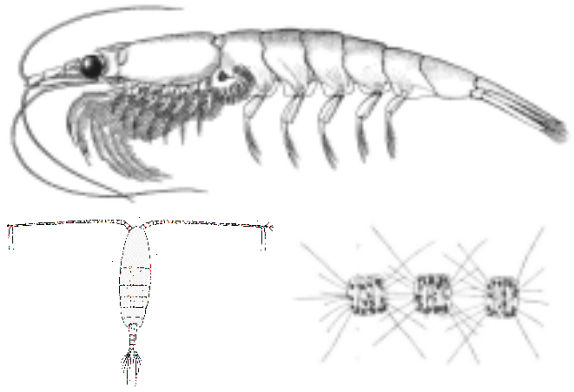
Fisheries and Oceans / Pêches et Océans
Maritimes Region

DFO Science
Stock Status Report G3-02(2000)



State of Phytoplankton, Zooplankton and Krill on the Scotian Shelf in 1998

Background

Phytoplankton and zooplankton constitute the base of the marine food chain. Their abundance in coastal waters sets an upper limit on the production of higher trophic level species and the variability in their distribution both seasonally and regionally may have an important impact on harvestable fisheries.

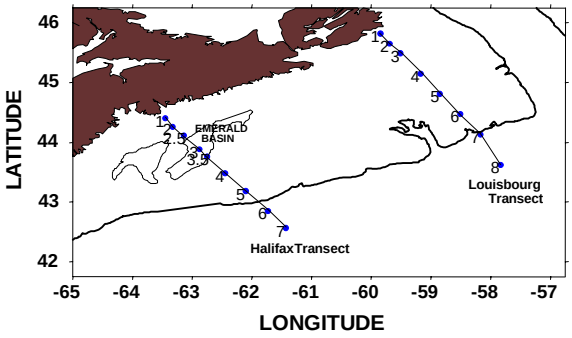
Phytoplankton are microscopic marine plants that form an important part of the diet of zooplankton and larval stages of a variety of other marine invertebrates. Zooplankton range in size from smaller than 1 mm (e.g. copepods) to about 4 cm (krill). They are fed on by all species of fish at some time in the fishes life cycle. There is evidence that the abundance of some species of zooplankton can influence recruitment and growth of fish such as cod, herring and capelin. The most important copepods to fish are ***Calanus finmarchicus*** *and* ***Pseudocalanus*** **spp**.*, and* ***Meganyctiphanes norvegica*** *is the most important krill species. The eggs and young of zooplankton are fed on by the youngest stages of fish and as the fish grow they feed on larger zooplankton. Many fish species also feed heavily on the adult krill.*

Temperature can have a large influence on the community structure and production of zooplankton and can cause large seasonal, yearly and multi-year changes in zooplankton population size. Zooplankton are sampled twice a year with a variety of nets, multifrequency acoustics and optical instruments over the Scotian Shelf. These data are used to monitor long-term changes in the levels of zooplankton species.

Summary

- Phytoplankton biomass levels on the Halifax and Louisbourg transects were higher in spring 1998 than in 1997; fall levels were similar between the two years. Biomass levels in 1998 were similar to the long-term (1974-1998) means.
- The satellite ocean colour data show a pronounced spring peak in phytoplankton abundance and a large-scale winter “bloom” in 1998. Compared with results from earlier ocean colour data (1978-86), phytoplankton biomass levels appear to be higher.
- The colour index for the Scotian Shelf derived from the Continuous Plankton Recorder (CPR) data showed a large increase in the 1990s compared to 1961 – 1975 that was due to an increase in the numbers of diatom and dinoflagellate phytoplankton.
- The CPR numbers of the early stages of the copepod *C. finmarchicus* and the total copepod numbers showed a general downward trend in the 1990s compared to 1961 - 1975.
- The CPR total numbers of krill (euphausiids) in the 1990s were below the long-term mean.
- Net samples of zooplankton biomass showed similar levels on the Halifax and Louisbourg transects in the spring and fall of 1998.
- The 1998 levels of *C. finmarchicus* in the Emerald basin were similar to those of 1997, but below the long-term mean value for the 1984 - 1997.
- The acoustic indices of krill suggested a slight increase on the Louisbourg transect and in Emerald Basin in 1998 compared to 1997.

Halifax and Louisbourg Transects

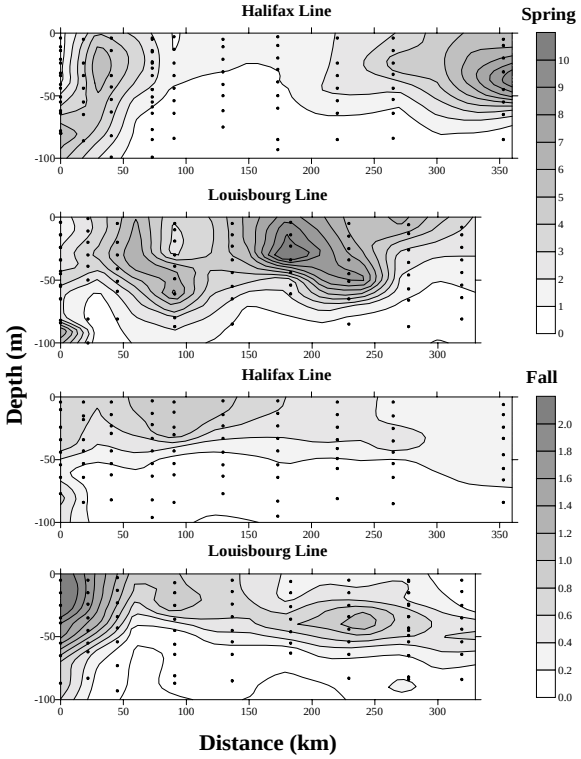


The Halifax and Louisbourg transects were sampled during spring (April) and fall (October) of 1998 using conventional bottle casts, plankton nets and multifrequency acoustics.

Phytoplankton Biomass on the Halifax and Louisbourg Transects

Phytoplankton biomass, as estimated by chlorophyll concentration, varied by depth and location along the transects. In spring, chlorophyll along the Halifax transect was highest at the inner and outer-most stations whereas concentrations peaked at the central stations along the Louisbourg transect; highest concentrations were observed below the surface along both transects. In fall, highest concentrations were observed inshore along both transects; along the Louisbourg transect a pronounced subsurface maximum was evident at the outer stations.

Chlorophyll (mg m^{-3}) Contour Plots



Column-integrated (surface to 100 m depth) chlorophyll concentrations in 1998 were five to seven times higher in spring than in fall as has been observed previously. In addition, concentrations along the Louisbourg transect were almost two times higher than along the Halifax transect in both seasons; a result observed in previous years.

Spring chlorophyll concentrations were two to three times higher in 1998 than in 1997. Fall concentrations were similar between the two years. Chlorophyll concentrations in 1998 along the Halifax transect were similar to the long-term (1974-1998) mean for the central Scotian Shelf but those along the Louisbourg transect were somewhat lower than the long-term mean for the eastern Shelf.

Mean Chlorophyll levels (mg m^{-2}) along Halifax and Louisbourg Transects. Standard deviations in parentheses.

	Halifax Transect		Louisbourg Transect	
Year	Spring	Fall	Spring	Fall
1995	180 (163)		-	-
1997	74 (95)	48 (10)	193 (104)	45 (14)
1998	211 (167)	31 (8)	299 (135)	56 (42)
Mean 74-98	205 (243)	40 (30)	346 (290)	24 (13)

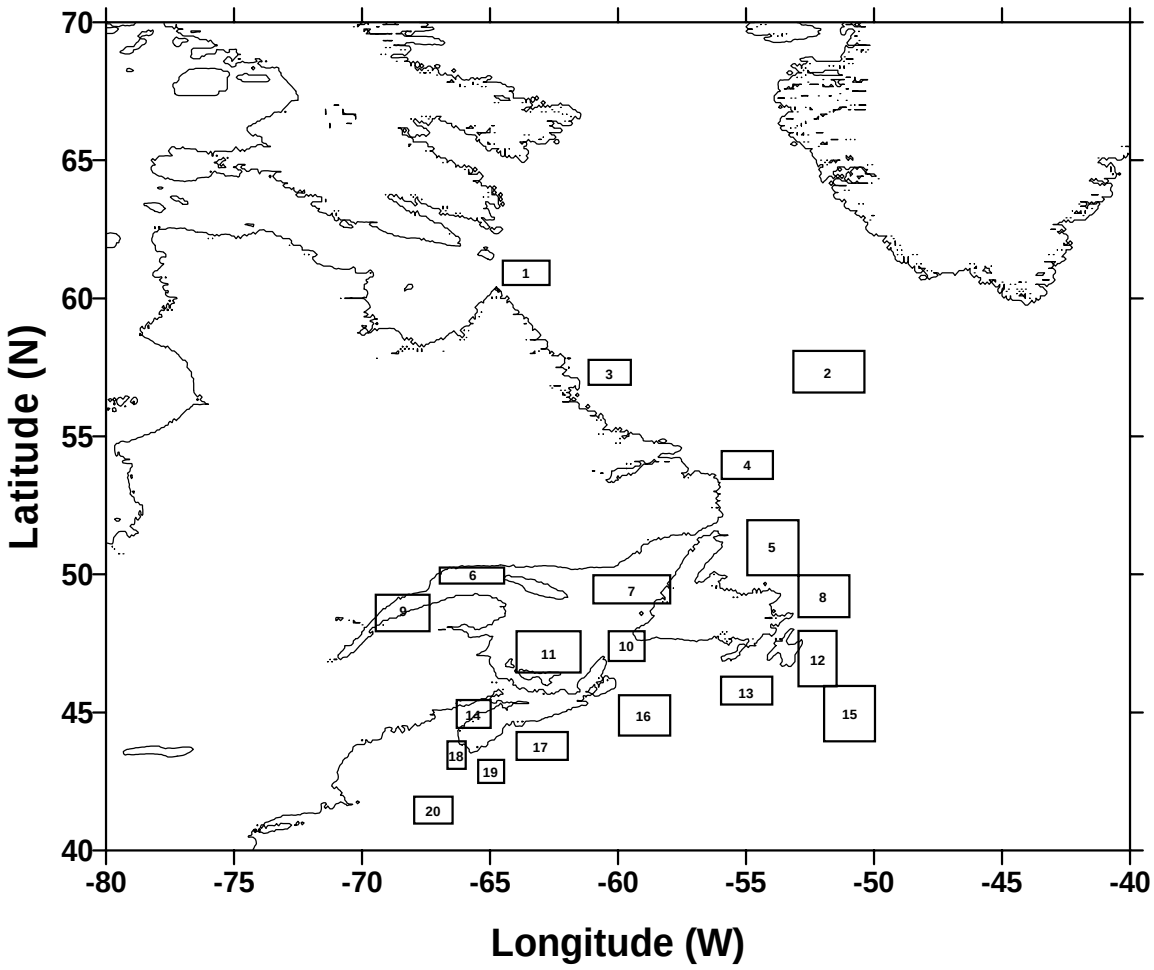
Satellite Ocean Colour from SeaWiFS

Phytoplankton biomass was also estimated from ocean colour data collected by the Sea-viewing Wide Field of View (SeaWiFS) satellite sensor launched by NASA in late summer 1997 (http://www.mar.dfo-mpo.gc.ca/science/ocean/ias/seawifs/seawifs_1.html). Satellite data do not provide information on the vertical structure of phytoplankton in the water column but do provide highly resolved (~1.5 km) data on their geographical distribution in surface waters at the large scale. Bi-weekly composite images of chlorophyll concentrations for the entire NW Atlantic have been produced from which 20 sub-regions have been selected for more detailed analysis.

The seasonal cycle of chlorophyll in the Maritimes sub-regions could be characterized by two periods of peak abundance; a spring "bloom" which occurred in the March-May time period and a late fall – early winter peak in the November-January time period. The spring bloom is a common phenomenon in the NW Atlantic and has been known and described since plankton studies began in the region more that 60 years ago. The winter bloom, however, has not been well described previously despite its apparent large-scale existence. The satellite data are consistent with observations from the Halifax and Louisbourg transects indicating that chlorophyll levels were considerably higher in spring on the eastern shelf than on the central shelf in 1998.

A comparison of SeaWiFS results for 1998 with the climatological mean chlorophyll concentrations derived from the Coastal Zone Color Scanner (CZCS) satellite-based sensor that flew from 1978-1986 revealed that contemporary chlorophyll levels appear to be somewhat higher than during the late 1970s to mid 1980s. This is consistent with observations from the CPR suggesting that phytoplankton biomass has been higher in the 1990s than previous decades; the Coastal Zone Color Scanner data filled an important gap in the CPR record, i.e. the late 1970s/early 1980s.

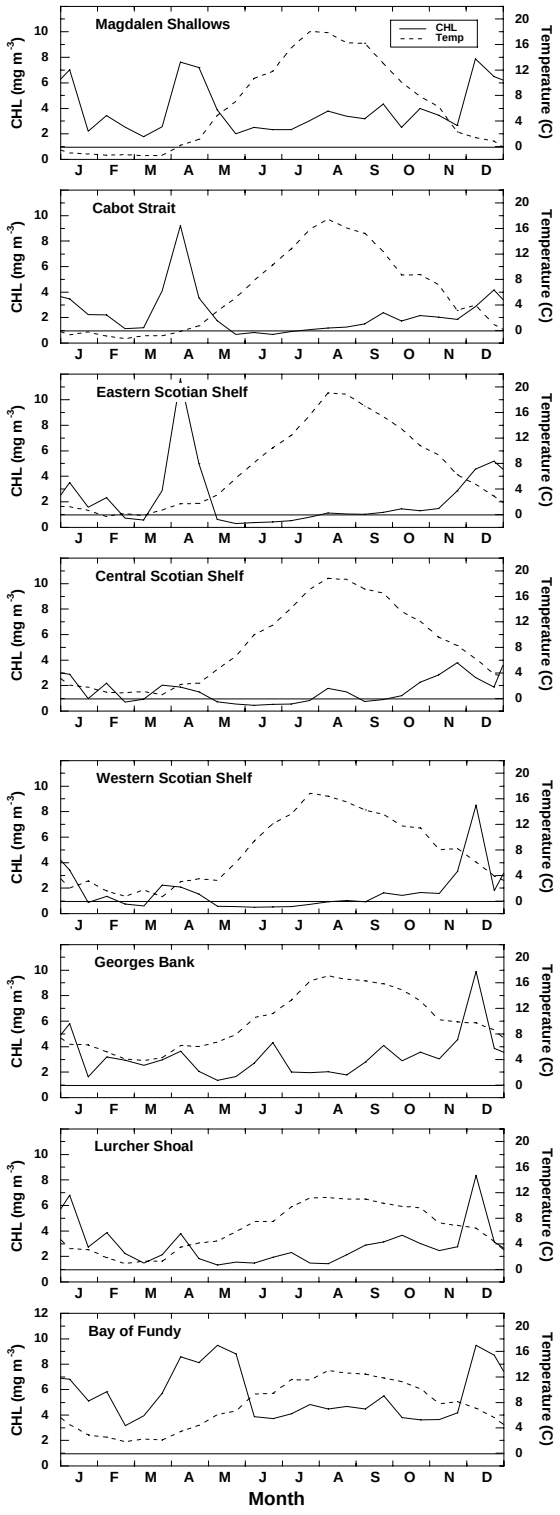
Sea surface temperature (SST) data were collected at the same time as ocean colour from another orbiting satellite sensor, the Advanced Very High Resolution Radiometer (AVHRR); patterns were similar in all sub-regions showing minimum surface temperatures in January-February and maximums in August-September.



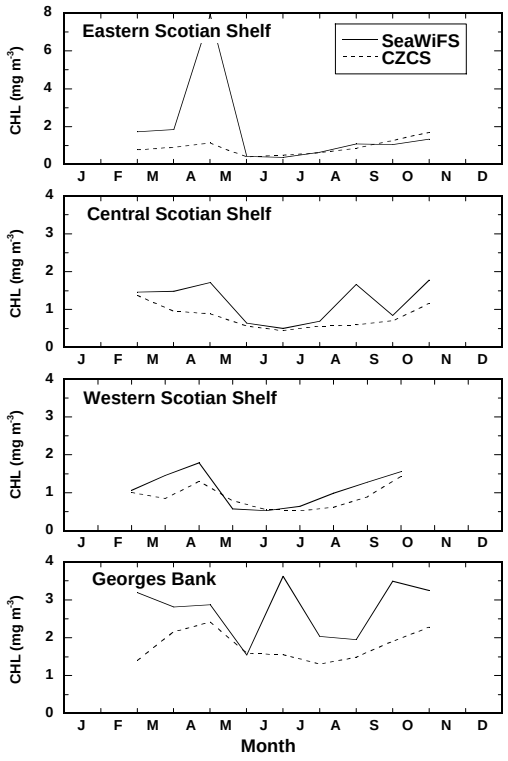
Sub-regions selected for satellite statistical analysis.

	Sub-Region	Latitude (N)	Longitude (W)
1	Hudson Strait	60.51-61.40	62.72-64.55
2	Ocean Station “Bravo”	56.63-58.13	50.42-53.17
3	N. Labrador Shelf	56.91-57.81	59.55-61.20
4	Hamilton Bank	53.50-54.50	54.00-56.00
5	St. Anthony Basin	50.00-52.00	53.00-55.00
6	NW Gulf of St. Lawrence	49.70-50.30	64.50-67.00
7	NE Gulf of St. Lawrence	49.00-50.00	58.00-61.00
8	NE Newfoundland Shelf	48.50-50.00	51.00-53.00
9	Estuary	48.00-49.30	67.40-69.50
10	Cabot Strait	46.90-48.00	59.00-60.40
11	Magdalen Shallows	46.50-48.00	61.50-64.00
12	Avalon Channel	46.00-48.00	51.50-53.00
13	St. Pierre Bank	45.33-46.33	54.00-56.00
14	Bay of Fundy	44.50-45.50	65.00-66.33
15	SE Shoal	44.00-46.00	50.00-52.00
16	Eastern Scotian Shelf	44.20-45.67	58.00-60.00
17	Central Scotian Shelf	43.33-44.33	62.00-64.00
18	Lurcher Shoal	43.00-44.00	66.00-66.70
19	Western Scotian Shelf	42.50-43.33	64.50-65.50
20	Georges Bank	41.00-42.00	66.50-68.00

Seasonal Phytoplankton and Surface Temperature Cycles from Satellites Maritimes Region 1998



Seasonal Phytoplankton Cycle CZCS (1878-1986) – SeaWiFS (1998) Monthly Imagery

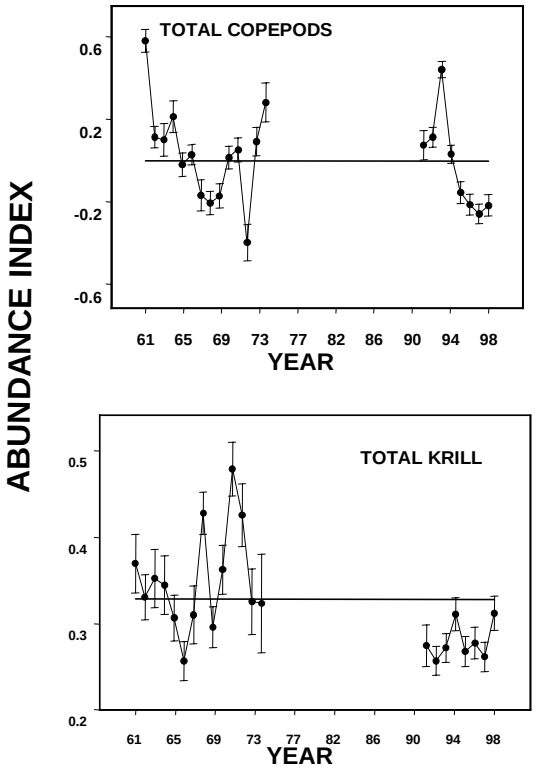


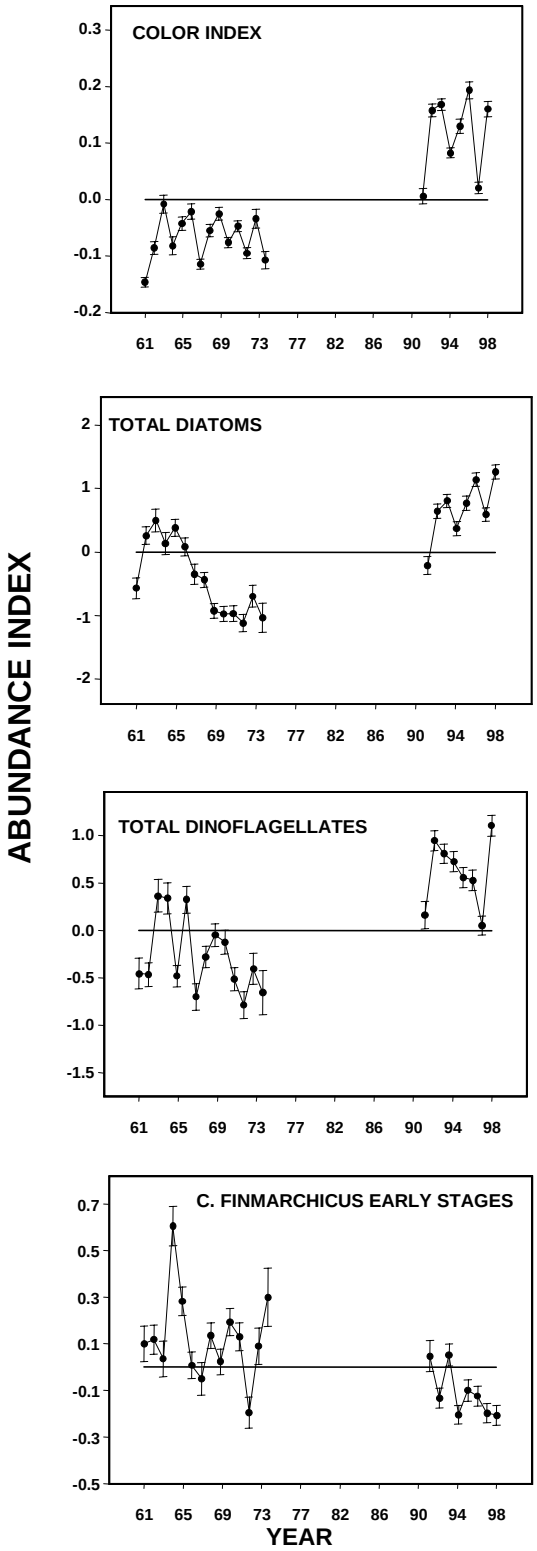
Continuous Plankton Recorder

The Continuous Plankton Recorder (CPR) is an instrument that collects phytoplankton and zooplankton at a depth of about 7m on a long continuous ribbon of silk while towed from commercial ships. 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.

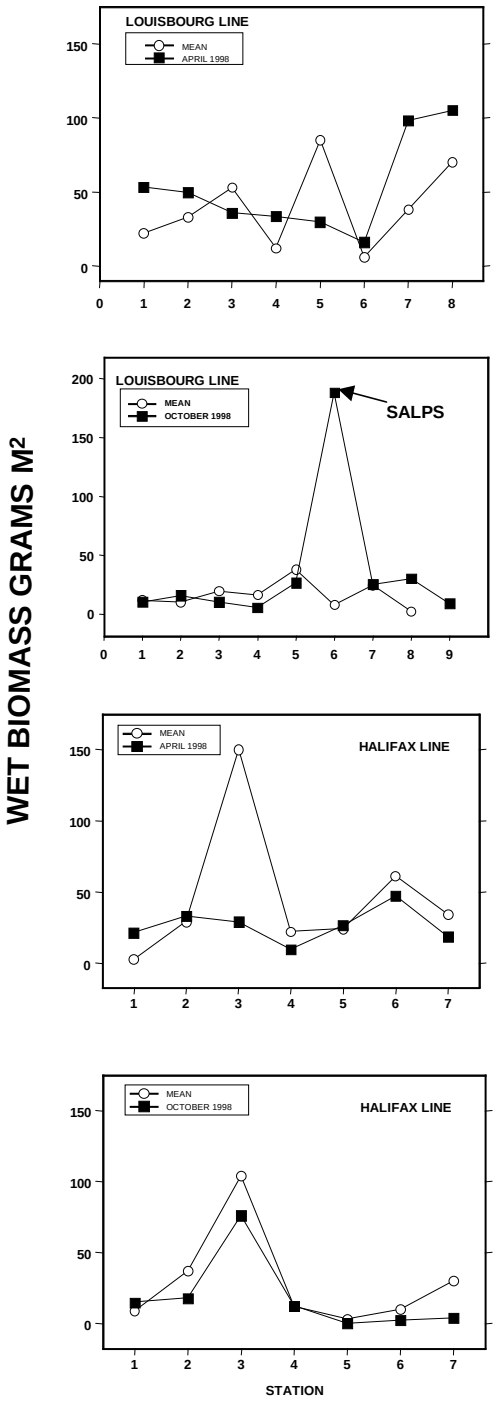
The sampling methods from 1961 – 1998 were exactly the same so that valid comparisons can be made between years.

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 the 1990s compared to the earlier period. In contrast, indices of both total copepods and early stages of *C. finmarchicus* have declined to low values since the mid 1990s. The CPR krill index has also been below the long-term mean throughout the 1990s, though the 1998 value approached the long-term mean.





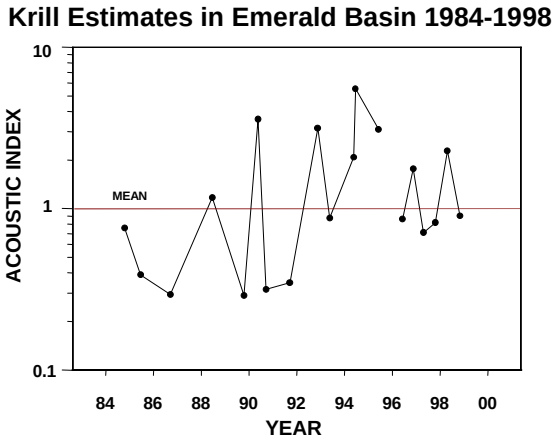
Zooplankton Biomass on Halifax and Louisbourg Transects



Ring net sampling along the Halifax and Louisbourg transects showed zooplankton biomass to be similar to the long-term mean at most stations in the spring of 1998. Exceptions were higher-than-average biomasses at stations 7 and 8 on the Louisbourg transect and lower-than-average biomasses at station 5 on the Louisbourg transect and station 3 on the Halifax transect. During the fall the biomass was similar to the long-term mean on all stations on both transects with the exception of stations 6 and 8 on the Louisbourg transect. These stations had very high concentrations of salps and low levels of copepods, which were likely consumed by the salps.

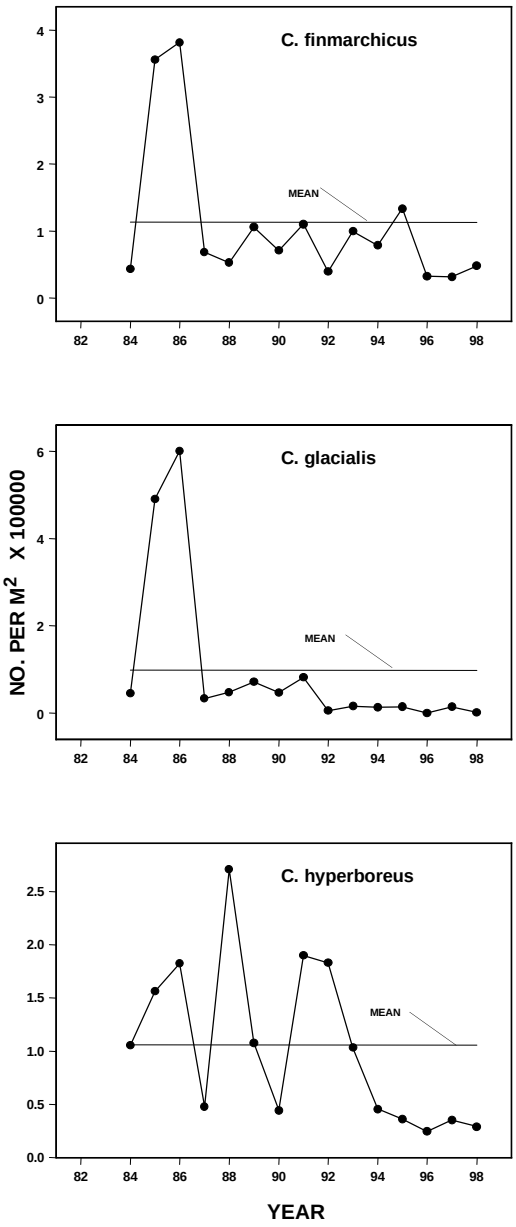
Acoustic Index

Acoustic data collected over the last decade in Emerald Basin had shown a close relationship between the acoustic index (volume backscattering at 200 kHz) and krill concentrations. Acoustic data are good indicators of changes in krill abundance both across the shelf and between different months of the year. Daytime levels of the 1998 acoustic krill index on the Halifax transect and in Emerald Basin were only slightly higher than in 1997. These data suggest the krill population in this region of the shelf changed little 1997. The acoustic krill index on the Louisbourg transect indicated a biomass about 50 % lower than that found on the Halifax transect. The Louisbourg index in 1998 was higher than it was in 1997, which may suggest an increase in the krill population on the Louisbourg transect.



Calanus species in Emerald Basin

The copepod, *Calanus finmarchicus* accumulates in Emerald Basin during the summer and fall and remains in the deep water until the breeding season in the late winter and early spring. It is believed that the size of the fall population of *C. finmarchicus* in the basin in the fall is a good indicator of the size of the previous spring and summer's population on the Scotian Shelf. The 1998 levels of *C. finmarchicus* in the basin were similar to those of 1997, but below the long-term mean value for the 1984 - 1997. The arctic species of *Calanus C. hyperboreus,* and *C. glacialis* were also below their long-term mean values and near the lowest levels on record.



Conclusions

The years 1991 to 1998 were a period of increased phytoplankton levels and reduced population levels of copepods and krill on the Scotian Shelf. The earlier 1990s were years of cold water temperatures on the northeastern Scotian Shelf. These cold temperatures are believed to have played a role in the changes seen in the phytoplankton and zooplankton

communities. The slight increases in the over-wintering population of *C. finmarchicus* in Emerald Basin and the krill populations in the basin and on the Louisbourg transect may indicate that the zooplankton levels are increasing on the Scotian Shelf. These increases may be a response to warming temperatures seen in the last few years.

In 2001, the state of the plankton will be presented in an integrated report on chemical and biological conditions in the Maritimes Region as part of the Atlantic Zonal Monitoring Program.

References

Sameoto D. N. Cochrane, A. Herman, E. Head and M.K. Kennedy. State of zooplankton on the Scotian Shelf in 1997. DFO Can. Stock Assess. Sec. Res. Doc. 98/130.

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