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Zooplankton Changes Along the Halifax and Louisbourg Transects in 1996

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ABSTRACT

Zooplankton data from the Continuous Plankton Recorder, vertically-towed nets, and high frequency acoustics all indicate that the levels of mesozooplankton (>200 mμ) and macrozooplankton (>1 cm) on the eastern region of the Nova Scotia Shelf are lower than the levels found on the Halifax transect and possibly the entire western region of the shelf. There may be a link between the colder bottom temperature on the eastern region and the lower biomass values found in the area compared to the western region with warmer bottom temperatures and a higher biomass.

RÉSUMÉ

Les données sur le zooplancton recueillies à l'aide d'un enregistreur à plancton en continu, de filets remorqués verticalement et d'appareils acoustiques à haute fréquence indiquent que l'abondance du mésozooplancton (>200 mμ) et du macrozooplancton (>1 cm) dans le secteur est du plateau néo-écossais est plus faible que celle relevée dans le transect Halifax et peut-être de l'ensemble du secteur ouest du plateau. Il pourrait exister un lien entre la température au fond plus froide du secteur est et la faible biomasse relevée dans ce secteur par rapport au secteur ouest, où la température au fond et la biomasse sont plus élevées.

Comparison of the Eastern and Western Scotian Shelf CPR data

Historical bottom temperature data for the Nova Scotian shelf show a consistent seasonal pattern of consistently colder water on the eastern end of the shelf compared to the central and western regions (Fig. 1). The growth rate of cod is known to be slower on the eastern regions of the shelf than on the western end and in the Gulf of Maine (Campana et al. 1995). To determine if zooplankton parameters showed differences on the eastern and western regions of the shelf that may reflect differences in the temperatures of the two regions data from various sources were examined. The data looked at were CPR data for years 1961 to 1994, ring net data, and ADCP data from the Halifax and Louisbourg transects collected during the spring and fall of 1996.

CPR data

The CPR data have a number of months missing in many of the years that reduces the amount of confidence one can place in the results for these years (Fig 2) . The years 1961, and 1972 to 1974 have large gaps in the data that make extrapolating trends for these years questionable. But since these are the only data that exist for this level of coverage for zooplankton and phytoplankton these limitations must be accepted.

The shelf was divided into a eastern and western area along longitude 62 ° W. The density and position of samples in the two areas is shown in Fig 2. Each area was considered to be a homogeneous unit and all the samples were given equal weight regardless as to where in the area they were taken. Monthly means were calculated and compared for four taxa groups, phytoplankton color, total copepods, *Calanus finmarchicus* stages 1 to 4 and *C. finmarchius stages* 5 and 6 for each year from the two areas. The means were contoured separately for the two regions using a Kriging method in the program Surfer 5 for Windows (Fig. 3). The yearly means for the phytoplankton color index and total copepods were plotted separately for the regions and the data parameters described with Box and Whisker plots (Fig. 4). The yearly medians from the two regions were also compared with the nonparametric Wilcoxan test and the Kolmogorov-Smirnov (K-S) two sample test.

The central region of the Scotian Shelf was dominated by cold water during the early years of the CPR sampling, from 1961 to 1969, after 1969, the deep water in this region warmed and remains warm today. The cold and warm periods are indicated on the contour plots in Fig. 3. The contours of phytoplankton color (a proxy for phytoplankton blooms) for the two regions showed differences in seasonal pattern in the two areas, particularly for the years 1961 to 1975. In the western region the color index pattern was high from summer to fall with almost no evidence of a spring increase during the cold years. During the warm years the spring high in color index appeared and the fall levels were significantly reduced in intensity and duration. The pattern in the eastern region was different than the western area in that the spring color index dominated during the cold period and was weaker in the fall. In the years since 1991 the two regions have had similar seasonal color index patterns, a strong spring and weaker fall bloom each year, and the eastern region has generally had a higher color index in spring.

The seasonal patterns of zooplankton abundance over years did not significantly change with both regions having similar patterns. In both regions *C. finmarchcus* stages 5 and 6 appeared to be higher in the warm period after 1969 than in the cold period. *C. finmarchicus* stages 1 to 4 did not show this apparent increase. Both the young and older stages of *C. finmarchicus* as well as total copepods were higher in the western region in all but a few years of the data series (Fig. 3).

There were no significant differences found between total numbers of zooplankton or phytoplankton color for the entire time period between the eastern and western shelf. However the K-S test for color index and total copepods showed the two regions were significantly different with the western region having a higher values of both variables.

Halifax and Louisbourg Transects

Sampling methods

The Halifax and Louisbourg transects were sampled during June and November, 1996 using 0.75 m diameter opening and closing vertically towed 200 mμ plankton net , the BIONESS, OPC/CTD and multifrequency acoustics (Sameoto et al. 1990a and 1990b, 1993, Herman et al. 1993). Zooplankton were sampled at different depth strata on each station (Fig. 5). Acoustic backscattering data were collected at 5 frequencies (12, 50, 105, 153 and 200 kHz) along each transect to map the distribution and estimate the concentration of macrozooplankton (> 1 cm), micronekton and pelagic fish.

Temperature and Copepod Concentrations

Temperature profiles are shown for selected stations (Fig. 6) for comparison on the two transects. During June the temperature profiles in the top 50 m on both transects were very similar, but below 50 m the water was significantly warmer on the Halifax line. The deep basin station 12 and Emerald Basin station 3 showed the most extreme contrast in temperature. Station 12 had temperatures <2 C° below 50 m in June and November, whereas the coldest water in Emerald Basin was about 3 C° in June. These data show that zooplankton living in the top 50 m on the two transects would be exposed to similar temperature regimes between June and November, but animals that vertically migrated diurnally into the upper 50 m would spend about half of their life in colder water on the Louisbourg transect than animals on the Halifax transect and therefore they would likely have slower growth rates.

Zooplankton Biomass on Halifax and Louisbourg Transects

Zooplankton samples were taken from the bottom to the surface giving an integrated estimate of the biomass for the entire water column. The wet biomass estimates for June and November on the stations are given in Fig. 7. The biomass values on the shelf stations (1 to 5 and 8 to 13) were compared with Wilcoxon nonparametric test to compare medians and it showed the Halifax transect shelf stations in June were significantly higher (P=0.03) than those on the Louisbourg transect. There was no significant difference between the means or medians in November using the Wilcoxon test. The stations off the edge of the shelf showed the reverse pattern with the Louisbourg stations 14 and 15 having higher biomass values than stations 6 and 7. A comparison between Emerald and Banquereau Bank stations(4 and 13), showed Emerald Bank with a higher biomass in both months. The same pattern was found for the deep basin station 12, and the Emerald Basin.

ADCP Backscattering

Acoustic backscattering levels at 153 kHz were recorded throughout the water column along the Halifax transect in June and October and Louisbourg transects during June, and November 1996 using a RDI ADCP (Cochrane et al. 1994, Zhou et al. 1994, RD Instruments 1990). The recorded backscattering was primarily from macrozooplankton and micronekton in the size range of 0.5 - 4 cm length. On the Shelf the principal acoustic scatterers at this frequency are euphausiid juveniles and adults (Cochrane et al. 1994, 1991). Therefore these acoustic data are good indicators of changes in euphausiid biomass both across the shelf and between different months of the year. The changes in volume backscattering strength from euphausiid backscattering are roughly equivalent to changes in their biomass concentration or density, i.e. a 10 dB change in backscattering corresponds to a 10 fold change in biomass density.

Simultaneously with the recording of the RDI data, acoustic backscattering data at 12, 50, 105 and 200 kHz were also recorded using conventional echosounders. The 12 kHz frequency provided information on the relative abundance and distribution of juvenile and adult fish throughout the water column. **(In the following discussion the term 'fish' will mean any fish in the water column including ground fish.)** During the spring the dominant pelagic and larval fish on the shelf was sand lance and in the fall it was the silver hake. By comparing the levels of backscattering at 12 kHz and 200 kHz it is possible to detect relative changes in the abundance of fish and euphausiids between different locations and seasons as well as to detect year to year changes in their relative abundance's.

Seasonal Changes in 153 kHz Backscattering

The patterns of backscattering on the Halifax transect in June and October were similar to those seen in the spring and fall of 1995, suggesting that no significant changes occurred in the composition of macrozooplankton during 1996 (Fig. 8). The Halifax transect was run in October as well as November, but because of sever weather in November the ADCP data were poor quality and therefore only the October data were used.

ADCP data were used to compare the relative biomass of macrozooplankton along the two transects. The average level of backscattering from macrozooplankton in dBs per m^2 on the Louisbourg transect was over 7 dB lower than that on the Halifax transect during both months, this is equivalent to a biomass difference of over 5 times. This means that the macrozooplankton levels were significantly lower on the Louisbourg transect during June and November. The levels of macrozooplankton in deep basins north of Banquereau Bank were similar to those in Emerald Basin in both the summer and fall, however, backscattering levels in the top 50 m of the Louisbourg transect were considerably lower during both periods.

Euphausiid and Pelagic Fish Trends 1984-1996

Acoustic data collected over the last decade in Emerald Basin has shown a close relationship between the volume backscattering at 12 and 200 kHz (Fig. 9). The 12 kHz data reflected the concentrations of pelagic fish in the basin and the 200 kHz frequency data provided an accurate estimate of the euphausiid concentrations. The relationship between these two frequencies over the years 1985 to 1995 showed a significant positive correlation ($r=0.91$, $P>0.001$). Both frequencies showed a general increase between 1985 and 1994 followed by a significant decrease in values in 1995. In June of 1996 the was a large increase in the levels of the 200 kHz backscattering indicating the krill stocks had increased from the low values seen in 1995. No 12 kHz backscattering data were collected in June 1996. These data indicated a close relationship between the fish and euphausiids in Emerald Basin. Silver hake and redfish, the two dominant pelagic species, feed primarily on euphausiids in the Basin (Waldon, 1988).

Calanus finmarchicus in Emerald Basin

C. finmarchicus accumulate in Emerald Basin during the summer and fall and remain 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 (Sameoto and Herman 1990) and may be an indicator of the size of the next year's *Calanus* population. The changes in the fall populations in the Basin between 1984 to 1996 are shown in Fig. 10. The 1996 population of *C. finmarchicus* decreased from the 1995 level to the lowest levels seen in the time series. *C. glacialis* and C. *hyperboreus* (both Arctic species) had very low concentrations in the Basin in 1996. The temperature anomaly at 50 m in June and the numbers of *C. finmarchicus* appeared to be related, showing that as the temperature increased there was a general increase in the size of *C. finmarchicus* population.

Conclusions

The CPR data suggested that during the cold years of 1961 to 1969 there were differences in the seasonallity of the phytoplankton bloom and possibly a reduction in the population of *C. finmarchicus stages* 5 and 6. The western region of the shelf generally had higher levels of copepods than the eastern region during the period of the CPR time series. However these data would have been more convincing if the time series were more complete.

The ADCP acoustic backscattering data showed the eastern region of the shelf , represented by the Louisbourg transect, had significant lower levels of macrozooplankton than were found on the Halifax transect. The macrozooplankton responsible for most of the backscattering were primarily euphausiids and to a less extent amphipods. Net samples showed that the levels of mesozooplankton measured by wet biomass were generally lower on the Louisbourg transect in June, and although the difference was not statistically significant in November the levels appeared generally lower on the Louisbourg transect.

The Emerald Basin *Calanus finmarchicus* data indicated that since 1987 the population levels have been stable but much lower than in 1985 and 1986. The 1996 levels were among the lowest in the data series. There was a gradual increase in both euphausiid and fish population in the Basin between 1984 and 1994 followed by a steep decline in their population size in 1995 and then a subsequent sharp increase in the euphausiid populations to pervious high levels in 1996. Why these large euphausiid population fluctuations occurred is unknown, we don't know if they reflect real changes in the size of the shelf population of krill or are only local changes due to advection of animals in and out of the of the Basin.

These data suggest that there may be lower mesozooplankton and macrozooplankton biomass and production on the eastern region of the shelf, and if true, this may be the consequence of the colder water found year around on the eastern region of the shelf.

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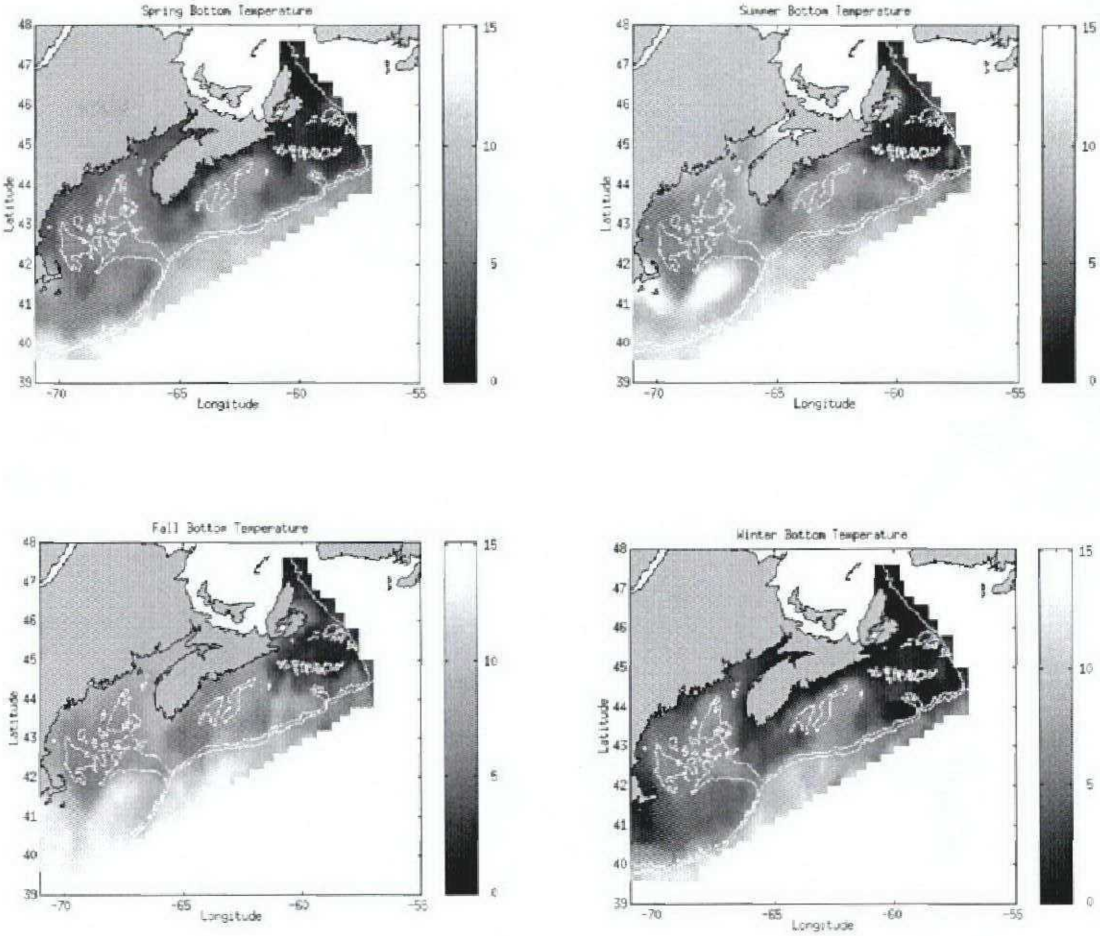

Fig. 1. The average seasonal bottom temperatures on the Scotian Shelf. (Provided by D. Gregory, Coastal Oceanography, Ocean Science, Bedford Institute of Oceanography)

MONTH	1	2	3	4	5	6	7	8	9	10	11	12
YEAR												
61							1	1	1	1	1	1
62	1	1	1		1	1	1	1	1	1		
63		1	1	1		1	1	1		1		1
64	1	1	1	1	1	1	1		1	1		1
65	1	1	1	1	1		1	1	1	1		1
66	1		1		1		1	1	1	1	1	1
67	1		1	1		1		1			1	
68	1	1		1	1		1		1	1	1	1
69	1	1	1	1	1	1	1	1	1	1		1
70	1		1	1	1		1	1		1	1	1
71	1	1	1	1		1		1	1		1	1
72	1	1	1				1		1		1	
73	1	1		1	1	1		1	1	1		
74				1	1					1		
91			1		1	1	1		1	1	1	1
92	1	1	1	1		1	1	1	1	1	1	1
93	1	1	1		1	1	1	1	1	1	1	1
94	1		1	1	1	1	1	1	1	1	1	1

Fig. 2. Solid black blocks respresent months during which no CPR data were collected and blocks with '1' represent months when data were collected.

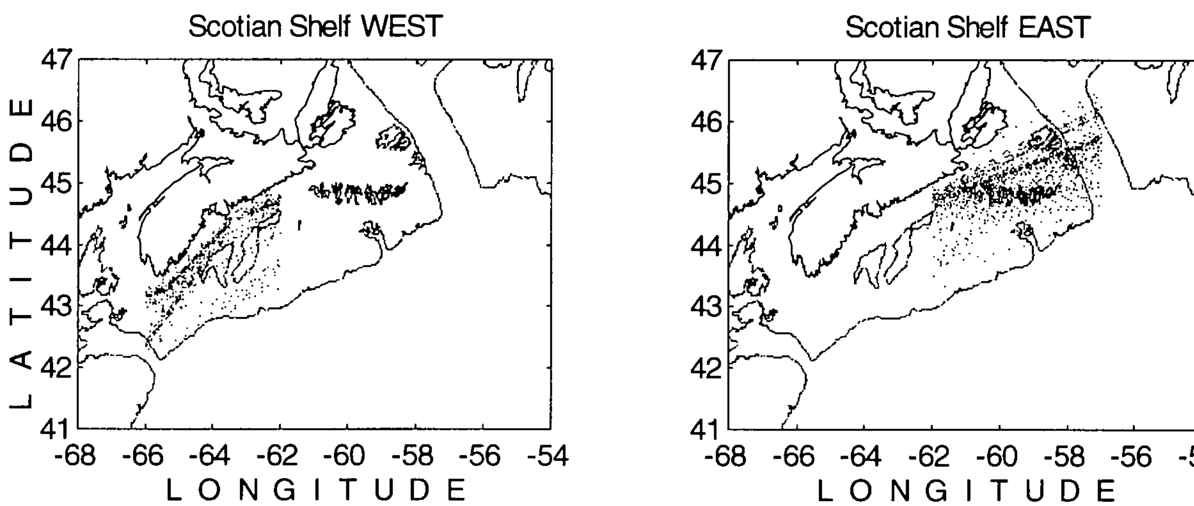

Fig. 3. CPR sample locations on the eastern and western Scotian Shelf for years 1961 to 1994.

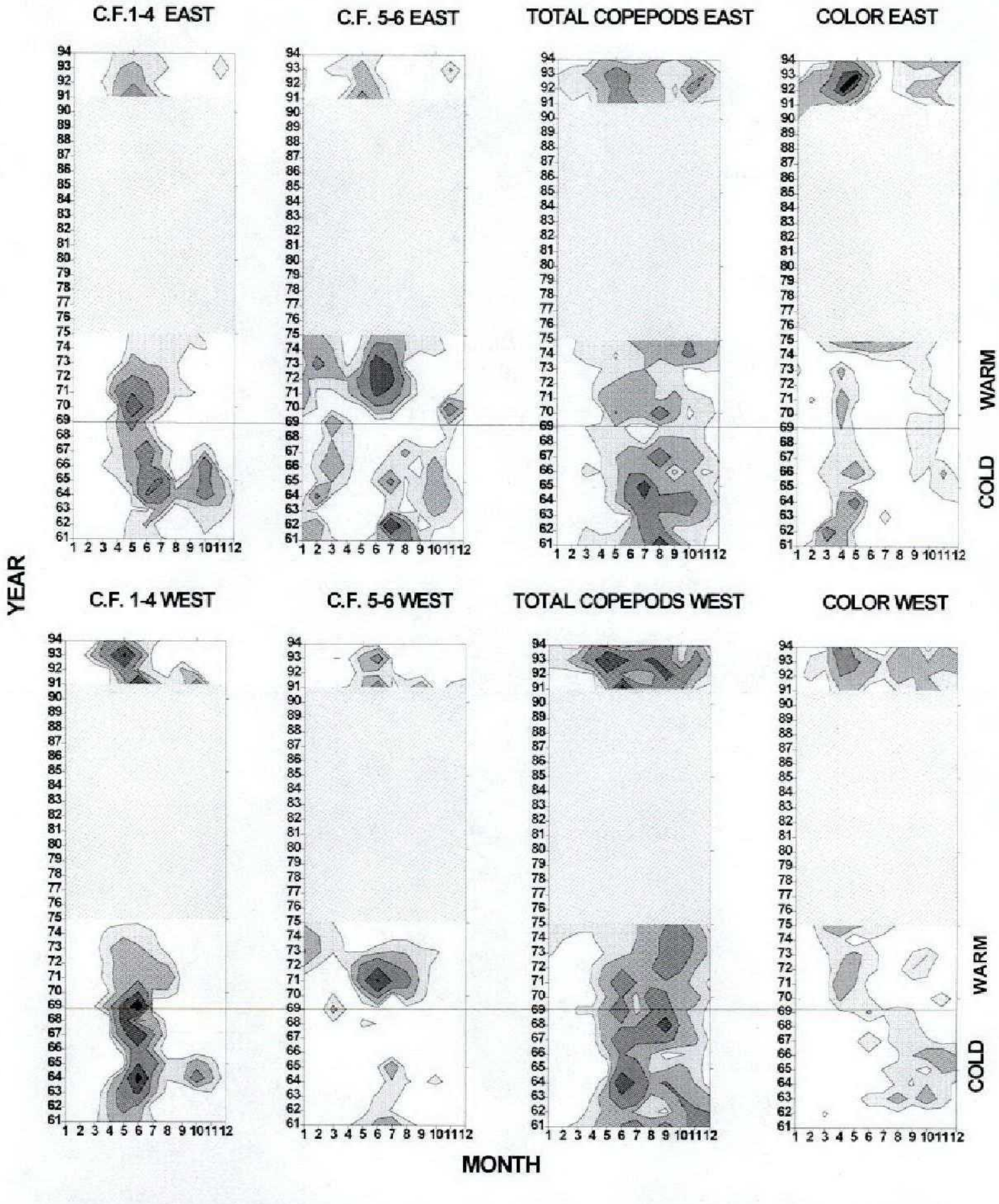

Fig. 4. Contours of monthly levels of *C. finmarchicus* stages 1 to 4, *C. finmarchicus* stages 5 and 6, total copepods and phytoplankton color index for the eastern and western regions of the scotian Shelf. 'COLD' and 'WARM' indicated years during which the water was colder and warmer than normal on the Shelf. The darker the contour the higher is its value. Hatched areas represent years in which no data were collected.

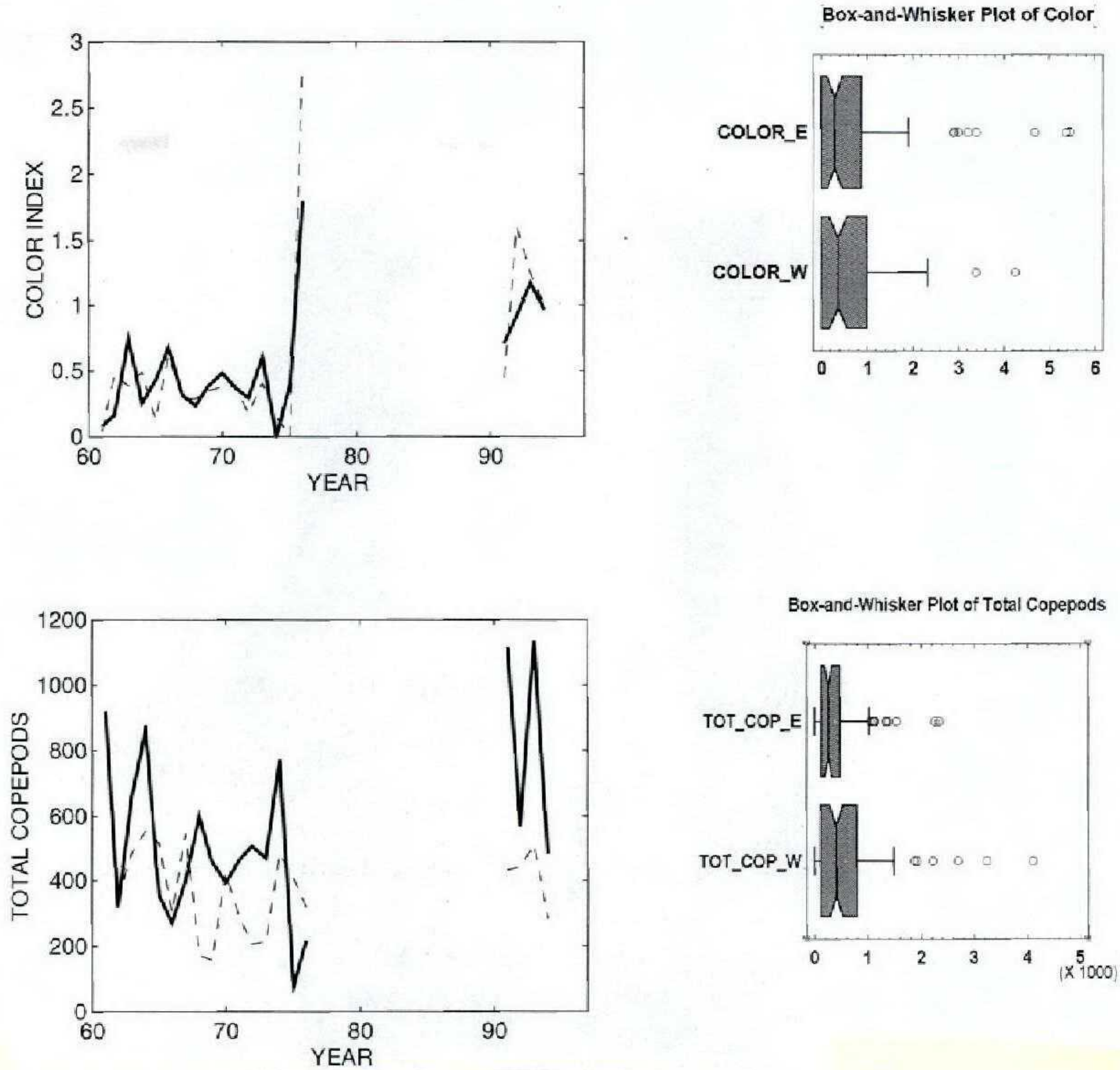

Fig. 5. CPR phytoplankton color index (top) and total copepods for years 1961 to 1994 for the eastern (dashed lines) and western areas (solid lines) of the Scotian Shelf. Plus Box and Whisker plots for the two areas (E-eastern and W-western areas).

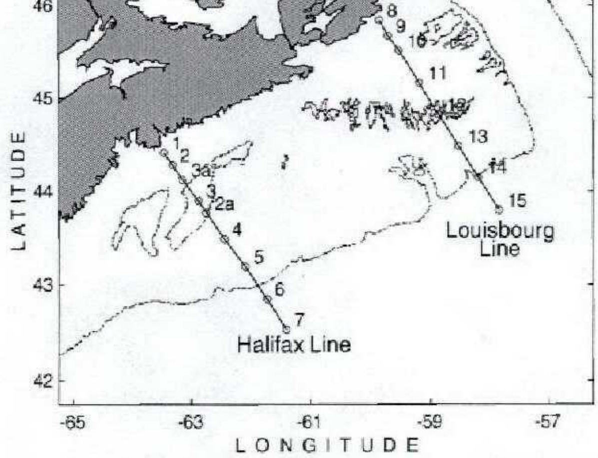

Fig. 6. Sampling stations on the Halifax and Louisbourg transects in 1996. Dashed line represents the 200 m contour, station 3 in in Emerald Basin, 4 and 5 are on Emerald Bank and station 13 in on Banquereau Bank.

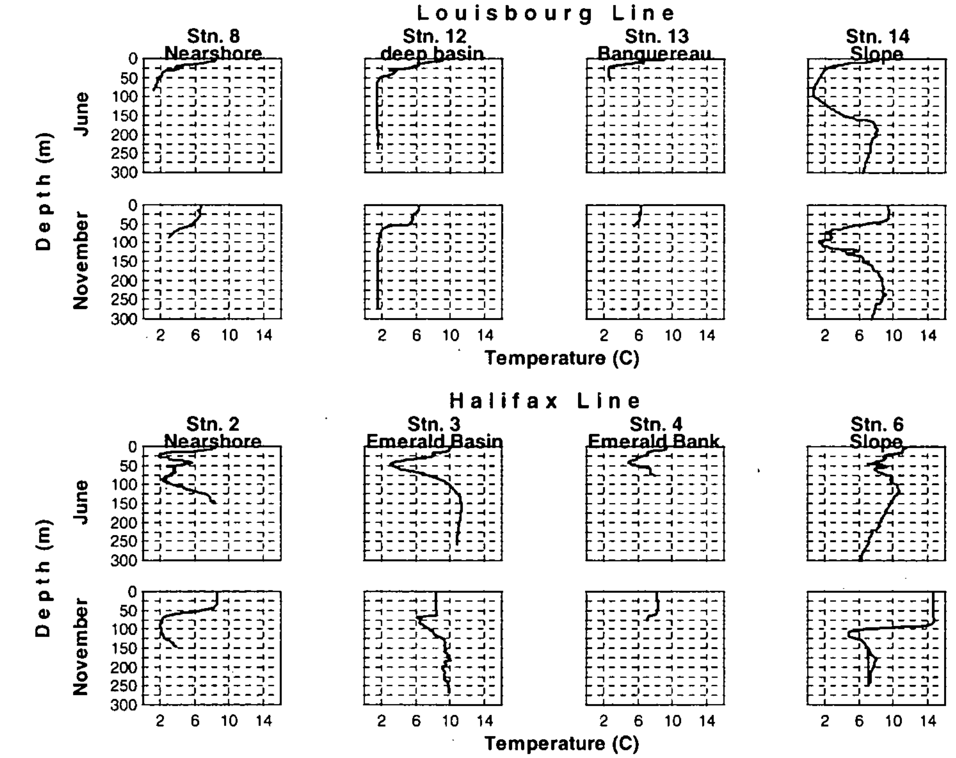

Fig. 7. Temperature profiles for selected stations on the Halifax and Louisbourg transects for 1996.

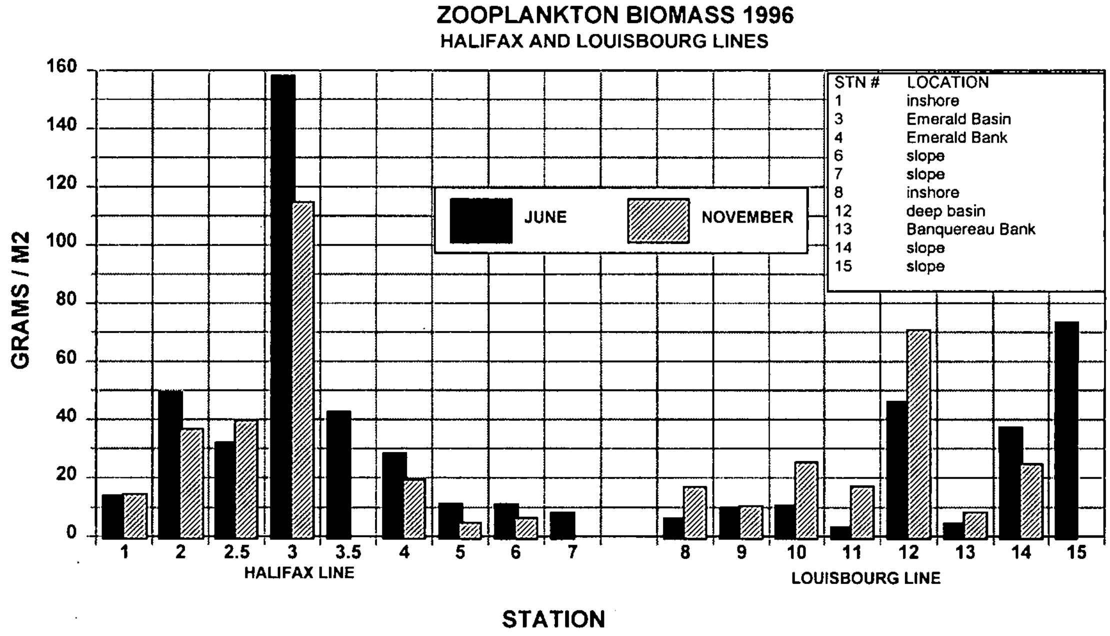

Fig. 8. Total wet biomass of meso and macrozooplankton per m^2 on the Halifax and Louisbourg transect stations. No data were collected on stations 3.5, 7 and 15 in November.

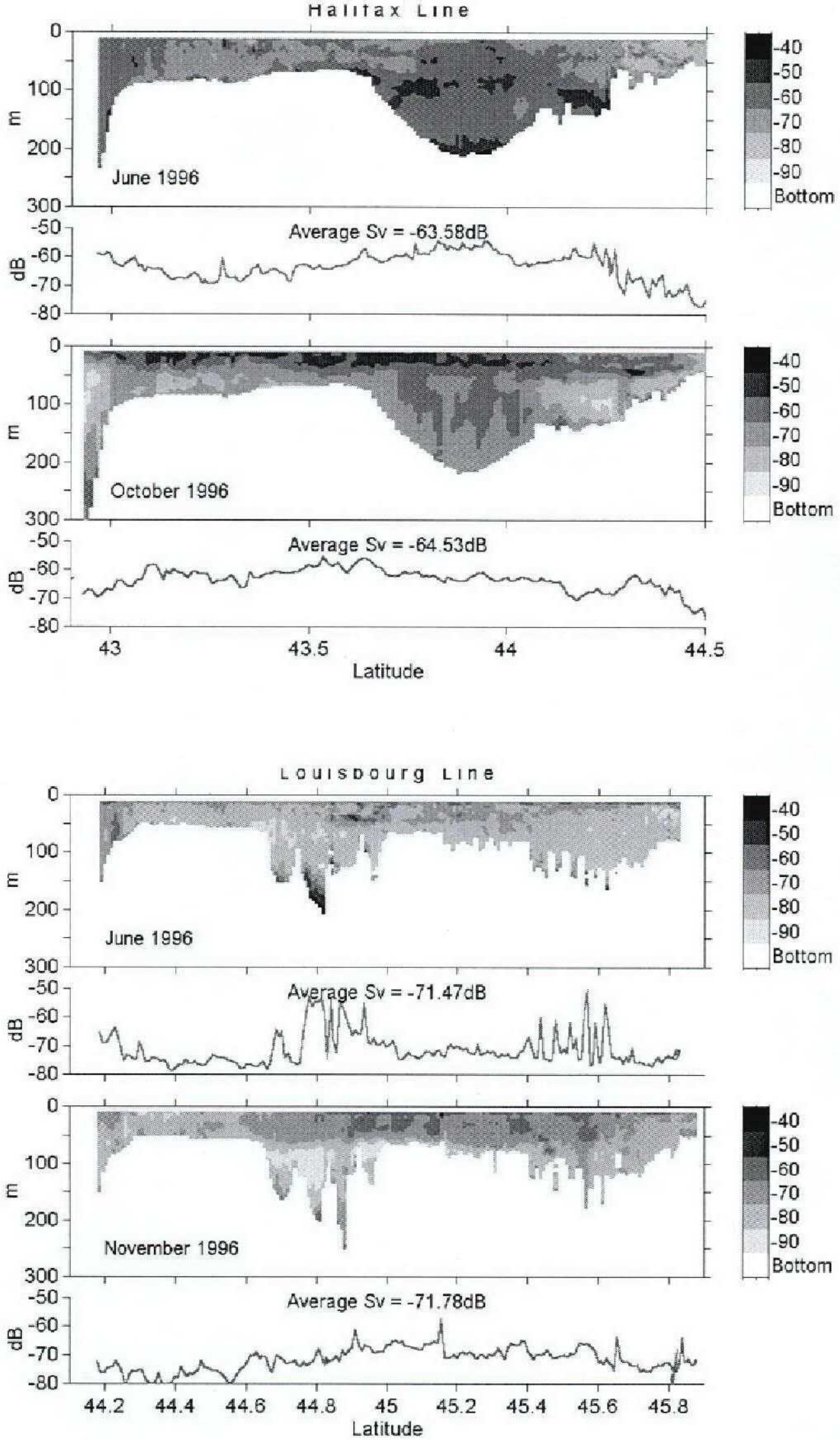

Fig. 9. ADCP volume backscattering strength across the Halifax transect during June and October and the Louisbourg transect in June and November 1996 showing the dB contours and dB color bar plus the average water column backscattering per m^3 (line drawing) and the spacially averaged dB per m^3 for the entire Line.

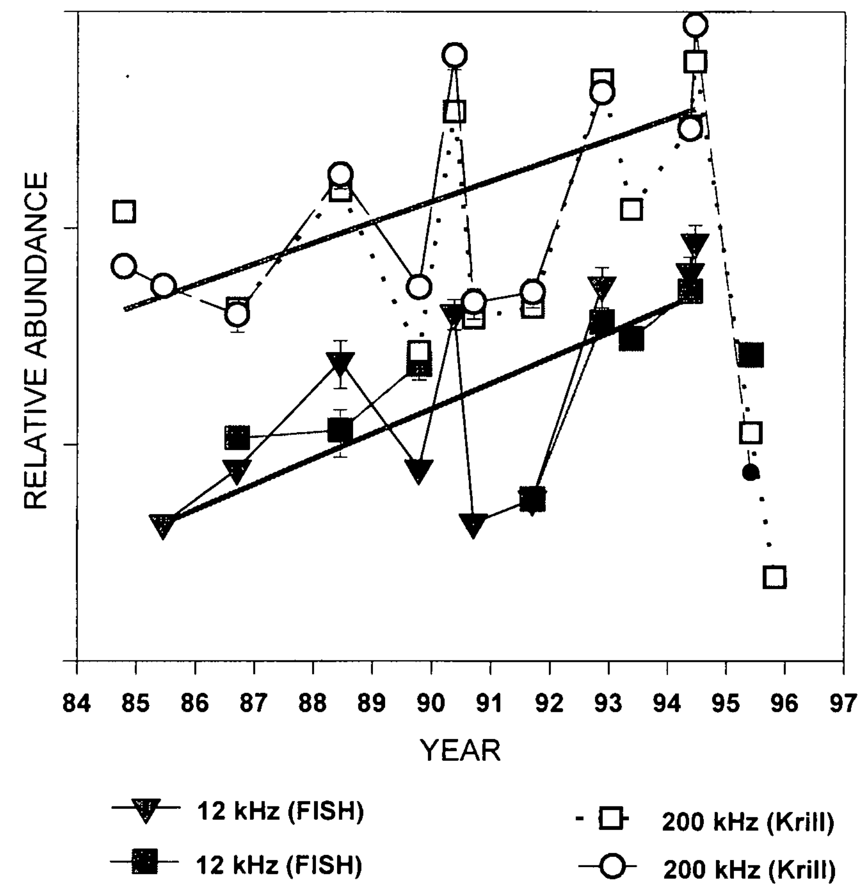

Fig. 10. Relationship between integrated volume backscattering for the pelagic fish (12 kHz) and euphausiids (200 kHz) in Emerald Basin from 1985 to 1996. The two sets of points for each frequency represent acoustic data collected during BIONESS and BATFISH sampling. The straight lines are the calculated linear regressions for each of the frequencies for the BIONESS acoustic data. Integrated depth limits were chosen to separate the fish and euphausiid populations.

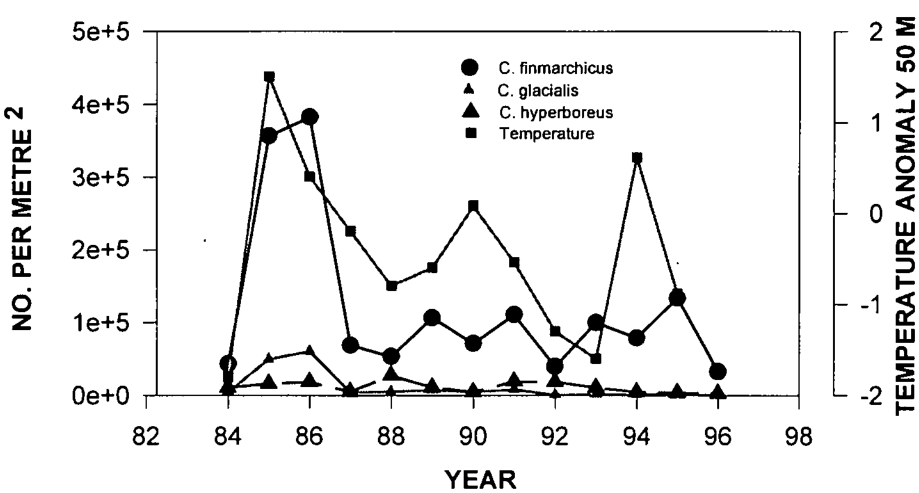

Fig. 11. Concentrations of *Calanus* spp. per m^2 in Emerald Basin during the fall from 1984 to 1996 plus the temperature anomaly in the Basin at 50 m during June. The circles represent *C. finmarchicus*, the small triangles *C. glacialis*, the large triangles *C. hyperboreus* and the squares the temperature anomaly.