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Final Report of the 1999 Annual Meeting

of the

Fisheries Oceanography Committee

Held on March 17-19, 1999
At the Maurice-Lamontagne Institute
Mont Joli, Québec

D.P. Swain, Chairman

July 1999

Canada

Atlantic Zone

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Executive Summary of the 1999 FOC Annual Meeting

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans (DFO) met in Mont-Joli, Québec, at the Maurice Lamontagne Institute on 17-19 March, 1999. The Committee reviewed environmental conditions in the Northwest Atlantic during 1998, held a theme session on the lower trophic levels in the marine ecosystems of the Northwest Atlantic, discussed the Zonal Monitoring Program and its linkages to the FOC, reviewed additional papers on physical and biological oceanography and on cod recruitment and growth, and conducted its annual business meeting.

1. **Physical Environment in 1998**: Six papers were reviewed on the meteorological and physical oceanographic conditions in 1998. Air temperature was warmer than normal in 1998 throughout the northwest Atlantic, particularly during winter and spring in the Gulf of St. Lawrence. Sea ice coverage and duration were below average. Water temperatures from southern Labrador to the Grand Bank and off southern Newfoundland were generally near or above normal values, continuing the moderating trend seen since 1995.This was reflected in below-average volumes of the cold intermediate layer (CIL) and reduced areas of subzero bottom waters off Newfoundland. In contrast, CIL minimum temperature declined and CIL thickness and volume increased in 1998 in the Gulf of St. Lawrence, where water temperatures remain colder than normal. On the Scotian Shelf, surface waters were generally warmer than normal and subsurface waters colder than normal. Cold, low salinity waters characteristic of Labrador slope water flooded into the Emerald Basin, the bottom water layers of the southwestern Scotian Shelf, and the Gulf of Maine early in 1998 and remained throughout the year. Temperatures dropped by 2-3°C and were the coldest observed since the 1960s. Stratification over most of the Scotian Shelf has increased in recent years to the highest levels in the approximately 50-yr record.

2. **Biological Environment in 1998:** Three papers on plankton and nekton in 1998 were reviewed. In 1998, total nekton biomass on the Northeast Newfoundland Shelf and Grand Banks was the highest in the 5-yr time series. Squid and arctic cod were less dominant than in previous years, capelin larvae were more widely distributed than in any other year, and the abundance index for sandlance increased by an order of magnitude. Large increases in the abundance of pelagic 0-group Atlantic cod, American plaice and haddock occurred on the southern Grand Bank, perhaps in response to the warming of these waters. Biomass of both mesozooplankton and krill in the lower St. Lawrence Estuary in September of 1998 declined below the 1997 levels to values near the 1995 and 1996 levels and well below the high 1994 levels. On the Scotian Shelf, biomass and abundance of *Calanus finmarchicus* were lower on the Halifax line in 1998 than in 1997, while biomass on the Louisbourg line was similar to the longterm mean. The concentration of *C. finmarchicus* in Emerald Basin in the fall of 1998 was the lowest recorded in the 14-yr time series. The abundance of macrozooplankton (primarily krill) continued to decline on the Halifax line in 1998, where abundance now approaches the low levels seen on the Louisbourg line.

3. Presentations were made on the **Zonal Monitoring Program** (ZMP) and **Climate Change programs**. A discussion of linkages between the ZMP and the FOC followed. It was

recommended that the ZMP should undertake the responsibility of providing the FOC with the annual environmental overviews.

4. The **theme session** on the lower trophic levels in the marine ecosystems of the Northwest Atlantic attracted only 3 papers: one on decadal changes in plankton on the Scotian Shelf, one on recent trends in pelagic fishes in the shelf waters off Newfoundland and one on trends in the mean trophic level of fishery landings in the southern Gulf of St. Lawrence.

5. Seven presentations were reviewed in the **general environmental session**: three on physical or biological oceangraphy, one on cod recruitment, and three on cod growth. The oceanography papers described seasonal and regional variability in phytoplankton biomass in the Northwest Atlantic, the development of a sea surface temperature index for the Canadian east coast, nutrient and dissolved oxygen variability on the Scotian Shelf, and the climatology of nutrients, phytoplankton and zooplankton for the Newfoundland Shelf and Labrador Current. The paper on cod recruitment tested effects of climate, spawning stock characteristics and pelagic fish biomass on pre-recruit survival of southern Gulf cod. The papers on cod growth included a comparative analysis of effects of temperature and abundance on growth for the Gulf of St. Lawrence and Scotian Shelf stocks, tests of density and temperature dependence of southern Gulf cod growth incorporating effects of size selective mortality, and an examination of possible explanations for changes in the direction of size selection for southern Gulf cod.

6. Reports of the **FOC working groups** were presented. The **Cod Growth Working Group** had completed a comparative analysis of effects of temperature and abundance on growth of the Gulf of St. Lawrence and Scotian Shelf stocks and planned to extend this analysis to the Newfoundland stocks in the coming year, as well as prepare for an upcoming ICES/GLOBEC workshop on cod growth (May 2000) and explore possibilities for laboratory studies on cod growth. The **Environmental Indices Working Group** had completed most of its objectives, documenting and standardizing the main physical oceanographic indices presented in the annual overviews. It was recommended that the work of this group should continue under the ZMP's data analysis subcommittee and should include the development of standard biological indices. The **Cod Distribution Working Group** had reviewed and evaluated methods and indices used to characterize fish distribution and had examined the use of fishery data to describe fish distribution. However, comparative analyses among stocks on the relative importance of temperature change and density dependence in explaining changes in cod distribution were not completed, and the WG was asked to continue this work during the coming year.

7. A proposal that the results of completed **High Priority research programs** should be presented at future annual meetings of the FOC was discussed and endorsed.

8. The **2000 Annual Meeting** will be held at the Northwest Atlantic Fisheries Centre in St. John's during the last week in February. A theme session on incorporating variability in environmental conditions and productivity into stock assessments was proposed. However, in response to requests made by senior Science managers and the FRCC subsequent to the meeting, the proposed theme session may be replaced by a workshop on recruitment.

9. A list of recommendations is given in Appendix 5.

Table of Contents

1. Introduction

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans (DFO) met in Mont Joli, Québec, at the Maurice Lamontagne Institute on 17-19 March, 1999, to (1) review the environmental conditions in the Northwest Atlantic during 1998, (2) examine abundance, distribution and production at lower trophic levels in the marine ecosystems of the Northwest Atlantic, (3) review other papers on the environment or fisheries-environment linkages, (4) discuss the Atlantic Zonal Monitoring Program (AZMP) and its linkages to the FOC, and (5) conduct the annual FOC business meeting and review progress of the working groups of the FOC. This report provides a summary of the working papers presented at the meeting, the discussions during the meeting and the recommendations following from these discussions. The agenda, list of working papers, meeting participants, recommendations and working group reports appear in the Appendices.

2. FOC Core-Membership

While participation in the activities of the FOC are open to all, the Committee formally consists of a number of core-members whose responsibilities are to disseminate information in their respective laboratories and to provide a leadership role within the committee. During the 1999 meeting, one change in core-membership was announced: Jacques Gagné stepped down as a core-member from Laurentian Region and was replaced by Martin Castonguay. At the time of 1998 annual meeting, the FOC core-members were:

Name	Region	Location
John Anderson	Newfoundland Region	NAFC
Denis D'Amours	DFO Headquarters	Ottawa
Martin Castonguay	Laurentian Region	IML
Eugene Colbourne	Newfoundland Region	NAFC
Ken Drinkwater	Maritimes Region	BIO
Ken Frank	Maritimes Region	BIO
Denis Gilbert	Laurentian Region	IML
Glen Harrison	Maritimes Region	BIO
Savi Narayanan	MEDS, DFO Headquarters	Ottawa
Patrick Ouellet	Laurentian Region	IML
Fred Page	Maritimes Region	SABS
Dave Reddin	Newfoundland Region	NAFC
Doug Swain, Chairman	Maritimes Region	Moncton
John Tremblay	Maritimes Region	BIO

3. 1998 Environmental Overviews

As part of the FOC mandate, the Committee provides an annual review of environmental conditions in the Northwest Atlantic. A total of 9 papers were reviewed, six on the physical environment and three on the biological environment. Each environmental overview paper was assigned two reviewers to improve the quality of the manuscripts by providing detailed comments, ensuring

editorial correctness and including possible suggestions for next year's overview papers. Reviewers delivered their comments to the senior authors before the end of the meeting or made arrangements to provide them shortly thereafter. A physical environmental "scorecard" was developed and is included below (Table 1).

3.1 ***Meteorological and Sea Ice Conditions*** *(K. Drinkwater et al.)*

Annual mean air temperatures throughout the northwest Atlantic warmed relative to 1997 and were warmer than the long-term normal by between 0.4° to 1.5°C (Fig. 1). The maximum air temperature anomaly, and largest increase relative to 1997, was in the Gulf of St. Lawrence. Seasonally, air temperatures in most areas of the northwest Atlantic were above normal in at least 10 out of the 12 months of 1998.

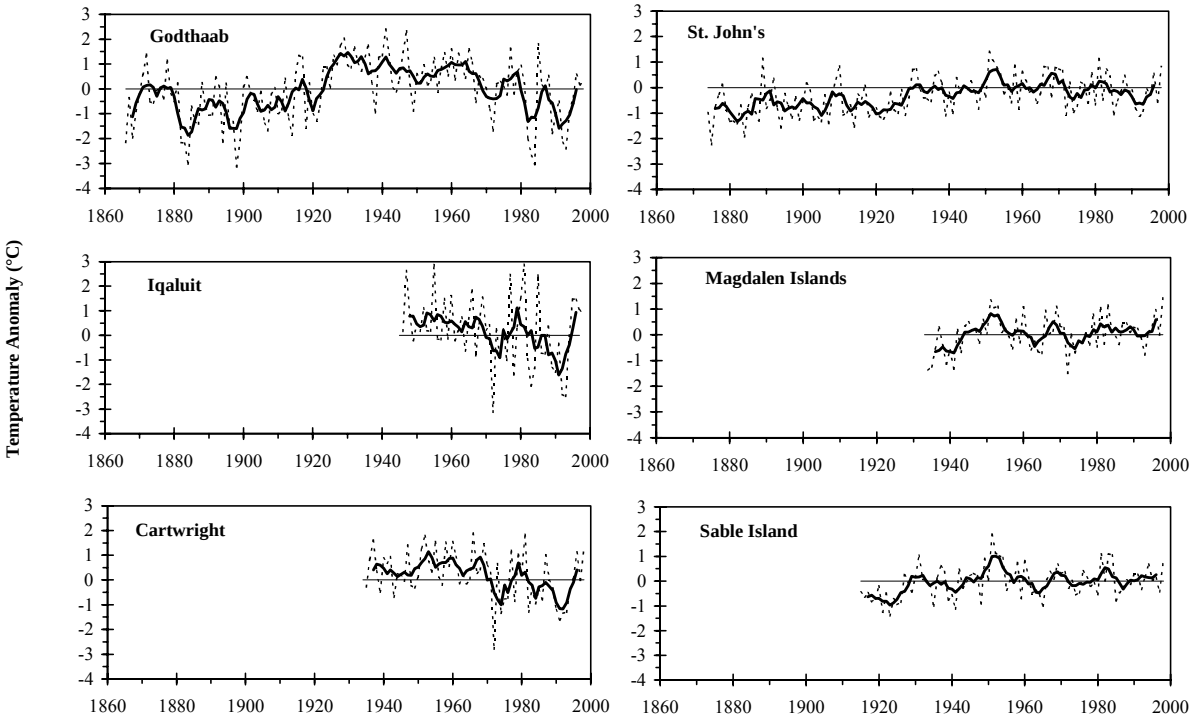

Fig. 1. Annual (dashed) and 5-yr running means (solid) of air temperature anomalies relative to 1961-1990 means at selected sites.

The North Atlantic Oscillation (NAO) index for 1998 was slightly above normal after two years of below normal values (Fig. 2). There was, however, only a slight increase in the index relative to 1997. This indicates that the large-scale atmospheric circulation, including the Icelandic Low, has been intensifying relative to events in 1996. The sea ice on the southern Labrador and Newfoundland shelves generally appeared late and left early, resulting in a shorter duration of ice than usual. The areal extent of ice in these regions during 1998 was less than in 1997 and lower than average (Fig. 3). The number of icebergs reaching the Grand Banks in 1998 was 1384 and increased over the numbers reported for 1997 by over 36%. This high number was unexpected

given the reduced sea-ice extent and warmer air temperatures. Still, it remained below the large number of icebergs reported in the early 1990s. In the Gulf of St. Lawrence, the sea-ice appeared late and disappeared early resulting in a lower than normal duration. Little to no ice reached the Scotian Shelf proper while the areal coverage of ice in the Sydney Bight area off eastern Cape Breton was much less than normal.

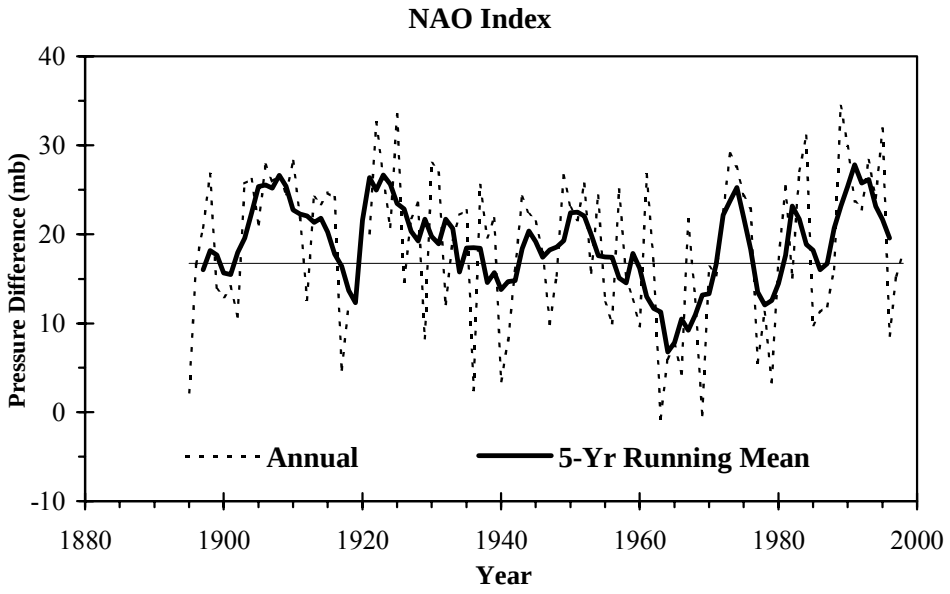

Fig. 2. Annual (dashed) and 5-yr running means (solid) of anomalies of the North Atlantic Oscillation (NAO) index.

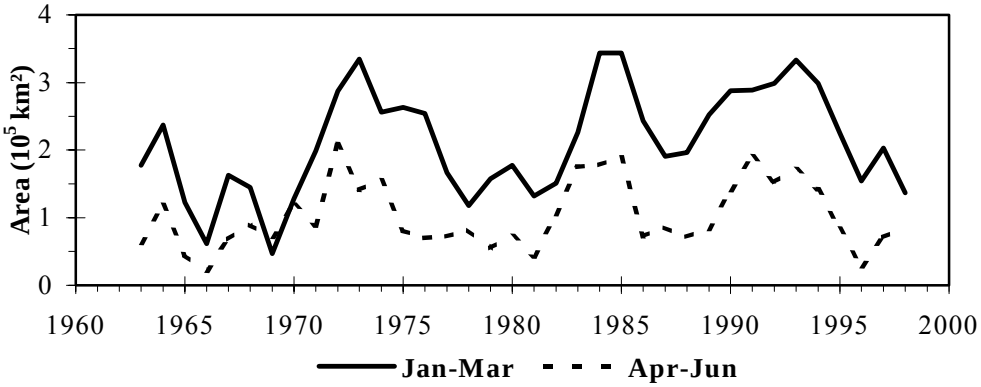

Fig. 3. Average ice area during January-March and April-June off Newfoundland and Labrador between 45°N and 55°N.

*3.2 **Physical Oceanographic Conditions***

3.2.1 Newfoundland/Southern Labrador (E. Colbourne)

The low temperatures and salinities established in the waters of the Northeast Newfoundland Shelf in the late 1980s and early 1990s moderated in the mid 1990s. Water temperatures were above

normal in 1996 and near normal in 1997. Conditions in 1998 were generally similar to the moderate conditions seen in 1997. Water temperatures were slightly above normal over many areas of Newfoundland and southern Labrador in 1998, particularly on the Grand Bank during spring and over the deeper portions of the Northeast Newfoundland Shelf. The main exceptions were colder-than-normal temperatures in the upper to mid water column during summer and early fall in nearshore coastal areas. At Station 27, the hydrographic monitoring site off St. John's, these colder-than-normal temperatures during summer and early fall combined with warmer-than-normal temperatures throughout the remainder of the year to produce an annual depth-averaged temperature in 1998 that was near normal (Fig. 4). Annual depth-averaged salinity was also near normal at Station 27, a combination of slightly fresher-than-normal values in the first half of the year and slightly saltier-than-normal values later in the year. The volume of the cold intermediate layer (CIL), defined as waters at temperatures below 0°C, over the Shelf from southern Labrador to the northern Grand Bank was below normal in 1998 (Fig. 5), reflecting the warming of these waters in recent years.

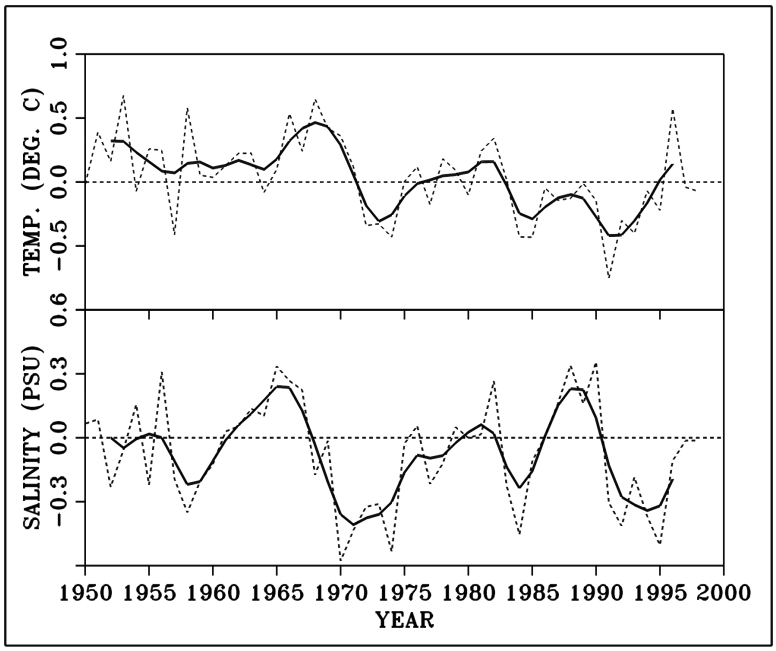

Fig. 4. Vertically-averaged annual temperature anomalies (0-176 m) and summer (Jul-Sep) salinity anomalies (0-50 m) at Station 27. Heavy lines are 3-yr running means.

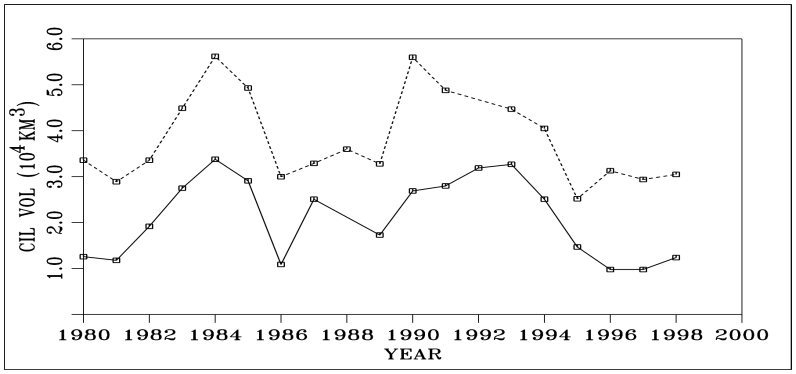

Fig. 5. Summer (dashed line) and fall (solid line) CIL volume over NAFO div. 2J3KL.

Bottom temperatures on the banks off southern Newfoundland were relatively cold in the mid to late 1980s and early 1990s (Fig. 6), resulting in large areas of subzero bottom waters (Fig. 7). Conditions moderated in the mid 1990s, with near average bottom temperatures and little subzero bottom water over the banks in 1996. Bottom waters cooled again in 1997 but returned to near average temperatures with little subzero bottom water in 1998.

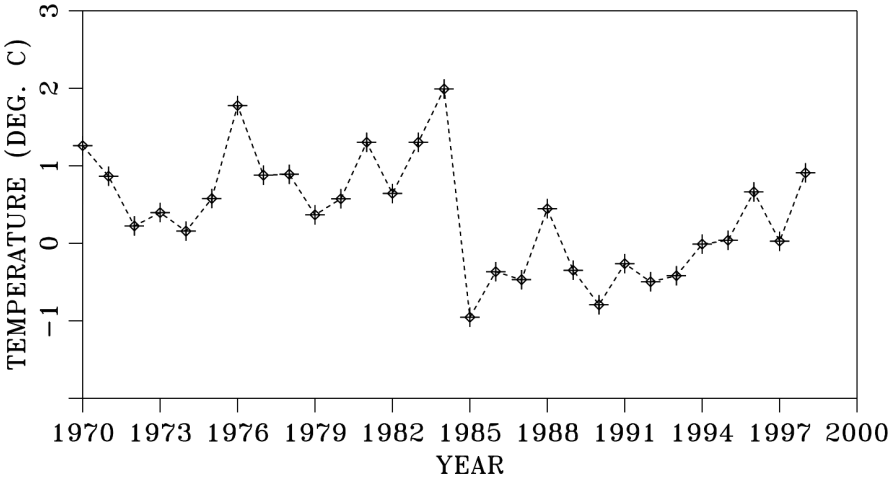

Fig. 6. Mean bottom temperature of Burgeo, St. Pierre and Green Banks.

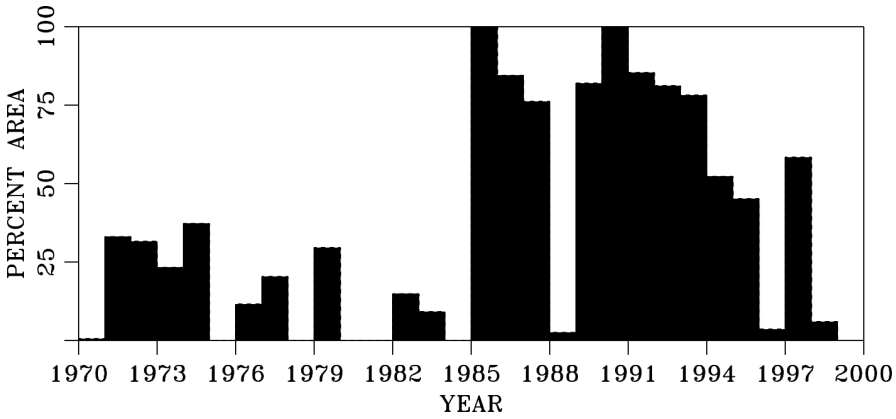

Fig. 7. Area of subzero bottom water on Burgeo, St. Pierre and Green Banks.

3.2.2 Gulf of St. Lawrence (D. Gilbert et al.)

Despite milder than normal winter conditions, CIL minimum temperatures cooled in 1998 by 0.3°C relative to 1997, resulting in the 15th consecutive year with colder-than-normal temperatures in the CIL waters of the Gulf of St. Lawrence (Fig. 8). Both CIL thickness and volume also increased in 1998 relative to 1997. However, there was a sharp contrast between eastern and western parts of the Gulf in this change in CIL thickness. CIL thickness increased by as much as 10 to 30 m in the Estuary, northwest Gulf and Laurentian Channel adjacent to the Magdalen Shallows, but decreased by similar amounts on the Newfoundland side of the Esquiman and Laurentian Channels. On the Magdalen Shallows, the area with bottom waters < 0°C and <1°C increased by 71% and 14%

respectively in 1998 compared to 1997 (Fig. 9). In deeper waters, temperatures changed little relative to 1997, and were near normal in 1998 in both the 100-200 m and the 200-300 m layers.

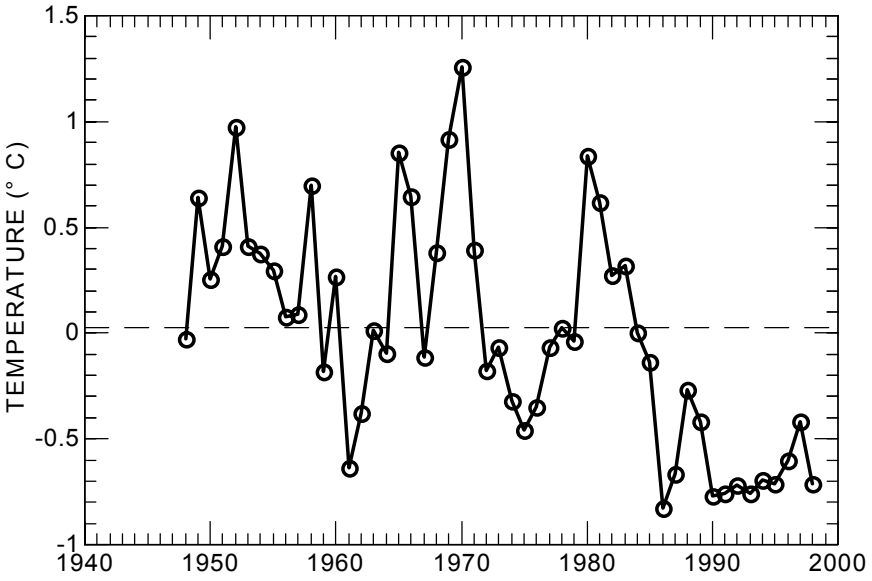

Fig. 8. Composite index of CIL core temperature anomaly (°C) in the Gulf of St. Lawrence (1961-1990 mean = 0.03°C).

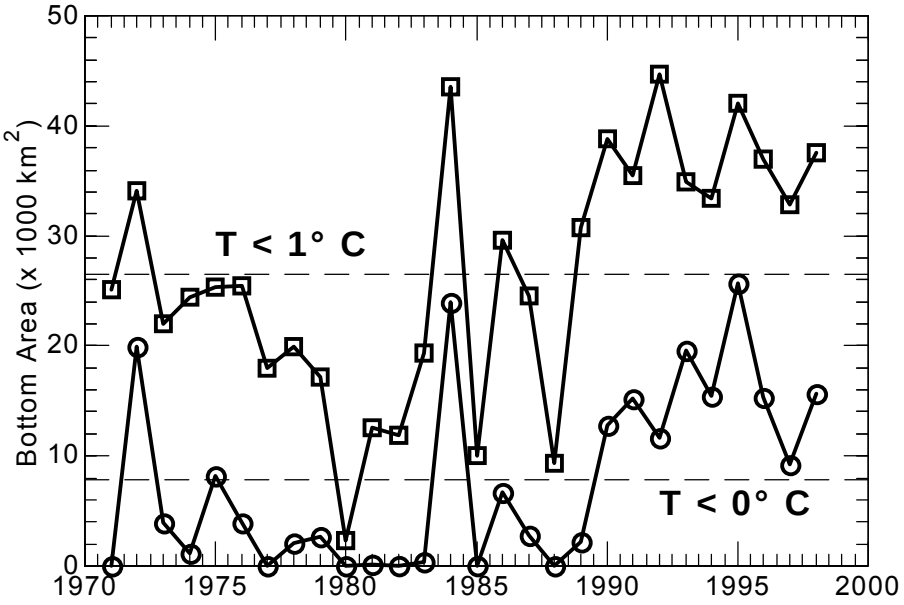

Fig. 9. Bottom area with T < 0°C (circles) and T < 1°C (squares) in September in the southern Gulf of St. Lawrence. The horizontal lines represent the 1971-1998 averages.

Dissolved oxygen saturation in the 200-300 m layer in 1998 was at the 1981-1998 average level of 56.4% at Cabot Strait and slightly (by 2% of the saturation level) below the average level (33.5%) at Honguedo Strait.

The RIVSUM index of freshwater runoff was well above normal in March and April due to an early snow melt but much below normal from October to December (Fig. 10).

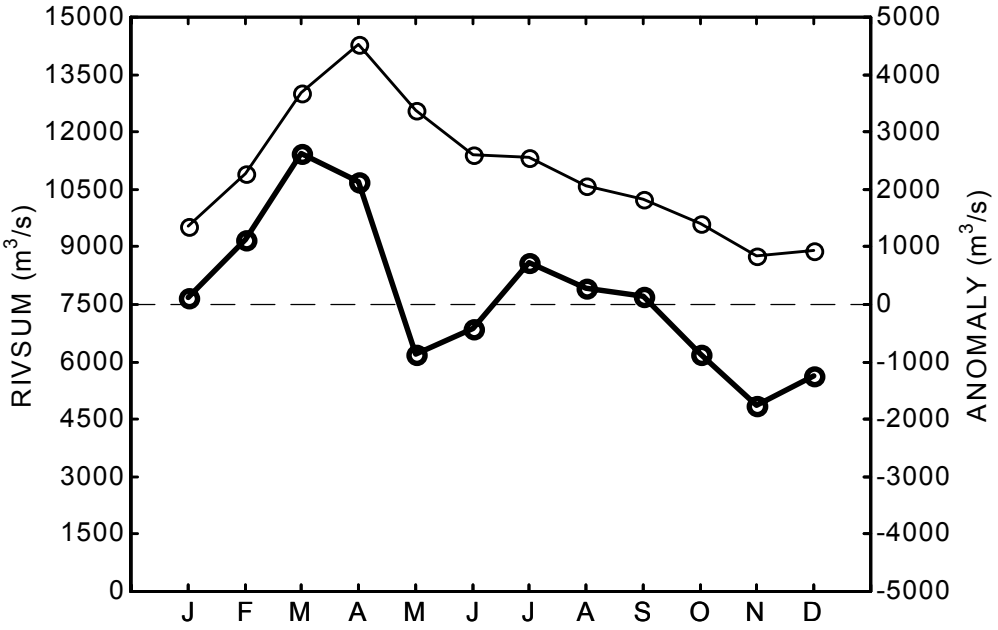

Fig. 10. Sum of the monthly averaged freshwater discharges of the St. Lawrence, Ottawa and Saguenay Rivers from January to December 1998 (RIVSUM index, thin line, left scale). The deviations with respect to the 1961-1990 mean (anomalies) are indicated by the thick line (right scale).

3.2.3 Scotian Shelf/Gulf of Maine (K. Drinkwater et al.)

While surface layers over most of the Scotian Shelf were generally warmer than normal, subsurface waters over the northeastern Shelf remained below normal. Below normal temperatures were established in this area in the mid-1980s with maximum cooling in the early 1990s Fig. 11). In recent years, including 1998, there has been a slow but steady increase in temperatures in this region. In contrast to the northeastern area, cold, low salinity waters flooded into Emerald Basin and most of the bottom layers of the southwestern Scotian Shelf and into the Gulf of Maine early in 1998 and have remained throughout the year (Fig. 12). Temperature and salinity in the deep regions of this area fell by about 2°-3°C and over 0.5 practical salinity units (psu) compared to 1997 values and are the lowest since the 1960s. This was due to the presence of the cold waters at the edge of the Scotian Shelf that were subsequently transported on shore through channels and gullies. The cold conditions off the slope were due to an increase in the southward transport of Labrador Current water. These cold slope waters were located on the outer edge along the entire length of the

Scotian Shelf by January of 1998 and extended along Georges Bank during February and March. These cold slope waters have also influenced the Gulf of Maine, including Georges Bank.

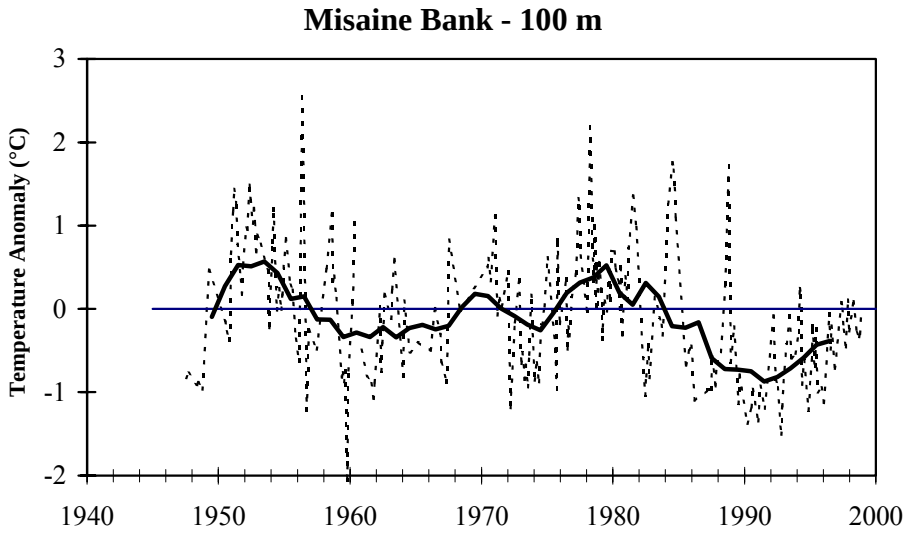

Fig. 11. Monthly mean temperature anomalies (dashed line) and 5-yr running mean of the estimated annual anomalies (solid line) at 100 m for Misaine Bank.

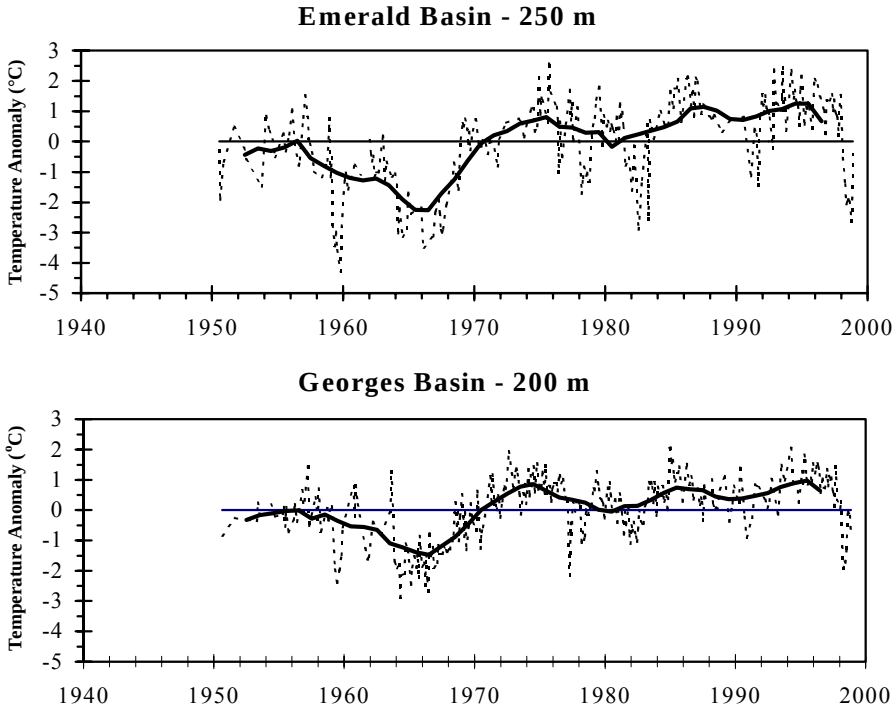

Fig. 12. Temperature anomalies (relative to the 1961-1990 mean) at 250 m in Emerald Basin and at 200 m in Georges Basin.

Near-bottom temperatures were below normal over most of the Scotian Shelf in July of 1998 (Fig. 13). The geographic distribution of temperature anomalies was the different from the pattern seen in recent years. In recent years, below normal bottom temperatures have been most prevalent on the northeastern Shelf. In 1998, below normal bottom temperatures were most prevalent on the southwestern Shelf, reflecting the inflow of cold slope waters in 1998.

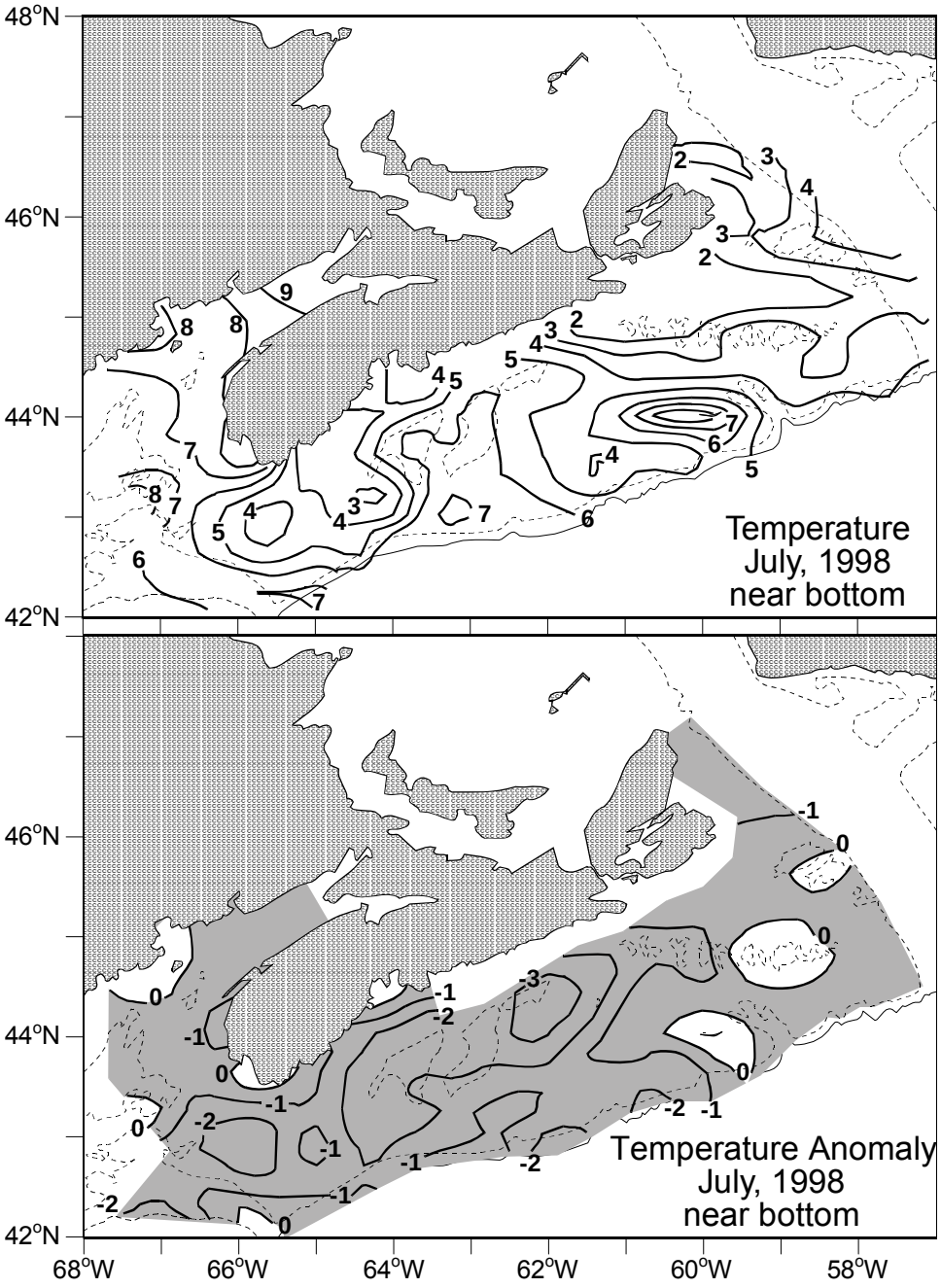

Fig. 13. Near-bottom temperature and temperature anomalies during the July groundfish survey. Negative anomalies are shaded.

Table 1. Environmental scorecard for 1998. Conditions for 1998 are shown as anomalies in standard deviations from the longterm average and are compared to 1997 and the previous 5 yr. Shading indicates conditions that were unusually cold/fresh or warm/salty. GSL = Gulf of St. Lawrence.

Index	Area	1998	Cold Fresh	Warm Salty	Relative To 1997	Relative to 1993-1997
NAO		0.11			Same	No trend
Annual	Labrador	1.19			Up	Up
Air	Newfoundland	1.32			Up	Up
Temperature	Gulf of St. Lawrence	2.49			Up	Up
	Scotian Shelf	1.62			Up	No trend
	Gulf of Maine	1.69			Up	No trend
Sea Ice	Nfld/Lab (Area)	-0.74			Down	Down
	GSL (Duration)				Down	Down
	Scotian Shelf (Area)	-1.40			Down	Down
Near-bottom	Nfld – Grand Bank	0.26			Up	Up
Temperature	Station 27	0.74			Same	Up
	St. Pierre Bank	0.71			Up	No trend
	Magdalen Sh. area T<0,1	0.97			Up	No trend
	Misaine Bank - 100 m	-0.27			Up	Up
	Emerald Basin - 250 m	-1.24			Down	Down
	Georges Basin – 200 m	-0.98			Down	Down
	Bay of Fundy P5 – 90 m	-0.14			Down	Down
CIL	Nfld Bonavista Bay (Area)	-0.15			Up	Down
	GSL (Volume)	-0.40				
	GSL (Min. Temp. 1985-98)	-1.39			Up	Down
Integrated	Station 27	-0.26			Same	Up
Temperature	Cabot Strait (200-300 m)	0.01			Same	No trend
	GSL 0-30 m					
	GSL 30-100 m	-1.79			Down	No trend
	GSL 100-200 m	-0.27			Same	Up
	GSL 200-300 m	0.14			Down	No trend
Surface	Station 27	0.35			Down	Up
Temperature	GSL				Up	
	Halifax	0.64			Up	Up
	Bay of Fundy – St. Andrews	0.93			Up	No trend
	Gulf of Maine – Boothbay	1.23			Up	No trend
Salinity	Station 27	-0.05			Same	Up
	Prince 5 (90 m)	-1.15			Down	Down

Stratification over most of the Scotian Shelf, as measured by the density differences between 0 m and 50 m, has increased significantly over almost the entire Scotian Shelf in recent years. Indeed, during the past few years, this index of stratification has been the highest in the almost 50 years on record. The cause of this increased stratification has not been examined in detail but it appears to be principally due to lower surface layer salinities. Increased stratification was not observed in the Gulf of Maine.

3.2.4 Physical Environment Scorecard

Following the practice instituted at the 1998 FOC meeting, a physical oceanographic "scorecard" was constructed to summarize changes in the many standard environmental indices (Table 1). Following suggestions made at the 1998 meeting, quantitative information was incorporated by indicating, where possible, the strength of the 1998 anomaly in terms of its standard deviation from the longterm average.

3.2.5 Questions and Discussion

The annual environmental overviews report on the areal extent of ice coverage. A question was raised regarding variation in ice thickness or volume in the Gulf of St. Lawrence. It was noted that estimates of variation in ice volume have been calculated based on percent composition by ice type and are presented in Can. Tech. Rep. Hydrogr. Ocean Sci. 199. Correlation analyses presented in this Report indicated that ice area is a good proxy for estimated ice volume during most of the ice season.

Analyses of variation in the areal extent of bottom water in different temperature bins were presented for areas off Newfoundland. The temperature ranges used for these analyses were discussed. Two temperature ranges were used: <0°C and 1-7°C. The first temperature range was based on a traditional definition of the CIL. The second was meant to reflect cod habitat preferences and was based on discussions with biologists working on cod. A fairly broad temperature range was used because of uncertainty in the preferred habitat of cod in the Newfoundland region, particularly on the Grand Bank. The committee felt that the area between 0 and 1°C should also be included for completeness.

A question was raised regarding the strength of the correlation between the CIL volume and area of ice coverage off Newfoundland. It was noted that years with high CIL volume did tend to have high ice coverage, and that the correlation between the two variables was about 0.7.

Clarification was sought on the methods used to calculate indices of bottom area within particular temperature ranges. Was information on bathymetry used in this calculation? It was reported that the calculation was based on contours of bottom temperature and that information on bathymetry was not used in the contouring.

It was reported that TS data collected in October of 1998 at the offshore monitoring station on the Halifax Line did not indicate the presence of cold, fresh Labrador Slope water. There was agreement that data from offshore stations did indicate some warming but that caution was required because these measurements may have been influenced by temporary eddies. Data collected in the spring of 1999 are needed to confirm whether a return to warmer slope water has occurred. Reports

of a decrease in the occurrence of sharks in Emerald Basin and a decrease in lobster catches on Georges Bank indicate that the cold conditions had an effect on at least the availability and catchability of some species.

The surprising cooling and expansion of the CIL in the Gulf despite the mild winter and warm spring was discussed. Suggested explanations included increased flow through the Strait of Belle Isle and changes in stratification. The development of stronger stratification earlier in the year could result from above-normal spring air temperatures and could limit the warming of CIL waters in the spring before stratification of the water column. TS data collected in August provide no signal of stronger-than-normal stratification. However, August data may not provide a good indication of events in the spring, and it was suggested that data from earlier in the year, perhaps the June mackerel egg and larvae survey data, should be examined for an indication of unusually early or strong stratification. It was agreed that inflow through the Strait of Belle Isle was likely to have an important effect on the CIL in the Gulf and that this should be monitored. This is possible from sea level data currently collected and is under investigation.

The recent increase in stratification on the Scotian Shelf was discussed. It was noted that there was no signal of stronger stratification during the cold period in the 1960s. Likewise, stratification is not stronger in the Sydney Bight, where temperatures at intermediate depths are the coldest on the Shelf. It was noted that temperature and salinity in surface waters are not generally coherent, and that the increased stratification appears to be primarily due to lower surface salinities.

3.3 ***Biological Oceanographic Conditions***

3.3.1 Newfoundland/Southern Labrador (E. Dalley and J. Anderson)

Plankton and nekton abundance and distribution were described for late summer 1998 based on a pelagic fish survey covering an area from southern Labrador to the southern Grand Bank. Results for 1998 were compared to results for 1994 to 1997. Geographic variation was greater than annual variation in all but three of 23 biological measures examined (catch rates of zooplankton<1mm, haddock & turbot), and was generally associated with latitudinal or inshore/offshore clines. Area differences were significant for all variables but haddock catch rates and annual differences were significant for all except catch rates of redfish, American plaice, alligatorfish and yellowtail flounder. Mean surface temperature in 1998 was significantly higher than 1997 and 1995 but lower than 1994 and 1996. There was a large body of relatively warm water on the Grand Bank in 1998. Ranking of mean temperature at 50m was opposite that of surface temperature, i.e. 1994 coldest, 1995 warmest. Zooplankton biomass was significantly higher on the Northeast shelf than on the Grand Bank. Total zooplankton biomass ranked second in 1998, behind the high 1997 level. Mean biomass of the large size fraction ranked lowest, the midsize fraction ranked third, and small size fraction ranked second, behind 1997. In 1998, capelin larvae were more widely distributed than in any other year, extending as far north as sampling occurred on the Labrador coast and also on the Southeast Shoal of the Grand Bank. Total nekton biomass (with jellyfish) was highest of the 5 years in 1998. There was a shift in distribution of largest catches to include the Grand Bank. Biomass was dominated by capelin and sand lance. Squid and arctic cod were less dominant than in previous years. In 1998 the mean catch rate of pelagic 0-group Atlantic cod was the highest since 1994, as a result of higher abundance on the southern Grand Bank, and not the NE Newfoundland Shelf. Species and

groups that occur predominantly on the Northeast Shelf including Arctic cod, blennies, sculpins, squid, alligatorfish, wolffish, and seasnails were all in relatively low abundance in 1998. Abundance of fish that occur on the Grand Bank, e.g. American plaice, Atlantic cod, redfish, hake, haddock, and in particular, sand lance all increased compared to 1997.

3.3.2 Gulf of St. Lawrence (M. Harvey et al.)

A zooplankton survey has been conducted in the lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence in September each year since 1994. The estimated average wet biomass of both mesozooplankton and krill were greatest in 1994 and lowest in 1996 (Fig. 14). For both components of the zooplankton, mean biomass in 1998 was comparable to the levels observed in 1995, 1996 and 1997 but much lower than the 1994 level. Comparison of daytime versus nighttime sampling indicated that the biomass of krill was underestimated by a factor of 2 at stations with high total biomass of zooplankton. The percentage of *Calanus* in the mesozooplankton and total zooplankton biomass was higher in 1997 and 1998 than in other years.

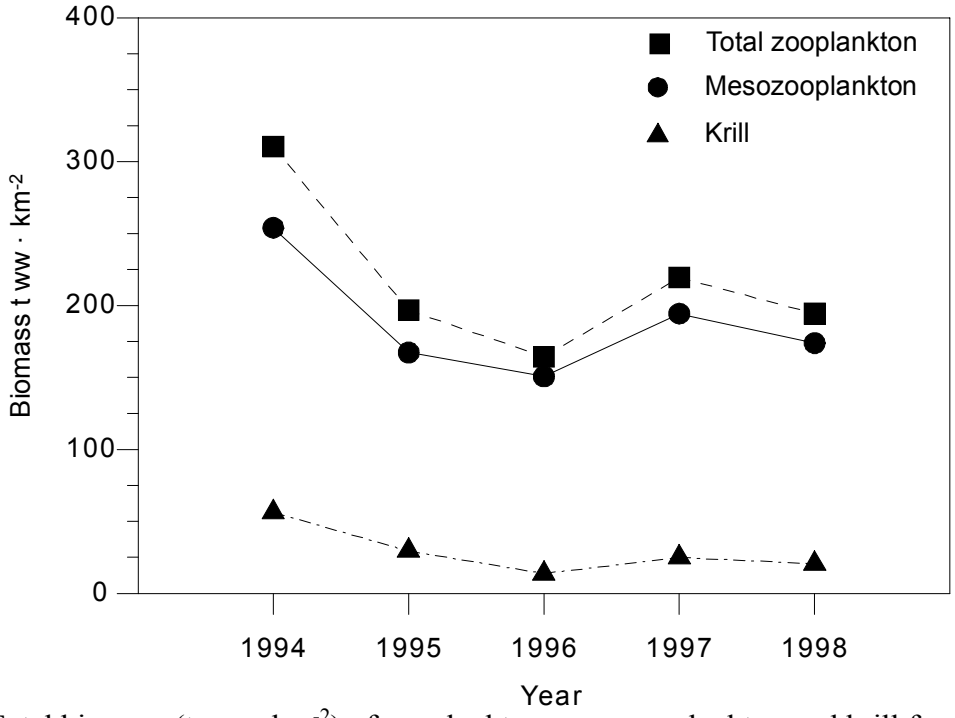

Fig. 14. Total biomass (t ww · km^{-2}) of zooplankton, mesozooplankton and krill for the whole lower St. Lawrence Estuary and northwest GSL from 1994 – 1998.

Spatial variability in zooplankton abundance, biomass and species composition in the Gulf of St. Lawrence was examined for November 1998 using data collected during the Ice Forecast Cruise. Maximum abundance occurred along the north shore of the Gulf of St. Lawrence. On the other hand, maximum biomass occurred over the Laurentian and Esquiman Channels, where *Calanus hyperboreus* and *C. finmarchicus / glacialis* were abundant (Fig. 15). Copepods were clearly dominant at all stations, both within the Gulf and outside of Cabot Strait. The copepod

community structure varied among areas in the Gulf in 1998 but was similar to previously-reported regional differences in species composition.

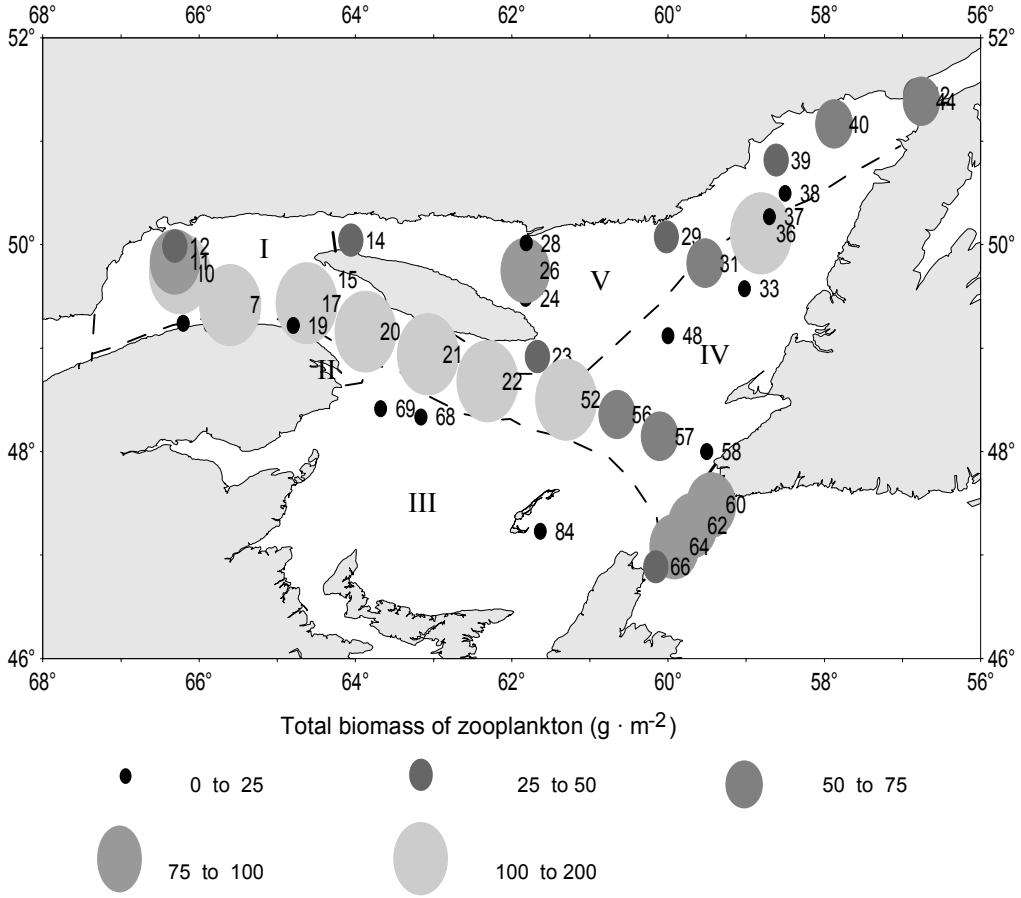

Fig. 15. Integrated biomass of zooplankton ($g \cdot m^{-2}$) at each of the 33 stations sampled during the November 1998 ice forecast cruise in the Gulf of St. Lawrence.

Seasonal variability in zooplankton abundance and biomass in 1998 was examined at two Zonal Monitoring stations, one in the Anticosti Gyre and one in the Gaspé Current. Zooplankton biomass in the Anticosti Gyre was relatively invariant (190-225 g m^{-2}) across seasons and was much higher than in the Gaspé Current on the 5 sampling dates in 1998. *Oithona* spp. (*similis*) was the dominant copepod species in abundance in the Gaspé Current and an important member of the zooplankton community in the Anticosti Gyre.

3.3.3. <u>Scotian Shelf</u> (D. Sameoto et al., presented by G. Harrison)

Zoopankton distribution and biomass estimates on the Scotian Shelf in April and October of 1998 were described and compared to estimates in previous years. Biomass and numbers of *C. finmarchicus* were lower on the Halifax line in 1998 than in 1997. The concentation of *C. finmarchicus* in Emerald Basin in the fall of 1998 was the lowest recorded in the 14 year data series. On the Louisbourg line, total zooplankton biomass was similar to the long-term means for the stations. There appears to be a general decline in the abundance of macrozooplankton,

which are primarily krill, on the Halifax line. The levels on the Halifax line are approaching the low levels seen on the Louisboug line.

3.3.4 Questions and Discussion

Methods used for the plankton and nekton survey of the northeast Newfoundland Shelf and Grand Bank were discussed. Three suggestions were made: (1) conversion to a 200 μm mesh instead of a 232 μm mesh would conform to the standard methods used by the Zonal Monitoring Program, (2) expressing abundance and biomass estimates as units/m^2 would ease interpretation and facilitate interregional comparisons, and (3) sampling beyond 100 m to a depth of 300 m would be desirable. The issue of day/night differences in catch rates was raised. It was noted that these differences were large for many species. The question of species composition of the zooplankton samples was raised. It was reported that the samples had been archived but that there were insufficient resources to undertake species identification.

A link between the 1996 zooplankton minimum in the Estuary and the 1996 Saguenay flood was suggested. It was acknowledged that flushing could have exported zooplankton out of the Estuary, leading to a low September 1996 biomass. Further discussion was differed to a general discussion of the Zonal Monitoring Program and the environmental overviews (see below).

*3.4 **Environmental Summaries***

As in past years, a brief environmental summary was written following the meeting and sent together with the working papers to the Regional Assessment Process co-ordinators for each of the regions. A copy of that summary is provided in Appendix 4. A second summary of the physical environment was assembled and presented in June to the North Atlantic Fisheries Organization (NAFO) Standing Committee on Fisheries and the Environment (STACFIN) as a research document (*Overview of environmental conditions in the Northwest Atlantic in 1998,* co-authored by Drinkwater, Colbourne and Gilbert, NAFO Res. Doc. 99/36).

4. Monitoring and Climate Change Programs

*4.1 **Zonal Monitoring Program***

J.-C. Therriault made a presentation to update the FOC on the present status of the Zonal Monitoring Program (ZMP). The ZMP has been given the general responsibility for the coordination and integration of DFO's ocean science monitoring activities. They have designed a field monitoring program over and above DFO's present activities with greater emphasis on phytoplankton and zooplankton variability than in the past. This includes the establishment of 4 new monitoring sites (3 in the Gulf and one on the Scotian Shelf) for a total of 8 fixed stations where hydrographic, chemical and biological measurements will be taken at intervals of weekly to seasonally. The longterm sites, Station 27 and Prince 5, will have an expanded measurement program that will include the collection of chemical and biological data, along with CTD profiles, on at least a monthly basis. Regular sampling along a number of standard transects within the zone will be carried out. The ZMP has set up a number of committees to oversee the program. These include the Permanent Management and Coordination Committee (PMCC)

which will coordinate and integrate the zonal monitoring activities, a Logistics Subcommittee which will execute and maintain the field activities and standardize sampling procedures, the Data Management Subcommittee which will deal with data management issues including displaying the results on the web and the Data Analysis Subcommittee which will carry out the analysis of the data and produce the annual reports on the state of the ocean. Three new positions per region have been created to carry out this expanded program and have been, or are in the process of being hired. The problem of whether there will be continued funding for the expanded monitoring within ZMP is still not resolved, however.

4.2 ***Climate Change Initiatives***

S. Narayanan reported on the progress in the development of a Canadian Climate Observing System. The Climate Change Action Fund (CCAF) was established following the Kyoto Conference and has been funded for three years at $150 million. Its mandate is very broad and includes, among other issues, science (i.e. targeting research to better understand climate processes) and assessing impacts of climate change on Canada. The work carried out under these issues will focus on developing a systematic climate monitoring program to detect climate change, as well as to improve and validate climate models, study key climate processes, develop regional-scale climate models, investigate possible impacts of climate change and examine adaptation responses. Nine main programs were funded under the Science Component and three under Impacts and Adaptation during 1998/99, the first year of CCAF. One of the Science programs was the preparation of a Canadian Global Climate Observing System (GCOS) Plan that is expected to be completed by the summer of 1999. A meeting to discuss GCOS was held in Ottawa in January. The possible Canadian components of the international coastal (non-climate) observing system, the Health of the Ocean (HOTO) and Living Marine Resources (LMR) modules of the Global Ocean Observing Systems (GOOS) were discussed. Reports are being drafted and should be published later this year. The ocean's field programs consist of two parts: one that will address Canada's contribution to GCOS in response to international requirements and a second one that addresses additional Canadian requirements. Proposed contributions to the international GCOS program includes maintenance of a number of specified tide gauges (for information on circulation and ocean volume changes), continuation of OWS Papa in the Pacific and Bravo in the Labrador Sea in the Atlantic, a contribution to the global PALACE floats for observing upper ocean temperature and salinity, and one standard transocean section in each of the Atlantic and Pacific Oceans to be taken once every 8 years. The Canadian enhancements for the Atlantic zone include the proposed fixed stations and transects under the ZMP, additional tide gauge stations, and a mooring array at Hamilton Bank to monitor the Labrador Current. It was also mentioned that there is presently a call for proposals under the title Climate Model Improvements that has a budget of $500K. The targeted areas under this proposal, on the oceans side, is on eddies, deep convection, overflow and/or bottom boundary layer schemes for high and coarse resolution ocean models.

4.3 ***General Discussion***

Initial discussion following these presentations was centered upon how the proposed ZMP annual report will fit in with the activities now undertaken within the FOC. The ZMP had not produced a report for 1998 but the Data Analysis Subcommittee was to convene shortly to determine what products should be presented in their annual reports. The FOC expressed the

view that the annual overviews presently undertaken and presented to the FOC should be part of the ZMP report. It was also felt that the ZMP could be given the responsibility for presenting the annual overviews to the FOC. This would have several advantages. First, if any of the individuals presently undertaking the FOC overviews were to leave or not continue this work, there would be a formal structure responsible for maintaining these activities. Second, the overviews represent legitimate monitoring activities and their inclusion in the ZMP will allow better accounting of the total number of personnel and resources required to adequately monitor the ocean environment. Third, presentation to the FOC will result in an annual scientific review of a major component of the ZMP. The personnel and presentations would not change significantly but the work would be done under the ZMP. J.-C. Therriault agreed that the present activities undertaken within the FOC to provide environmental overviews would fit within the ZMP. Although expressing some concerns regarding resources, he felt that if the present personnel responsible for providing the FOC overviews would continue to do so, then it makes sense for them to be absorbed within the ZMP. Those scientists involved in the overviews and that were present at the meeting agreed that they intended to continue these activities. The ZMP also had plans to expand the number of variables and indices in the overviews, especially those related to plankton. The format of the overviews was also discussed. The suggestion was made that a format similar to that used in the past, including continued submission of the regional overviews as Research Documents, be adopted for presentation at the FOC. These could then be combined into an overall ZMP annual state-of-the-ocean report. Details would need to be worked out by the ZMP data analysis subcommittee. A close working relationship between the FOC and the ZMP was noted. For example, Denis Gilbert, Eugene Colbourne and Glen Harrison are active members of both groups. Also, many of the biological indices presented at the FOC are based on data currently or soon to be collected within the ZMP. Finally, the FOC Environmental Indices Working Group has a mandate similar to that of ZMP in terms of documenting and standardizing physical indices and includes Brian Petrie of the Maritimes Region who has been heavily involved in the development of the ZMP.

The FOC therefore recommends *that the present monitoring-related activities undertaken within the FOC be incorporated within the ZMP and the ZMP take the responsibility for providing the FOC with the annual environmental overviews (both physical and biological) beginning with the 2000 meeting.*

There was also discussion on what new indices or variables should be included in the overviews. It was suggested that the tide gauge data that are highlighted in GOOS should perhaps be included. Other suggestions included data from Ocean Weather Station Bravo (since renewed monitoring has recently been undertaken there) and data from sentinel fisheries. In addition, it was felt that a integrated report of the biology from the three regions was needed in much the same way that the physical environment is combined in the annual report to NAFO. This will require standardization of the biological products produced from the monitoring activities. While recognizing the difficulties in this, the FOC felt that it was needed in order to make comparisons between the regions. It was also noted by the committee that zooplankton collected during the juvenile fish surveys from southern Labrador to the Grand Banks were being preserved but are not identified or processed due to a lack of resources. These are a potential source of important information given that they span a period from cold to warm conditions. As a result of these discussion a number of recommendations were made.

The FOC recommends *further development of biological indices and standardization of such indices between regions. In addition, a zonal biological overview analogous to the present physical oceanographic overview, should be produced for the next FOC meeting.*

The FOC recommends *that data from Ocean Station Bravo be included as part of annual environmental overviews, including an index of deep convection.*

The FOC recommends *that hydrographic data collected during sentinel surveys and additional fisheries surveys (such as the June mackerel survey in the Gulf) be included in the overviews.*

The FOC recommends *that potential changes in the zooplankton community in the 1990s on the Newfoundland Shelf be examined from existing archived samples collected during the juvenile fish survey.* New funding would be required to carry out such work.

F. Saucier of IML generated discussion on the role of models and modelers within both the FOC and ZMP. He noted that there are no modelers as members of either group. He felt that closer links between the field studies and the model requirements was needed, and suggested increased consultation with modelers about their needs for calibrating and evaluating models. This may influence the location or sampling frequency of the data collection. In addition, he noted that many data sets of use to the environmental reviews are being obtained on a regular basis for operational purposes by the modelers (e.g. winds, runoff, etc.). Finally he felt that model results should be incorporated into the overviews. The FOC acknowledged its lack of modeling expertise as well as its desire to forge closer links to the modelers. The regional state-of-the-art models are beginning to include most of the important physical processes and probably could be used to produce certain products such as flows through straits or transects based upon the wind fields. These could be hindcast but included in the overviews. Several of the models have focused upon shorter time scales (days) than are of usual interest to fisheries oceanographers but others have, or could be, extended out to seasonal and interannual time scales.

The FOC recommends *that there be increased effort made towards incorporating model currents or other indices into the environmental overviews.*

D. Gilbert noted that the environmental summaries are presently published as Stock Status Reports (SSRs). He felt that since they are not "stocks", the reviews should be presented in a different series. Members noted that there are Habitat Status Reports (HSRs) and that perhaps these might be a better format for the environmental summaries. K. Drinkwater agreed to ask the RAP coordinators and Jake Rice of the Canadian Stock Assessment Secretariat whether it is more appropriate or if it is even possible to publish the environmental summaries as HSRs rather than SSRs.

There was discussion on the kinds of climate proposals that would be interest to the FOC under the CCAF program. There is no money under this program to establish new monitoring stations, but there would be funds for other issues of interest to monitoring. For example, under remote sensing a possible proposal could be to compare satellite data collected by SEAWIFFS and in situ data, thus calibrating the colour data on a region by region basis. Also, the connection between tide gauge data and satellite altimetry information has been proposed. The latter can be used to obtain tidal constituents in shelf seas. No specific proposals were suggested by FOC at the meeting. The FOC was also informed that the Minister is presently asking for additional

money to be given to DFO for climate research. If successful, it is not clear whether this money will go towards implementation of GOOS or to other sources.

5. 1999 Theme Session: Abundance, distribution and production at lower trophic levels in the marine ecosystems of the Northwest Atlantic: effects of environment, predation and fishing down the food web.

5.1 Introduction

In contrast to many Northwest Atlantic groundfish stocks which have declined sharply with few signs of recovery, many species at lower trophic levels in the same ecosystems are currently at relatively high levels of abundance. The relationship, if any, between the current low abundance of groundfishes and high abundance of many of the species at lower trophic levels is poorly understood. High abundance at the lower trophic levels could reflect favourable environmental conditions, or reduced predation by depleted groundfish stocks. However, with the decline in traditional groundfish fisheries, many of the species at lower trophic levels are now facing increasing exploitation pressure (e.g., euphausids, shrimp, capelin, rock crab, toad crab, razor clam, Stimpson's surf clam, sea urchin, sea cucumber, kelp, etc.). This trend toward fishing down food webs can have important consequences for marine ecosystems (e.g., Pauly et al. 1998, Science 279: 860-863).

In view of the growing demand for exploitation of forage species and the concern for the consequences of fishing down food webs, the FOC convened a theme session dedicated to presentations on the ecology of resources at the lower trophic levels. Contributions on the consequences of increasing exploitation at lower trophic levels were of particular interest. However, presentations on other aspects of variation in the abundance, distribution and production of species at lower trophic levels, including currently unexploited species, were also encouraged. Papers were requested on the following and related topics:

(1) How have fishing effort and landings varied in recent years for species at the lower trophic levels, and how do the current levels of exploitation compare to those in earlier time periods? What are the expected or projected future levels of fishing effort?

(2) How have abundance, distribution, recruitment and growth varied over time for species at lower trophic levels? Are changes in these population parameters linked to changes in exploitation, or in environmental conditions, or in losses to predation?

(3) What are the risks or possible ecological impacts of exploiting species at lower trophic levels: could this have any effects on the potential recovery of top predator species (e.g., cod)?

(4) What are the current DFO initiatives to monitor and assess the impact and implications of the new or expanding fisheries at the lower trophic levels?

(5) Are the oceanographic and environmental data available through independent programs (e.g., Zonal monitoring program?) adequate? What are the needs?

Response to the theme session was poor, with only 3 presentations given. This poor response may be partly attributable to insufficient notice of the theme session. Announcement of the theme was delayed for a number of reasons. A decision on the theme was delayed by the vacancy in the position of FOC Chair for several months. A theme session comparing the cod collapses and recoveries of the 1970s and 1990s was decided upon but was discouraged by CSAS and the RAP coordinators due to the close timing of the FOC and zonal cod assessment meetings. This led to a change at a late date to the present theme, though the 1999 meeting was delayed by 3 weeks to permit more time to prepare for the session.

5.2 ***Presentations***

G. Harrison led off with a presentation prepared by D. Sameoto on decadal changes in phytoplankton and zooplankton based on Continuous Plankton Recorder (CPR) data for the Iceland and Scotian Shelf CPR lines in the years 1961-1969 and 1991-1997. These data showed that the phytoplankton indices, the color index, the numbers of diatoms and numbers of dinoflagellates increased significantly above the long-term mean during the years 1991 to 1997. These increases were seen along the entire CPR transect on the Scotian Shelf and on the western half of the Atlantic transect. In contrast to the phytoplankton indices, the numbers of the copepod *C. finmarchicus* decreased significantly during the 1991 to 1997 period and were at historically low levels on the two transects. The data suggested that the phytoplankton bloom on both transects occurred earlier in the year during 1991 to 1997 than it did during the years 1961 to 1969. The peak concentration of *C. finmarchicus* stages 1 to 4 on the Scotian Shelf occurred about a month later in the year during 1991 to 1997 than it did during the years 1961 to 1969.

J. Anderson described recent trends in the dominant pelagic fishes in the shelf waters off Newfoundland and Labrador. The pelagic ecosystems in these waters were classified into three regimes: a northerly Arctic regime in which the dominant fish species was Arctic cod, a southerly Temperate regime dominated by sandlance, and an intermediate Boreal regime dominated by capelin. The ocean environment in this area has been warming since 1991. Surface layer waters have been near normal or above since 1994. On the Grand Bank, there was a large increase in warm water habitat on the bottom in the spring of 1998. During this warming period, the abundance of Arctic cod declined, and their range contracted to the north. In contrast, capelin abundance increased and range expanded. These changes are consistent with those expected in a warming ocean environment. In 1998, the abundance index for sandlance increased by an order of magnitude (Fig. 16). This large increase occurred over all lengths and thus was not a simple increase in the production of 0-group sandlance. Order-of-magnitude increases in the production of young (0-group) fishes occurred on the southern Grand Bank in 1998 for several species, including capelin, Atlantic cod, American plaice and haddock (Fig. 16). It was suggested that this apparent large increase in fish production resulted from the migration of adults onto the southern Grand Bank during the spring of 1998 in response to warm bottom temperatures.

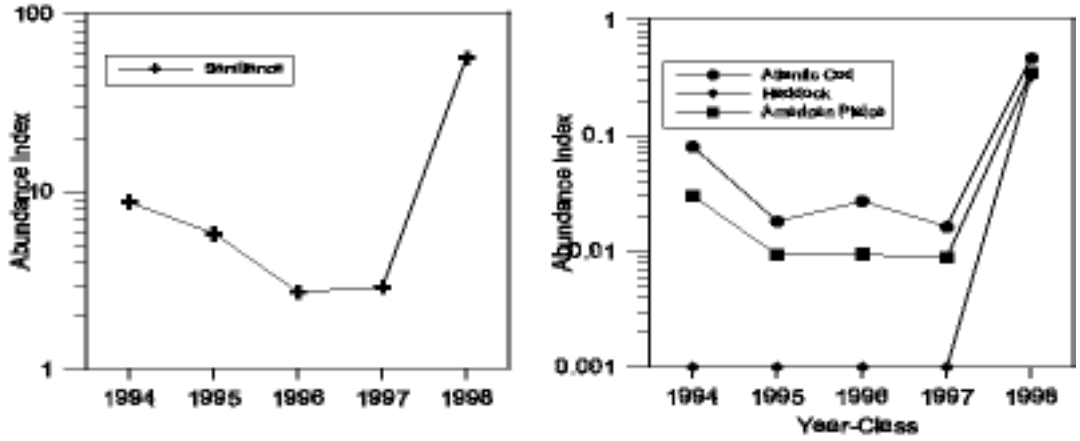

Fig. 16. Relative abundance of a) sandlance (*Ammodytes* sp.) and b) Atlantic cod, haddock and American plaice (0-group) on the Grand Bank, 1994-1998.

A world-wide decline in average trophic level of fisheries landings has been observed in the last 30 years. Elimination of large, long-lived, predatory species from ecosystems has forced many commercial fishing fleets to adapt and turn their attention to short-lived, small-sized, pelagic fishes and invertebrates. D. Swain described trends in the mean trophic level of landings for the southern Gulf of St. Lawrence ecosystem. The observed changes in mean trophic level with time reflected the domination of catches by Atlantic herring and Atlantic cod. When only fishes were examined, the mean trophic index dropped 0.6 units as a result of the elimination of large cod followed by the 1993 moratorium on cod fishing and an increase in landings of herring following the stock crash of the early 1970s. When landings of all species were considered, the overall change was 0.4 units. The smaller change was primarily due to the effect of snow crab and American lobster, which have surprisingly high trophic levels and act as a buffer between the effects of changes in cod and herring landings. Nevertheless, the patterns in landings in the fishery in the southern Gulf of St. Lawrence was not different from that observed worldwide – the abundance of the largest predatory species has been greatly reduced and the fishery is now dominated by pelagic fishes and invertebrates.

5.3 ***Discussion***

It was noted that it is uncertain whether funding would be available for the annual plankton and nekton survey of Newfoundland shelf waters in 1999. The FOC again acknowledged the importance of these surveys and noted that continuation of this survey in 1999 was particularly important given the striking results observed in the 1998 survey, e.g., the dramatic increases in the abundance of sandlance and 0-group cod, plaice and haddock on the Grand Banks.

The FOC recommends *that the annual pelagic 0-group survey conducted by Newfoundland Region should be continued in 1999.*

6. General Environmental Sessions

Each year the FOC receives several papers unrelated to the major theme session. This year the committee reviewed 7 presentations in this category.

6.1 ***Physical and Biological Oceanography***

G. Harrison described seasonal and regional variability in phytoplankton biomass in the NW Atlantic. Bi-weekly composite images of sea surface ocean colour in the northwest Atlantic Ocean have been processed using data acquired from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) launched in September, 1997. To date, a complete year of imagery has been archived and preliminary analysis of these data is underway. For this summary, fourteen sub-regions were selected in order to characterize regional variability in the annual phytoplankton biomass (chlorophyll) cycle. Bi-weekly composites, comprised of ~60 individual scenes on average, provided sufficient temporal resolution to differentiate periods of rapid growth, i.e. "blooms". Common among most regions was evidence for both spring and fall blooms, as is generally observed in north temperate waters. However, a third late winter "bloom" was observed for many regions. Regional differences were most apparent in the residual amount of phytoplankton biomass, i.e. between bloom periods; highest levels were observed on Georges Bank, the Magdalen Shallows, NW Gulf of St. Lawrence and the Estuary. A comparison of these data with data collected in the late 70s and early 80s from the Coastal Zone Scanner Sensor (CZCS), suggests that phytoplankton biomass may be somewhat higher now than 20 years ago.

Discussion focussed on the need for groundtruthing of the satellite data. Winter poses a particular problem for groundtruthing because data are typically sparse during that season. The possibility that the apparent winter blooms may instead be artifacts was raised and underscored the need for further groundtruthing.

K. Drinkwater presented a report prepared by B. Petrie et al. on (1) the development of a sea surface temperature index for the Canadian east coast, and (2) nutrient and dissolved oxygen variability on the Scotian Shelf. A single ocean climate index based on empirical orthogonal function (EOF) analysis was calculated from a 17 year time series of satellite-derived, sea surface temperatures for the Canadian east coast from Hamilton Bank to Georges Bank. This index accounted for 59% of the annual and 49% of the seasonal temperature variability. The index is in phase throughout the region, i.e., shows widespread warming or cooling episodes. Comparison with in situ data indicated that the index captures the broad-scale variations of the regional ocean climate, particularly for the Newfoundland Shelf. The annual cycle of nitrate variability for the central Scotian Shelf shows a typical cycle: high nitrate levels at shallow depths during winter, followed by a rapid depletion in spring, low levels throughout the summer and a gradual increase in the late fall. Estimates of the primary production, derived by converting nitrate to carbon, compare favourably with in situ measurements but are substantially smaller than satellite calculations. The nitrate and dissolved oxygen pool on the Scotian Shelf has varied substantially over the past 30 years. Recently, the invasion of the Scotian Shelf by Labrador Slope Water has lead to decreasing nitrate and increasing dissolved oxygen levels, much like what transpired during the mid-60s when a similar event occurred.

J. Anderson presented a description (prepared by Pepin and Benoît) of the climatology of nutrients, phytoplankton and zooplankton for the Newfoundland Shelf and Labrador Current. Seasonal and interannual fluctuations in biological oceanographic variables showed considerable coherence. Chlorophyll and nutrient concentrations showed large-scale spatial correlations. Although strong signals occurred at the surface, the greatest variability was often found in subsurface layers. It was concluded that the large decorrelation scales for this region indicate that the combination of fixed station and cross-shelf transects should be adequate to provide a clear picture of the general patterns of variability in environmental conditions. However, better understanding of the degree of temporal variability is required before the question of the need for enhanced seasonal coverage can be addressed.

6.2 ***Cod Recruitment***

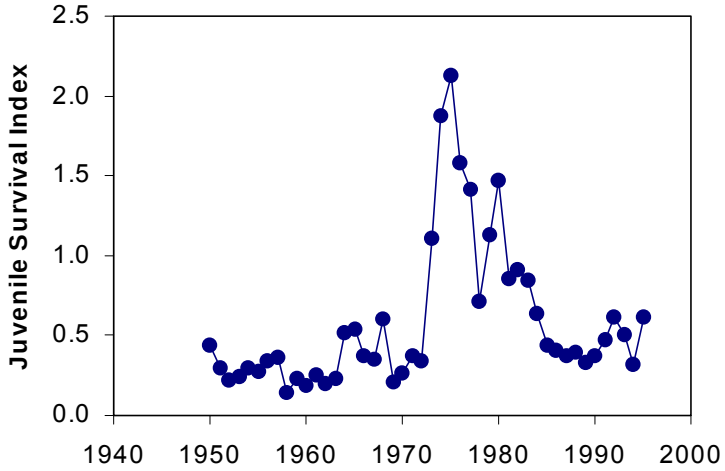

Fig. 17. Index of pre-recruit survival (age-3 recruits/SSB) for southern Gulf of St. Lawrence cod.

Spawning biomasses of many stocks of cod in the Northwest Atlantic had fallen to low levels by the mid1970s. However, in contrast to the very slow recovery from the recent collapses of these stocks, recovery from these earlier collapses was rapid. This rapid recovery was fueled by good recruitment produced by low spawning stock biomasses. An index of juvenile or pre-recruit survival can be calculated by dividing the number of recruits by the spawning stock biomass that produced them. This index suggests that pre-recruit survival was remarkable in the mid-1970s (e.g., Fig. 17). D. Swain explored hypotheses for the cause of high pre-recruit survival of southern Gulf cod in the 1970s. Three types of explanatory variables were examined: 1) climatic forcing (e.g., indices of air temperature, freshwater discharge, timing of ice-out); 2) spawning stock characteristics (e.g., condition and size of spawners); and 3) abundance of predators or prey, (e.g., biomass of herring and mackerel, potential predators or competitors of cod eggs and larvae). The unusually high pre-recruit survival in the 1970s did not appear to be attributable to any of the physical environmental factors examined, though further work is needed to investigate nonlinear relationships. The index of survival was also unrelated to characteristics of the spawning stock (age, size and condition of spawners) over the 1950-1995 period. The strongest support was for the hypothesis that unusually high cod pre-recruit survival in the 1970s was related to variation in the abundance of their predators. A strong negative correlation existed between the survival index and indices of herring and mackerel abundance (Fig. 18). A similar

coincidence between collapses of herring and mackerel stocks and improved gadoid recruitment has been noted for the North Sea (the gadoid outburst; e.g., Daan et al. 1994 ICES mar. Sci. Symp. 198: 229-243).

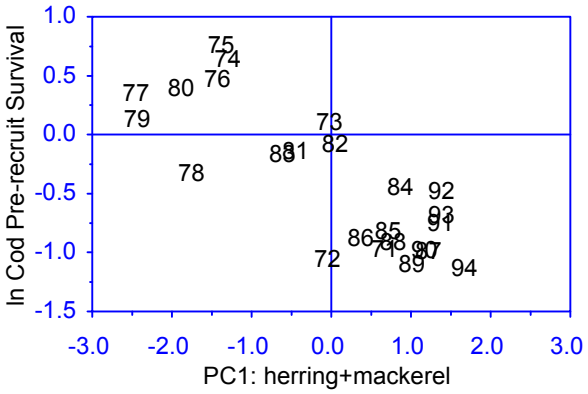

Fig.18. Relationship between indices of cod pre-recruit survival and herring and mackerel biomass in the southern Gulf of St. Lawrence in 1971-94.

6.3 ***Cod Growth***

D. Swain described a comparative analysis of the effects of abundance and temperature on cod growth for the Gulf of St. Lawrence and Scotian Shelf stocks. The Millar and Myers approach was followed, employing a modified von Bertalanffy growth curve with L_∞ modelled as functions of temperature and cod abundance. In all cases, the temperature index used was a measure of environmental conditions (rather than cod-weighted temperatures). Age alone accounted for 95% of the variation in length of 4X cod but only 58% of this variation for southern Gulf (4T) cod, and intermediate amounts of variation for the 3Pn4RS (85%) and 4VsW (79%) stocks. Both abundance and temperature conditions accounted for substantial amounts of the variation in length-at-age of 4T cod, with faster growth occurring when abundance was low or temperatures high. Variation in the growth of 3Pn4RS and 4VsW cod was more closely associated with variation in temperature than with variation in abundance, though for 3Pn4RS cod even temperature accounted for only a small portion of the variation in length at age. Growth of 4X cod appeared to be unrelated to variation in both abundance and temperature conditions. Possible reasons for these differences among stocks in the effects of abundance and temperature on growth were discussed. Residuals from the growth models tended to be positive in the mid to late 1970s and negative in the 1990s for the 4T, 3Pn4RS and 4VsW stocks, suggesting the operation of factors not acounted for by the models.

D. Swain also presented an analysis by A. Sinclair et al. testing the density and temperature dependence of 4T cod growth while accounting for effects of size-selective mortality. Indices of size selective mortality were calculated based on relationships between back-calculated length-at-age and the age of capture. Calculations used a database of backcalculated lengths-at-age based on over 12000 otoliths. These calculations indicated that in the mid to late 1970s mortality tended to be greater for slower growing fish whereas in the 1980s and early

1990s it tended to be greater for the faster growing fish. These indices were used in analyses testing effects of abundance, temperature and size selection on length-at-age. Tests were based on the von Bertalanffy growth curve with L_∞ modelled as functions of temperature, cod abundance, and size selection. Nonlinear analyses were conducted on both observed and backcalculated mean lengths at age. Linear analyses could also be conducted on the backcalculated data by including the length at the start of growth increments as an independent variable. All analyses indicated that variation in length-at-age of 4T cod was most strongly related to variation in size selective mortality. Density and in most cases temperature dependence of growth remained significant after accounting for variation in size selection, though the relative importance of these other factors depended on the analysis. Inclusion of the size selection index eliminated the strong residual pattern described above.

D. Swain explored causes of the changes in the direction of size selective mortality of 4T cod. Mortality was greatest for slow-growing fish in the 1970s and for fast-growing fish in the 1980s and early 1990s. During an intervening period, size selection appeared to be disruptive, with greatest mortality for fish with intermediate growth rates. Relative fishing mortality at length was examined for 4 periods: 1971-76, 1977-81, 1982-86, and 1987-92. In all cases, the curve of relative fishing mortality against length was dome-shaped, though the curves became more sharply peaked in the later periods. Effects of variation in selectivity by the fishery were examined in simulations using these curves. Switches in the direction of size selection could not be generated by fishing the same population with the different observed curves of fishing mortality at length. However, switches from selection against (i.e., highest mortality for) slow-growing fish to disruptive selection to selection against fast-growing fish could be generated by varying growth rate. This suggests that the observed changes in the direction of size selective mortality result from an interaction been domed curves of fishing mortality at length and variation (presumably density- or temperature-dependent) in the growth rate of cod. As a result of this interaction, effects of changes in growth rate are magnified by size selective fishing mortality.

7. General Business

7.1 ***Stock Status Reports***

Draft Stock Status Reports (SSRs) on the State of the Ocean for Newfoundland (E. Colbourne), the Gulf of St. Lawrence (D. Gilbert), the Scotian Shelf, Bay of Fundy and Gulf of Maine (K. Drinkwater) and for the Northwest Atlantic (K. Drinkwater) were provided to the FOC and discussed in detail. Minor changes in all documents were suggested to achieve uniformity in content to the extent possible and consistency in form, e.g. the inclusion of "Background" and "Summary" sections for all SSRs; the inclusion of only directly relevant references, etc. The individual authors will incorporate these suggestions before submitting them for consideration by the regional RAP offices or the CSAS.

7.2 ***FOC Working Groups***

7.2.1 *Cod Growth Working Group Report*

K. Drinkwater presented the report on the Cod Growth Working Group (given in Appendix 6). The group met once during the year (at the CDEENA workshop) but the goals for the year, outlined by Drinkwater, were not fully achieved: IML has essentially completed their analysis on the northern Gulf stock, GFC (Swain, Sinclair) analyses on the southern Gulf stock are almost complete, but progress on the Newfoundland and Scotian Shelf stocks has been slower. A comparative analysis using the same methods for the Gulf of St. Lawrence and Scotian Shelf stocks was completed and presented at this meeting (see section 6.2). Drinkwater mentioned the upcoming ICES Cod & Climate workshop on growth that will convene in May 2000. He also related the plans outlined at the annual ICES meeting for a laboratory study comparing growth characteristics among cod stocks reared in common environments. Initially, plans are to study 4 stocks (from Norway, Irish Sea, Iceland and Canada). Drinkwater noted that many of the CGWG members felt that a separate Canadian study should be feasible; the Working Group will be contacting Jeff Hutchings of Dalhousie University who is also interested in pursuing this idea. The Cod Growth Working Group would like to continue its work and make a follow-up report at the FOC annual meeting next year. The FOC agreed that the CGWG should continue and accepted their proposed mandate:

1. To complete analysis of the relative importance of temperature and density dependence on growth rates of the major cod stocks off eastern Canada, including the comparative analysis.
2. To prepare for the upcoming ICES/GLOBEC workshop on cod growth.
3. To discuss further the possibility of participating in cod growth laboratory studies, including meeting with European colleagues to develop procedures, to consider a Canadian study parallel to that developed in Norway, and to seek funding for such a project.
4. To report to the FOC at the annual meeting in 2000.

7.2.2 *Environmental Indices Working Group Report*

E. Colbourne presented the report of the Environmental Indices Working Group (Working Paper 99/19, see Appendix 7). The group was formed in 1997 with 3 broad objectives: (1) to better document how the various environmental indices are calculated, (2) to compile references on the data and analyses used in developing the various indices and (3) to evaluate to what extent the various indices differ due to (1) above. To date, most of these objectives have been met; i.e. a list of the indices has been provided, standardization among regions has been accomplished, references have been compiled and additional indices have been proposed (relevant to the Zonal Monitoring Program, ZMP). There was considerable discussion about whether the ZMP should take on the responsibility of this working group. It was concluded that it should since indices development is an activity of the ZMP's data analysis subcommittee. It was also recommended that a comparable suite of biological indices be developed (by the ZMP). There was also discussion about fisheries indices. It was recognized that progress has already been made on this within the regions but that these indices should be integrated with the environmental and biological ones as part of the ZMP's deliverables.

The FOC recommends *that the work of the Environmental Indices Working Group continue under the ZMP's data analysis subcommittee and that a report on their progress be presented to the FOC at the 2000 annual meeting.*

7.2.3 *Cod Distribution Working Group*

M. Castonguay presented the report of the Cod Distribution Working Group. This working group was formed last year to investigate the relative roles of changes in temperature and abundance in determining shifts in the distribution of cod in the NW Atlantic. Specifically, the group would evaluate methods, consider the use of research survey versus commercial fishery data and undertake a comparative analysis among stocks of density- versus temperature-dependence of cod distribution. The group met in December for a 2-day workshop. Methods and indices used to characterize fish distribution (in particular, cod distribution in the NW Atlantic) were reviewed and the important properties of indices of distribution (e.g., the need to disentangle distribution and abundance) were identified. The working group concluded that most of the methods and indices that have been used to study cod distribution have the required properties to produce reliable measures of distribution. Examples of the use of commercial fishery data to describe cod distribution were presented for northern cod. A second presentation described some of the difficulties that can be encountered using fishery data to map fish distribution, and concluded that fishing effort may map fish distribution better than do fishery catch rates. Analyses of the relative importance of density dependence versus temperature effects on changes in distribution were presented for the Gulf stocks, but comparative analyses evaluating the relative importance of these factors using the same methods for all stocks have not yet been done. J. Anderson questioned whether temperature and abundance alone would be sufficient to describe distributional patterns, citing the importance of prey distributions. The impact of directed fishing was also posed. Castonguay recognized that a variety of factors in addition to temperature and abundance affect distribution but noted that simultaneous tests of even these two factors are rare. The working group asked the FOC to continue its work in order to complete its comparative analysis, write up the results and present their findings at the next FOC meeting. The FOC agreed.

7.2.4 *Further Discussion on Working Groups*

The chairman asked if there were any proposals to form new working groups within the FOC. The possibility of a working group on recruitment was raised. It was recognized that this continues to be an important issue that has been highlighted by the FRCC as requiring work. However, it was decided that work on a precise mandate for such a working group would need to be done, and so no working group was formed on this issue at this time.

7.3 ***Other Business***

J. Anderson recommended that the FOC build a close link with the CDEENA program (if funded) because of the similarity of the objectives of that program and the terms of reference for the FOC. Ken Drinkwater proposed that some time should be allocated in the agenda of future FOC meetings for the presentation of results from completed High Priority research programs that are relevant to the FOC, e.g. the Cod Mortality, Redfish and CLAWS programs. This

suggestion was broadly endorsed; the members present thought that the review of a few of these programs each year would be very useful for the FOC as well as for the High Priority program itself. The FOC chairman will draft a letter to Bill Doubleday seeking his opinion and agreement on this**.** Results from the Cod Mortality Project and the Cod Stock Mixing Project were of particular interest to the FOC because of their previous involvement with the cod collapses and the cod mixing problem. Other HP projects of interest to the FOC were the Lobster and Redfish projects.

7.4 ***Next Year's Meeting***

7.4.1 *Possible Theme Sessions*

The chairman opened the discussion with three suggestions for possible themes for the 1999 FOC meeting:

1. the cod recovery problem
2. incorporating environmental data in the stock assessment process
3. causes of variation in recruitment of finfishes and shellfishes

M. Castonguay argued for (2), stating that this is an extremely important issue and that the FOC should tackle the problem because there are no other groups in DFO with an interest in pursuing it. There was considerable discussion and support for this theme. It was recognized that the involvement of stock assessment workers would be important for the success of the session. A suggestion was also made that we should invite individuals with special (or practical) experience in using environmental data in assessment, e.g. Dave Reddin's experience with salmon. The discussion of indices should include not only environmental information but biological indices; examples of biological indices were introduced a number of years ago to the FOC but should be revisited at the next meeting. The point was also made that the theme should also be broadened to include the prediction and forecasting potential of the suite of environmental and biological indices. Again, it was reiterated that this effort should be coordinated closely with assessment people in order to develop practical solutions. The committee also agreed that inclusion of environmental indices into the assessment process through the precautionary approach is another topic that should be explored and would fit well within the proposed Theme Session. It was also emphasized that an early announcement of the theme session was needed to promote participation in the session. The chairman was charged with preparing an announcement of the theme session in consultation with several of the FOC core-members for wide distribution in the spring of 1999.

Postscript: The April 1999 report of the FRCC again emphasized the need for a report from DFO on the "recruitment dilemma". A workshop on recruitment is planned for the winter of 1999/2000. This workshop may be held in conjunction with the 2000 annual meeting of the FOC, replacing the theme session proposed above.

7.4.2 *Date and Location*

The next annual meeting will be held at the Northwest Atlantic Fisheries Centre in St. John's during the last week of February 2000.

Appendix 1: Agenda

FOC Annual Meeting, March 16-18 1999
Room A-554
Institut Maurice-Lamontagne, Mont-Joli, Québec

Tuesday, Mar. 16

9:00 Introduction and administrative details
- Chairman

1998 Environmental Overviews

Physical Environment

9:15 Ken Drinkwater, Roger Pettipas and Liam Petrie
- *Meteorological and Sea Ice Conditions off Eastern Canada in 1998.*

9:45 Eugene Colbourne
- *Oceanographic Conditions in the Newfoundland Region in 1998.*

10:15 Break

10:45 Denis Gilbert
- *Oceanographic conditions in the Gulf of St. Lawrence in 1998: physical oceanography.*

11:15 Ken Drinkwater, Roger Pettipas and Liam Petrie
- *Physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine during 1998.*

11:45 Lunch

Biological Environment

13:00 Edgar L. Dalley and John T. Anderson
- *Plankton and nekton of the northeast Newfoundland Shelf and Grand Banks in 1998.*

13:30 Michel Starr
- *Oceanographic conditions in the Gulf of St. Lawrence in 1998: Phytoplankton*

14:00 Michel Harvey, Jeffrey Runge, Pierre Joly and Jean-François St-Pierre
- *Oceanographic conditions in the Gulf of St. Lawrence in 1998: zooplankton.*

14:30 Doug Sameoto (presented by Glen Harrison)
- *The State of zooplankton on the Scotian Shelf, 1997 and 1998*

15:00 Break

General Environmental Session

15 :30 W.G. Harrison and T. Platt
- *Seasonal and regional variability in phytoplankton biomass in the NW Atlantic: Results from the first year of the SeaWIFS ocean colour mission.*

16 :00 B. Petrie, P. Yeats and P. Strain
- *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*

16 :30 P. Pepin (presented by J. Anderson)
- *Climatology of nutrients, phytoplankton and zooplankton*

Wednesday, Mar. 17

8 :30 Jean-Claude Therriault
Atlantic Zone Monitoring Program (ZMP) update

9 :00 Savi Narayanan
Climate Change Initiatives

9 :15 Recommendations and Discussion:
ZMP
Environmental Overviews
Climate Change Initiatives

10:00 Break

Theme Session: Abundance, distribution and production at lower trophic levels in the marine ecosystems of the Northwest Atlantic: effects of environment, predation and fishing down the food web.

10:30 Introduction
-Chairman

10:45 Doug Sameoto
Decadal changes in phytoplankton and zooplankton on the Iceland and Scotian Shelf CPR lines

11:15 John T. Anderson and Edgar L. Dalley
Recent trends in distribution and abundance of the dominant pelagic forage species of the Newfoundland Shelf

11:45 Lunch

13:00 J. M. Hanson and D. P. Swain
Fishing down the food web? Trends in mean trophic level of landings from the Magdalen Shallows.

13:30 Discussion and Recommendations

General Environmental Session-Part 2

14:00 D.P. Swain, G.A. Chouinard, K.F. Drinkwater and R. Morin
The Northwest Atlantic cod outburst of the 1970s: an exploration of possible causes in the southern Gulf of St. Lawrence

14:30 Break

15:00 D.P. Swain, M. Castonguay, K.F. Drinkwater, P. Fanning, and D. Clark
A comparative analysis of the effects of abundance and temperature on the growth of cod in the Northwest Atlantic: preliminary results for the Gulf of St. Lawrence and Scotian Shelf stocks.
15:30 A. F. Sinclair, D. P. Swain, and J. M. Hanson
Tests of effects of abundance and temperature on growth of southern Gulf of St. Lawrence cod: accounting for effects of size-selective mortality
16:00 A. F. Sinclair and D. P. Swain
Changes in the direction of size-selective fishing on southern Gulf cod: effect of changes in selectivity or changes in growth rate?

Thursday, Mar. 18

FOC Business Meeting

9 :00 General Business of the FOC
1. Stock Status Reports
   -Discussion and Approval of Environmental Overview SSRs
2. FOC Working Groups
   -Cod Growth Working Group
   -Environmental Indices Working Group
   -Working Group on the relative role of temperature and abundance on the distribution of cod in the northwest Atlantic
   -Other possible Working Groups?
3. Other Business
4. Next year's Meeting
   -Theme Session
   -Date and Location

Changes to the Agenda

The Institute was closed March 16 due to a winter storm. The schedule for March 16 was carried over to March 17, with the addition of WP 99/05 by K. Drinkwater and the cancellation of the presentation by M. Starr due to illness. The agenda for March 18 began with the presentations on the ZMP and climate change initiatives, followed by a general discussion. This was followed by the Business Meeting and the Theme Session. The General Environmental Session, Part 2, was deferred to the morning of March 19.

Appendix 2: Working Papers

WP 99/01: *Overview of meteorological and sea ice conditions off eastern Canada during 1998.*
- Ken Drinkwater, Roger Pettipas and Liam Petrie

WP 99/02: *Oceanographic conditions in NAFO Divisions 2J3KLMNO during 1998 with comparisons to the long-term (1961-1990) average*
- Eugene Colbourne

WP 99/03: *Oceanographic conditions in NAFO subdivisions 3Pn and 3Ps during 1997 and 1998 with comparisons to the long-term (1961-1990) average*
- Eugene Colbourne

WP 99/04: *Oceanographic conditions in the Gulf of St. Lawrence in 1998: physical oceanography.*
- Denis Gilbert

WP 99/05: *Changes in the slope water properties off the Scotian Shelf and Gulf of Maine during 1997-1998 and their effect on the Shelf*
- K. F. Drinkwater, D. B. Mountain, and A. Herman

WP 99/06: *Physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine during 1998.*
- Ken Drinkwater, Roger Pettipas and Liam Petrie

WP 99/07: *Plankton and nekton of the northeast Newfoundland Shelf and Grand Banks in 1998.*
- Edgar L. Dalley and John T. Anderson

WP 99/08: *Oceanographic conditions in the Gulf of St. Lawrence in 1998: zooplankton.*
- Michel Harvey, Jeffrey Runge, Pierre Joly and Jean-François St-Pierre

WP 99/09: *The State of zooplankton on the Scotian Shelf, 1998*
- D. Sameoto, N. Cochrane, E. Head, M. K. Kennedy

WP 99/10: *Seasonal and regional variability in phytoplankton biomass in the NW Atlantic: Results from the first year of the SeaWIFS ocean colour mission.*
- W. Glen Harrison and Trevor Platt

WP 99/11: *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.*
- B. Petrie, P. Yeats and P. Strain

WP 99/12: *Seasonal and interannual variations in biological oceanographic variables on the Newfoundland Shelf and Labrador current.*
- Pierre Pepin and Hughes Benoît

WP 99/13: *Decadal changes in phytoplankton and zooplankton on the Iceland and Scotian Shelf CPR lines*
- Doug Sameoto

WP 99/14: *Recent trends in the dominant pelagic fish species in the Northwest Atlantic, NAFO 2J3KLNO.*
- John T. Anderson, Edgar L. Dalley and Eugene Colbourne

WP 99/15: *Fishing down the food web? Trends in mean trophic level of landings from the Magdalen Shallows.*
- J. M. Hanson and D. P. Swain

WP 99/16: *The Northwest Atlantic cod outburst of the 1970s: an exploration of possible causes in the southern Gulf of St. Lawrence.*
- D.P. Swain, G.A. Chouinard, K.F. Drinkwater and R. Morin

WP 99/17: *A comparative analysis of the effects of abundance and temperature on the growth of cod in the Northwest Atlantic: preliminary results for the Gulf of St. Lawrence and Scotian Shelf stocks.*
- D.P. Swain, M. Castonguay, K.F. Drinkwater, P. Fanning, and D. Clark

WP 99/18: *Tests of effects of abundance and temperature on growth of southern Gulf of St. Lawrence cod: accounting for effects of size-selective mortality.*
- A. F. Sinclair, D. P. Swain, and J. M. Hanson

WP 99/19: *The 1999 report of the Environmental Indices Working Group (EIWG).*
- E. B. Colbourne, K. F. Drinkwater, D. Gilbert

Appendix 3: Meeting Participants

Name	Affiliation	e-mail Address
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* FOC Core-member

Appendix 4: Summary of Environmental Conditions off Eastern Canada in 1998

Newfoundland and Labrador

Along the Labrador coast and over Newfoundland, air temperatures were warmer-than-usual throughout most of 1998 resulting in positive annual anomalies of from 0.4° to over 1°C. Air temperatures also warmed relative to 1997. The North Atlantic Oscillation index (NAO), which is a measure of the strength of the large-scale atmospheric circulation pattern, was near normal. This was similar to 1997, up from the minimum value of 1996 and down from the high values of early 1990s. The warm air masses of 1998, coupled with a reduction in the northwest winds during winter, caused sea ice on the southern Labrador and Newfoundland shelves generally to appear late, leave early and be of shorter duration than usual. The areal extent in 1998 was less than in 1997 and about half that observed in the early 1990s. The number of icebergs reaching the Grand Banks increased over 1997 by over 36% but still remained below the large number of icebergs reported in the early 1990s. For the third consecutive year, water temperatures from southern Labrador to the Grand Banks generally showed near or above normal values. At Station 27, the hydrographic monitoring site off St. John's, Newfoundland, the annual depth-averaged temperature for 1998 was near normal. This resulted from above normal temperatures during the first half of the year but below normal through most of the second half. Evidence of the warm conditions was seen by the lower amount of cold intermediate layer (CIL), defined by waters <0°, off Bonavista and Hamilton Bank. This continues a trend established in 1995 of less CIL waters than normal. The volume of the CIL waters over the entire southern Labrador to northern Grand Bank also was below normal and has been since 1995. This was in spite of near normal amounts of CIL along the Flemish Cap transect across the Grand Bank. The warm conditions were also evident from the above normal near bottom temperatures on the Grand Bank during the spring and on the northern Newfoundland shelf during the fall of 1998. As a result, the areal extent of bottom waters with temperatures below 0°C over most of these areas declined in recent years with a corresponding increase in waters of temperatures >1°C. Off southern Newfoundland waters temperatures over much of St. Pierre Bank increased significantly in 1998 to near normal values. This resulted in a dramatic decrease in the amount of bottom covered by temperatures <0°C.

Gulf of St. Lawrence

Air temperatures over the Gulf were warmer-than-normal throughout 1998, particularly in the winter and spring. The highest annual anomaly (1.5°C) within 8 stations around the NW Atlantic was in the Gulf on the Magdalen Islands. Ice coverage was less extensive than usual in 1998, and of shorter duration. Despite these milder than normal winter conditions, CIL minimum temperatures surprisingly cooled in 1998 by 0.3°C relative to 1997. No satisfactory explanation has yet been found for this unexpected cooling. Not only did the minimum temperatures with the CIL decline, but also the CIL thickness and volume both increased in 1998 relative to 1997. A direct consequence of this is that the area of bottom in the southern Gulf of St. Lawrence in contact with waters < 0°C and <1°C both increased in 1998. In the 100-200 m layer throughout the Gulf, 1998 temperatures remained stable relative to 1997, and were close to the long-term mean. In the 200-300 m layer, a slight warming of 0.2 to 0.3 C was observed in the northwest Gulf and Estuary. At the same time, a pulse of colder water has begun to propagate along the Laurentian Channel, reaching Cabot Strait with temperatures dropping by 0.7°C. Dissolved oxygen concentrations were normal at Cabot Strait in 1998, but were 2% of O2 saturation level below normal at Honguedo

Strait. A stratification index of the upper layer (0-30 m as well as 0-50m) shows similar overall values in the 1997 and 1998 groundfish surveys. There were regional differences however; the 1998 waters being more stratified than in 1997 in the Estuary and northwest Gulf as well as in Cabot Strait. On the other hand, surface waters were less stratified in 1998 than in 1997 over the Magdalen Shallows and in the northeast Gulf.

Scotian Shelf

As in other regions, air temperatures were well above normal with the 1998 annual anomalies being over 1°C. Normally, sea ice extends onto the northeastern Scotian Shelf during February and March, however, in 1998 the warm air temperatures and reduced ice coverage in the Gulf of St. Lawrence meant that little to no ice appeared on the Scotian Shelf proper. The only significant amount of ice observed seaward of the Gulf was on Sydney Bight, but it arrived late, left early and was of shorter duration than normal. While surface layers over most of the Scotian Shelf were generally warmer than normal, subsurface waters in the northeastern Shelf remained below normal continuing a pattern that was established in the mid-1980s with minimum temperatures in the early 1990s. In recent years, including 1998, there has been a slow but steady increase in temperature in this region. In contrast to the northeastern area, cold, low salinity waters flooded into Emerald Basin and most of the bottom layers of the southwestern Scotian Shelf and into the Gulf of Maine early in 1998 and has remained throughout the year. Temperature and salinity in the deep regions of this area fell by order 2°-3°C and over 0.5 practical salinity units (psu) compared to 1997 values and are the lowest since the 1960s. This was due to the presence of the cold waters at the edge of the Scotian Shelf that was subsequently transported on shore through channels and gullies. The cold conditions off the slope were due to an increase in the southward transport of Labrador Current water. These cold slope waters were located on the outer edge along the entire length of the Scotian Shelf by January of 1998 and extended along Georges Bank during February and March. These cold slope waters have also influenced the Gulf of Maine, including Georges Bank. Stratification over most of the Scotian Shelf, as measured by the density differences between 0 m and 50 m, has increased significantly over almost the entire Scotian Shelf in recent years. Indeed, this index of stratification during the past few years has been the highest in the almost 50 years or record. Cause of this increased stratification has not been examined in detail but is believed to be due to increased warming and perhaps lower salinities of recent years.

Appendix 5: Recommendations from the 1999 Annual Meeting

The Fisheries Oceanography Committee recommends:

1. that the present monitoring-related activities undertaken within the FOC be incorporated within the ZMP and the ZMP take the responsibility for providing the FOC with the annual environmental overviews (both physical and biological) beginning with the 2000 meeting.

2. further development of biological indices and standardization of such indices between regions. In addition, a zonal biological overview analogous to the present physical oceanographic overview, should be produced for the next FOC meeting.

3. that data from Ocean Station Bravo be included as part of annual environmental overviews, including an index of deep convection.

4. that hydrographic data collected during sentinel surveys and additional fisheries surveys (such as the June mackerel survey in the Gulf) be included in the overviews.

5. that potential changes in the zooplankton community in the 1990s on the Newfoundland Shelf be examined from existing archived samples collected during the juvenile fish survey.

6. that there be increased effort made towards incorporating model currents or other indices into the environmental overviews.

7. that the annual pelagic 0-group survey conducted by Newfoundland Region should be continued in 1999.

8. that the work of the Environmental Indices Working Group continue under the ZMP's data analysis subcommittee and that a report on their progress be presented to the FOC at the 2000 annual meeting.

Appendix 6: Report of the Cod Growth Working Group

Members-Martin Castonguay, Ghislain Chouinard, Don Clarke, Ken Drinkwater (Chairman), Jean-Denis Dutil, Paul Fanning, Dominique Gascon, George Lilly, Alan Sinclair, Doug Swain

The CGWG meet in November to discuss objectives, activities and future work. Progress on the growth studies conducted on the individual cod stocks vary greatly between labs. IML scientists have completed most of their work; Moncton has completed much of their study but are still working on other aspects; and the analysis for Newfoundland, the BIO and St. Andrews stocks has been slow because of other commitments. Paul Fanning feels that some component of the proposed CDEENA (Comparative Dynamics of Exploited Ecosystems in the North Atlantic) Strategic Fund Project, if successful, may allow hiring of a PDF who could undertake the necessary growth studies, at least for the Scotian Shelf.

One of the mandates of the CGWG was to undertake a comparative analysis of changes in growth in the major stocks in eastern Canada. Following a suggestion by Doug Swain, the working group agreed that two approaches should be undertaken. First is a simple time series analysis comparing growth rates over time for all of the stocks looking for similarity or differences in amplitude and phase of the growth rate changes. The second was to perform a Miller and Myers analysis. The CGWG felt it would be most efficient to have one individual perform these analyses. Doug Swain agreed to undertake these analyses with data provided by members and present the results at the 1999 FOC meeting. The analyses would be performed on length-at-age data. Following the FOC meeting, the working group will examine the possibility of undertaking a weight-at-age analysis.

An ICES Cod and Climate Change Working Group sponsored Workshop on Cod Growth will take place during May 2000 in Halifax. Doug Swain is one of the co-convenors together with G. Otterson of Norway and N. Anderson of Denmark. The CGWG members are very interested in the workshop and many hope to participate. Keith Brander, of the ICES/GLOBEC secretariat, who attended our November meeting, felt that the approaches and results of the FOC CGWG study would be of special interest to the ICES workshop. He further suggested that our methods and results should be provided to the larger CCCWG community prior to the workshop. A short summary of the CGWG activities was written by the Chairman for the March ICES/GLOBEC newsletter.

Following a meeting at the ICES Annual Meeting in September 1998, Ken Drinkwater and Svein Sundby discussed the possibility of a laboratory study on cod growth involving fish from different stocks covering the extreme temperature range of the species. The idea would be to measure the growth of cod from the egg stage under different temperature conditions. The fish from the different stocks would be raised under the same conditions so that comparisons could be made between the stocks. The facilities in Bergen, Norway would be used; there are no difficulties with quarantining fish brought in from other countries. More recently, Svein Sundby has informed us that several other scientists have become interested in such a project. He is now proposing cod from four stocks be used, including the Arcto-Norwegian, the Irish Sea, the Icelandic and one from Canada. The scientists from the Bergen Laboratory that are interested in the project will be meeting at the end of March. Funding for the project will be sought from EU sources but this will only cover the European activities, including the actual laboratory studies.

Many members of the CGWG are interested in participating in such a study. There was some discussion on the possibility of undertaking an identical parallel study within Canada using the major Canadian cod stocks. The Bergen study would make the comparisons between one Canadian stock and the European stocks and the Canadian study would allow comparisons within Canadian stocks. A joint meeting of interested participants in the overall project is being planned for Iceland in the near future, although the time for the meeting has not yet been scheduled. The CGWG will discuss further our participation, including possible funding sources (e.g. DFO Strategic Funds, NSERC, etc.) during the coming months. The Working Group requests the FOC to allow it to continue its work during the coming year, with the following recommended mandate:

Recommended Mandate:

1. To complete analysis of the relative importance of temperature and density dependence on the growth rates of the major cod stocks off eastern Canada, including the comparative analysis.

2. To prepare for the upcoming ICES/GLOBEC workshop on cod growth.

3. To discuss further the possibility of participating in the cod growth laboratory studies, including meeting with European colleagues to develop procedures, to consider a Canadian parallel study to that developed in Norway and to seek funding for such a project.

4. To report to the FOC at the annual meeting in 2000.

Appendix 7: Report of the Environmental Indices Working Group

Chairman: E. B. Colbourne

Purpose and Mandate

During the 1997 Fisheries Oceanography Committee (FOC) meeting a working group on environmental indices (EIWP) was formed to address some of the issues brought forward by the regional RAPs and from internal discussions within the FOC. Some of the issues discussed were; a lack of details on how environmental indices were calculated, variations of the same environmental index from paper to paper and/or from author to author as a result of different analysis techniques, available data and different averaging or filtering windows etc. Also it was evident that there was no comprehensive reference available giving detailed information on the available oceanographic and environmental data sets, their spatial and temporal coverage, data collection methods and instrument types.

The working group presently consists of those directly involved in preparing the physical environmental overviews for each region, **D. Gilbert** from the Laurentian Region, **K. Drinkwater** and **B. Petrie** from the Maritimes Region and **E. Colbourne** from the Newfoundland Region.

The following mandate was developed for the working group.

1) To list the major physical environmental indices presently used in the overviews and document both the source of the data and how the indices are calculated.

2) To recommend a common set of standardized indices and methods of estimating indices for all regions.

3) To recommend additional indices or data products basis on special data sets that individual regions may be collected.

4) To place the main indices on the worldwide web.

5) To present the results into a technical report, and/or to provide necessary references.

6) To report to the FOC at the 1999 annual meeting.

Accomplishments to date

The accomplishments to date deal mainly with item number 1 of the mandate. Details of the various data sets are listed, their sources, instrumentation and data products currently generated from the data and a brief description of how the indices were computed. The data sources are summarized below and elaborated upon in the working paper. In addition, a comprehensive list of references is included at the end of the working paper. It should be noted that details of many of the historical data sets discussed here are published or pending in various technical and data reports of the Canadian Hydrography and Ocean Science Series.

Summary

Appendix A. Large-scale environmental (meteorological and ice) data sets and derived climatic indices that are common to all Atlantic Zone regions.

1. Northwest Atlantic air temperature fields;
2. Northwest Atlantic Sea Level Atmospheric pressure fields;
3. The North Atlantic Oscillation index (NAO);
4. Northwest Atlantic Ice analysis;

Appendix B. Regional-scale environmental data sets and derived climatic indices.

Newfoundland Region

1. Station 27 temperature and salinity time series;
2. Temperature and salinity time series from other areas;
3. The LTTMP temperature time series;
4. Standard NAFO transects;
5. Fisheries assessment survey data;

Scotia – Fundy Region

1. Coastal SST stations;
2. Prince 5 Time series;
3. Other temperature and salinity data;
4. Groundfish surveys;
5. Frontal analysis (Shelf/Slope front and Gulf stream);
6. Gulf of Maine transect;

Laurentian Region

1. Fixed monitoring station temperature and salinity time series;
2. LTTMP temperature time series;
3. Standard ZMP transects;
4. Groundfish assessment survey data;
5. Freshwater discharge index (RIVSUM);

ZMP Recommended Indices

1. Time series of winds for selected sites;
2. Air-Sea heat flux time series;
3. A freshwater runoff index for the Newfoundland Shelf should be investigated;
4. Stratification index for selected areas;
5. Remotely Sensed Zonal SST maps;

Next steps

The next steps will be to fill in any missing information from 1 and to recommend and develop if necessary, a set of standardized indices and methods for their estimation to be used by all Regions. The results will then be rolled into a technical report and a web site established to display the main indices. Discussions with the Zonal Monitoring Group data analysis sub-committee may lead to a common and enhanced set of data products with a common web site.

Appendix 8: Report of the Cod Distribution Working Group

Chairman: M. Castonguay

General objective: Investigate the relative roles of temperature and abundance on the distribution of cod in the NW Atl. Interest in interpretation of causes of declines of cod stocks. The **terms of reference** (TOR) are:

1. Investigate the different methods used to examine role of temperature and abundance on changes in cod distribution.
2. Determine relative usefulness of RV and commercial data to examine distribution changes.
3. Conduct a workshop in the autumn of 1998 where analyses would be presented. A report of the workshop will be written.
4. Report to FOC at the 1999 annual meeting

The **first meeting** was held on Dec. 7-8, 1998 in Moncton. Its agenda was:

Monday, December 7

10:00-10:10 Martin Castonguay
Introduction and identification of rapporteurs

10:10-11:00 Doug Swain
Disentangling distribution and abundance: necessary properties of indices of distribution

11:00-11:45 Fred Page
Overview of association analyses done on cod and haddock for the Scotian Shelf area

11:45-12:15 Martin Castonguay
Distribution changes of northern Gulf cod in winter: temperature- and/or abundance-related?

12:15-13:15 Lunch

13:15-14:00 George Lilly
An overview of studies of cod distribution in NAFO Divisions 2J3KL

14:00-14:30 Doug Swain
Changes in the distribution of southern Gulf cod during the summer feeding season: density-dependence versus environmental effects

14:30-15:00
Coffee

15:00-16:00 Dave Kulka
Application of potential mapping to commercial and research fisheries data for northern and 3Ps cod

16:00-16:30 Doug Swain
Optimal foraging theory and the use of commercial fisheries data to describe fish distributions

16:30-17:00
Discussion of how to orient the debate on the next day. Also, are there additional published methods to describe distributions that should be discussed?

Tuesday, December 8

08:30-12:00

General discussion on the merits of the various methods in use to describe distributions. Can we come to a consensus on a common method to apply to all stocks? If we do come to a consensus, do we agree that the next meeting of the CDWG will be to report on those common analyses? When would that be?

The work of this working group may provide the foundation for an interesting primary publication that would compare how cod distributions (with respect to temperature, depth, latitude, salinity) have changed over time in the various stocks and also how cod distributions vary across stocks irrespective of temporal changes.

12:00 (or later if needed)
End of meeting

Summary of work accomplished during the Workshop

TOR 1. Investigate the different methods used to examine role of temperature and abundance on changes in cod distribution

- We examined the different methods used: measures of range, indices of concentration, cumulative distribution function (cdf) type association analyses, SPANS GIS, statistical ellipse method. We concluded they all seem right although some questions were raised with respect to the latter.
- Concerning causes, model joint effects of abundance and temperature on some index of distribution (e.g., median latitude)

TOR 2. Determine relative usefulness of RV and commercial data to examine distribution changes

- RV and commercial data both useful, especially when used together to bring a seasonal perspective to distribution changes
- However need to interpret fishing data carefully because of fishermen interactions and other factors

TOR 3. Conduct comparative analyses of distributional changes in the major Canadian cod stocks

- We decided to undertake this work, using research survey data, possibly under Doug Swain's and Martin Castonguay's leadership. This will involve comparing how geographic, depth and temperature distributions of the various cod stocks have changed over the past 20-30 years within and across stocks, including seasonal aspects, and what have been the relative roles of temperature and abundance in driving those changes.