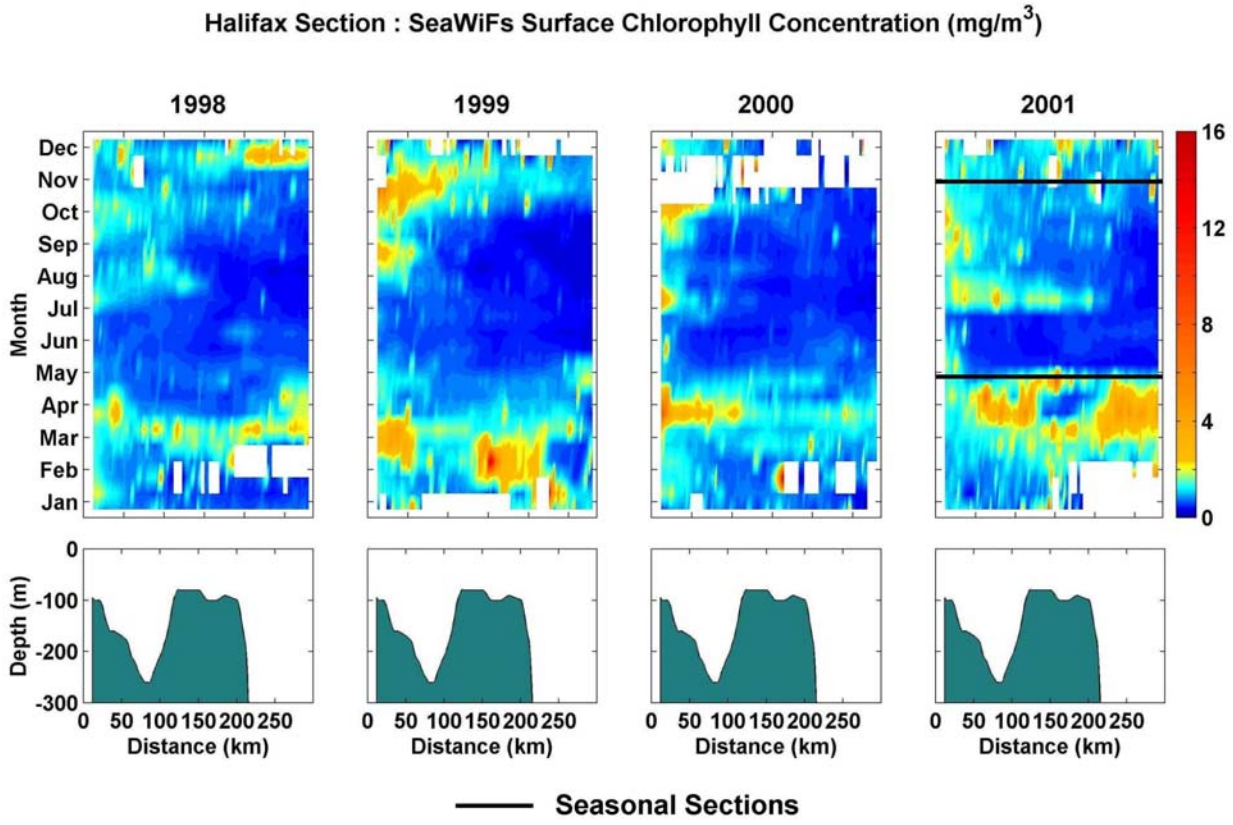
Groundfish Surveys. Near surface chlorophyll concentrations on the Scotian Shelf during the summer groundfish survey were low. "Hot spots" of elevated concentrations were observed near the coast of central and SW Nova Scotia, Western Bank and approaches to the Bay of Fundy. Most of those areas are characterized by strong vertical mixing. Similar chlorophyll hot spots were observed in 2000. Bottom water concentrations in 2001 were uniformly low, and similar to those seen in previous years. Surface chlorophyll concentrations were comparable to or slightly higher than the long-term mean.



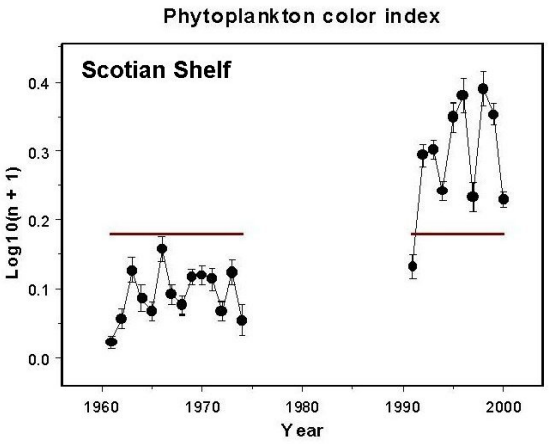
Near surface chlorophyll hot spots were also observed in the Shediac Valley, in the eastern Gulf off PEI and around the Magdalen Islands during the fall Southern Gulf groundfish survey. Similar but more conspicuous hot spots were observed in 2000. Overall, surface chlorophyll levels in the Southern Gulf were lower in 2001 than in 2000. In general, bottom water chlorophyll levels were uniformly low as seen in previous years, however, elevated concentrations were observed in 2001 off southeast PEI where vertical mixing is strong. Synopsis: chlorophyll concentrations observed during the summer (Scotian Shelf) and fall (Southern Gulf) groundfish surveys of 2001 were generally similar to levels observed in 2000.

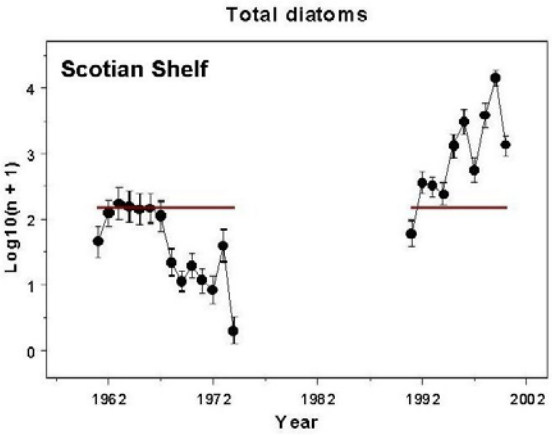
Satellite Remote-Sensing. The satellite-derived chlorophyll data can be used to generate graphical representations of the seasonal chlorophyll biomass and distribution along the section lines. It is evident from the satellite-data, for example, that the May 2001 surveys of the central

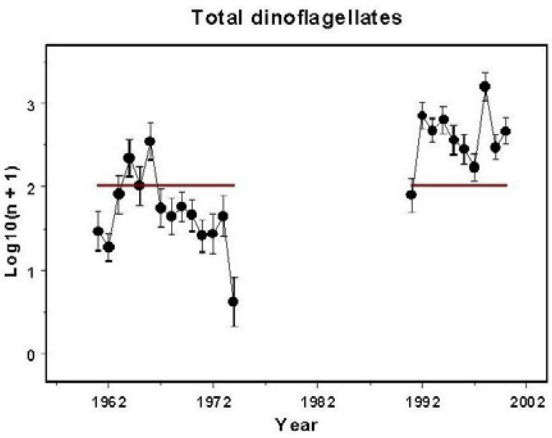
Scotian Shelf (Halifax line) and eastern shelf (Louisbourg line) were too late to catch the major surface spring bloom. This representation also reveals the nature of the onset, duration and termination of the spring and fall blooms and shows where phytoplankton biomass accumulates in the surface. Synopsis: compared with 2000, the spring bloom along the Halifax line in 2001 lasted longer and was confined more offshore; the bloom along the Louisbourg line in 2001, in contrast, was of a much shorter duration than in 2000.



Continuous Plankton Recorder. The CPR is the longest data record available on plankton in the Northwest Atlantic. CPR data analysis lags AZMP reporting by one year; thus, only data up to 2000 are currently available. Nonetheless, the phytoplankton colour index and adundance of large diatoms and dinoflagellates on the Scotian Shelf have been dramatically higher, starting in the early 1990s and continuing into the 2000s when compared with levels seen in the 1960s and early 1970s. On the shorter time scale, phytoplankton colour index and diatom abundance on the Scotian Shelf decreased in 2000 relative to 1999 (dinoflagellates increased slightly). Synopsis: phytoplankton abundance on the Scotian Shelf continues to be well above levels observed in the 1960s and 1970s.



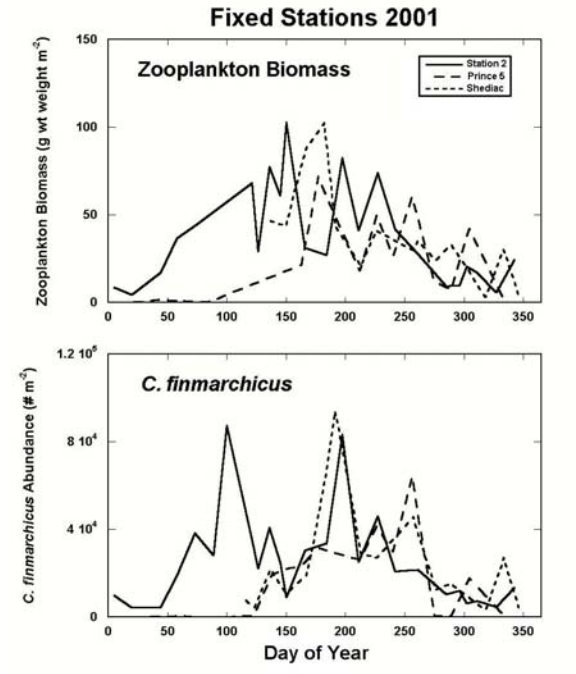




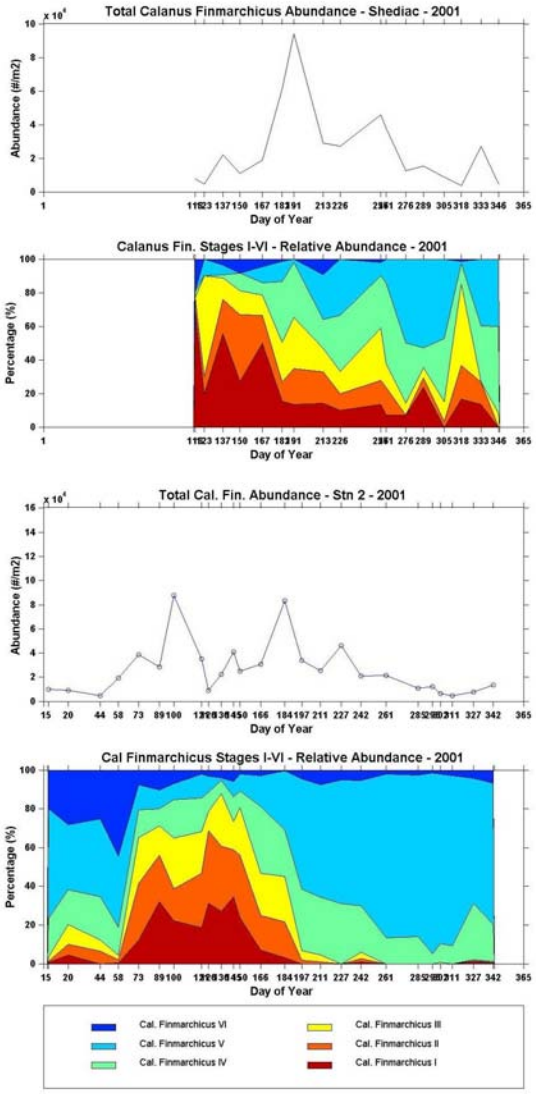
Zooplankton

Fixed Stations. A broad summer peak in zooplankton biomass was observed at all fixed stations although the seasonal increase started at Station 2 and Shediac at least two months earlier than at Prince 5. Biomass levels were comparable at all stations in 2001 and two to three times higher than in 2000. The only long-term data of zooplankton biomass and abundance on the Scotian Shelf are the summer collections of over-wintering plankton from Emerald Basin starting in the mid-1980s. Both biomass and abundance have decreased over the past few years, with levels in 2001 well below the long-term mean.

Two broad peaks in *Calanus finmarchicus* abundance were observed at Station 2: one in spring and one in late summer. At Prince 5 and Shediac, only the late summer peak was observed. Maximum abundances were similar at all stations. Overall, *C. finmarchicus* was less abundant at Station 2, similar at Shediac and substantially more abundant (approximately six-fold) at Prince 5 in 2001 compared to 2000.

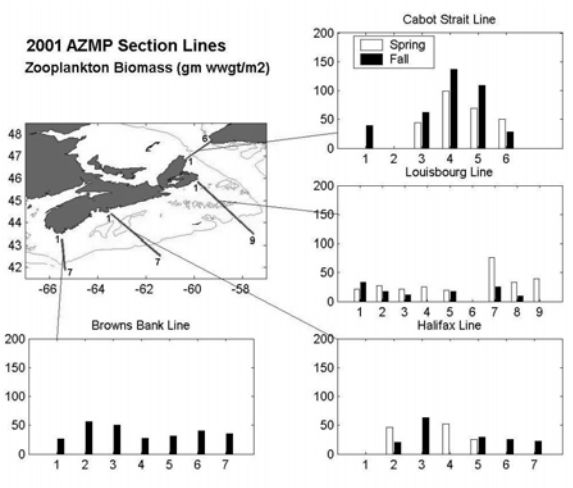


Copepods numerically dominated the zooplankton year-round at all fixed stations. The copepods were in turn dominated by small species. The larger *Calanus* sp. accounted for 20% or less of the total copepod abundance and were most abundant generally in the first half of the year. Reproduction (indicated by presence of early developmental stages, I-III) was generally confined to the spring of the year at Station 2 but was spread more broadly over the year at Shediac and Prince 5. However, the major reproductive activity appeared to occur in spring at all stations. In general, zooplankton community structure at Shediac and Station 2 in 2001 was similar to observations during 2000. At Prince 5, however, as mentioned previously, *C. finmarchicus* abundance was much higher and its contribution to the copepod community more significant in 2001 than in 2000, particularly in late summer. Synopsis: zooplankton biomass and *C. finmarchicus* abundance were significantly higher at the fixed stations in 2001 than in 2000. Species composition in 2001and 2000 were similar at Shediac and Station 2; at Prince 5, however, *C. finmarchicus* increased in relative importance in 2001.

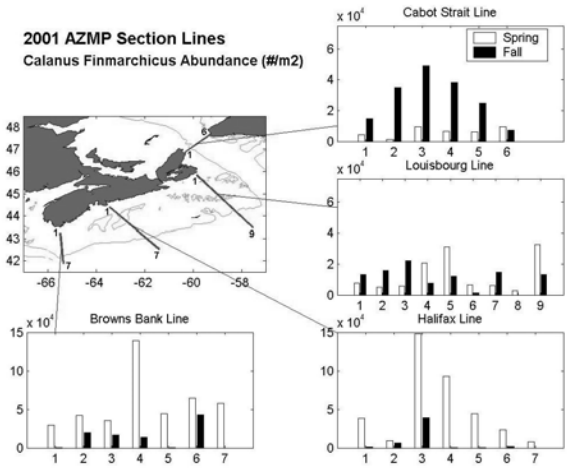


Seasonal Sections. Zooplankton biomass distribution on the shelf was highly variable both geographically and seasonally. Spring levels were about a factor of two higher than fall levels except along the Cabot Strait line where spring and fall biomass levels were comparable. Irrespective of season, biomass appeared to be persistently high at stations overlying deep basins (e.g. Emerald Basin on the Halifax Line) off the edge of the shelf and in deep waters of Cabot Strait. High biomass in the deep basins was predominantly comprised of over-wintering populations.

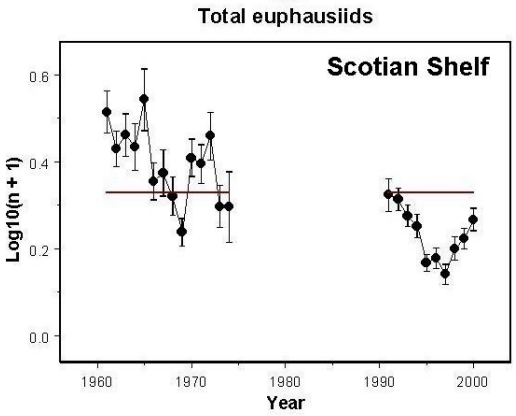
Compared with the biomass observed in spring 2000, levels in 2001 were about 2-fold higher along all of the sections. Again, this difference may be attributable to the fact that the 2001 survey was later by a month than in 2000; zooplankton biomass increases during the spring and doesn't peaks until summer, at least on the central shelf. Fall levels in 2001 were similar to those in 2000.

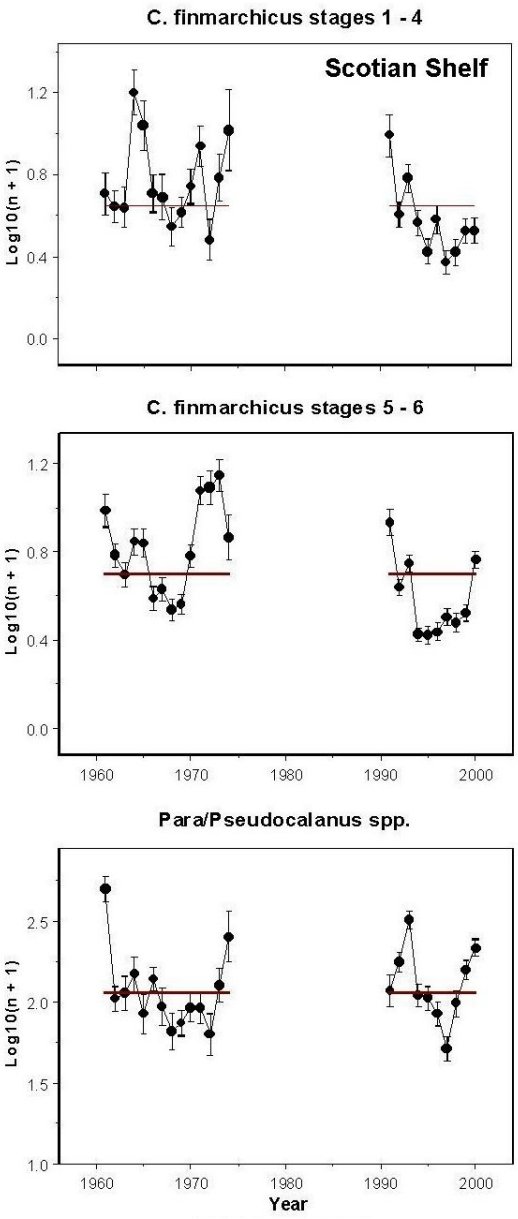


C. finmarchicus distribution was similar to zooplankton biomass with high concentrations observed in the basins, off the shelf and in deep waters of Cabot Strait. Whereas high zooplankton biomass was observed in Cabot Strait in both spring and fall, *C. finmarchicus* was abundant only in the fall along this line. Spring concentrations were approximately two times higher than fall concentrations shelf-wide. *C. finmarchicus* was slightly more abundant in spring and fall in 2001, compared with 2000. Synopsis: adjusting for survey timing, zooplankton levels on the Scotian Shelf in spring and fall 2001 were similar to levels observed in 2000.



Continuous Plankton Recorder. While phytoplankton were increasing on the Scotian Shelf in the 1990s, zooplankton were generally decreasing, particularly during the early to mid 1990s. In the last 3-4 years, however, zooplankton trends have reversed and numbers appear to be recovering. Synopsis: zooplankton abundance on the Scotian Shelf continues to be well below levels observed in the 1960s and 1970s although recovery is apparent.





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