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# Final Report of the Fisheries Oceanography Committee 2002 Annual Meeting

**March 25 - 28, 2002**
**Bedford Institute of Oceanography**
**Bedford, Nova Scotia**

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**Fisheries and Oceans Canada,**
**Quebec Region,**
**Maurice Lamontagne Institute**
**850 route de la mer**
**Mont-Joli, QC G5H 3Z4**

**Ken Drinkwater, Chairperson (Theme Session)**
**Fisheries and Oceans Canada,**
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**Box 1006, Dartmouth, NS. B2Y 4A2**

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Canada

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# Executive Summary of the 2002 FOC Annual Meeting

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans (DFO) met in Bedford, Nova Scotia at the Bedford Institute of Oceanography on 25-28 March 2002. The Committee reviewed environmental conditions in the Northwest Atlantic during 2001, convened a theme session on incorporating environmental information into fisheries stock assessments, reviewed additional papers on physical and biological oceanography, and conducted its annual business meeting.

1. **Physical Environment in 2001**: Five papers were reviewed on the meteorological and physical oceanographic conditions. Annual mean air temperatures throughout most of the northwest Atlantic were warmer-than-normal, generally increasing relative to 2000 but below the record-setting level of 1999. Sea ice in the southern Labrador and Newfoundland shelves appeared late and left early resulting in shorter ice duration than normal. In the central Gulf of St. Lawrence, sea ice appeared late and disappeared early while the opposite was observed in the southwestern and northeastern Gulf. The cross-sectional area of the CIL on the Newfoundland and Labrador shelves decreased in summer 2001 relative to 2000, except on the Grand Bank where there was a slight increase. However, bottom temperatures on the Grand Bank during spring of 2001 were generally above normal over most area. Monthly mean coastal sea surface temperatures in the Gulf of Maine during 2001 were warmer-than-normal continuing the recent trend of positive temperature anomalies. However, in July 2001, near-bottom temperatures over most of the Scotian Shelf were below normal, representing cooling relative to 2000. In the Gulf of St. Lawrence, the freshwater run-off index was below normal throughout the year. The minimum temperature within the CIL dropped by 0.6°C relative to 2000, returning to the 1997 value of –0.42°C, and the thickness of the CIL increased by 30 m relative to 2000.

2. **Biological Environment in 2001**: Five papers were reviewed on the biological oceanographic conditions. On Newfoundland Shelf, the magnitude of the spring bloom was comparable between 2001 and 2000, but the timing and duration of the bloom occurred earlier and persisted longer in 2000. In 2001, the abundance of major zooplankton groups at Station 27 was similar to 1999 and 2000. On Scotian Shelf, lower chlorophyll concentrations were observed on the 2001 spring section compared to 2000; however, the timing of the survey (later in 2001) may explain the differences. Nutrients and chlorophyll concentrations were lower in the southern Gulf in the fall 2001 relative to fall 2000. In general, zooplankton was more abundant in 2001 relative to 2000. In the Lower St. Lawrence Estuary, the spring bloom occurred 6 to 8 weeks earlier than usual and the average phytoplankton biomass was much lower compared to the 1995-1999 period (but comparable to the 1992-1994 period). For the entire Gulf, satellite observations indicate that the spring bloom occurred in late April. The diatom *Neodenticula seminae* dominated the phytoplankton community during the 2001 spring bloom. This is the first occurrence of this species in the Gulf of St. Lawrence. In the northwest Gulf, total zooplankton abundance in 2001 was comparable to 1999 and 2000. There were significant changes in the mean abundance of some macrozooplankton species. For example, there is a negative relationship between the annual CIL core temperature index and the abundance of the amphipod *T. libellula* in the Lower Estuary and the northwest Gulf of St. Lawrence from 1994 and 2001.

**3. Recruitment**: For the second consecutive year, recruitment indices for selected fish and invertebrate stocks were reviewed and progress was made toward the development of a standard recruitment scorecard for each region. Although specific recruitment indices were presented, there is still work necessary for the uniformity of the presentations among regions. For many stocks there are no survey data and no age information, and in many cases limited knowledge of stock structure. Recruitment rate (R/S) was considered the appropriate index for the analysis but there are still concerns about the approach. The approach that should be taken to investigate the potential relationship between environment and recruitment variations was also discussed. The working group formed in 2000 will continue to work toward the development of the recruitment indices.

**4. General Environment Session**: Four presentations were reviewed at the General environment session. Two papers touched different methodological aspects; 1) the problem of non-independent observations in oceanographic and fisheries time series was discussed along with methods to deal with serial correlation in regression analysis, and 2) a discussion on the impact of shifting from the 1961-1990 to the 1971-2000 base period to compare ocean climate conditions.

**5. Theme Session**: The theme session on incorporating environmental information into fisheries stock assessment was a success with a total of 11 presentations. Five papers presented case studies where environmental information is presently being incorporated into assessments or offered ways in which it could be achieved. Other talks provided potential examples, showing how the environment affected distributions, survival and catchability. An extensive discussion followed the presentations. One important recommendation was to find ways to promote direct discussions between the fisheries assessment people and those working on environmental issues.

**6. Business meeting**: The activities of the FOC working groups were discussed. The *Working Group on Recruitment Indices* will continue to assemble data and develop a scorecard and the results will be presented at the 2003 annual meeting. The *Working Group on Monitoring of Pelagic Ecosystems* formed last year will continue for another year is effort on the development of terms of reference and the preparation of a proposal. The *Working Group on Incorporating Environmental Information into Stock Assessments* will also continue for another year. The WG will also be involved in the organization of a FOC-AZMP sponsored workshop on strategies to increase interactions between AZMP and stock assessments planned for the fall of 2002. The FOC also decide that the Labrador Sea biological and physical data time series will be incorporated into the environmental overviews for next year.

**7.** The 2003 Annual Meeting will be held at Maurice Lamontagne Institute in late March. The theme session will discuss the events that may have been responsible for high recruitment of various fish stocks in eastern Canada in 1999.

## Résumé de la réunion annuelle de 2002 du COP

Le comité sur l'Océanographie des Pêches (COP) du ministère des Pêches et des Océans (MPO) s'est réuni à l'Institut d'océanographie de Bedford (Nouvelle-Écosse) du 25 au 28 mars 2002. Le Comité a revu les conditions environnementales dans le nord-ouest Atlantique en 2001, a tenu une session thématique sur l'incorporation de l'information environnementale dans l'évaluation des stocks, a revu des documents sur l'océanographie en général et a discuté des affaires courantes.

**1. L'environnement physique en 2001** : Cinq documents ont été présentés sur les conditions météorologiques et physiques. Les moyennes annuelles des températures de l'air ont été plus élevées que la normale sur toute la Zone, plus élevées qu'en 2000 mais légèrement plus basses qu'en 1999. Au sud du Labrador et sur le plateau de Terre-Neuve, la glace est apparue tardivement pour partir plus tôt, créant une durée de la glace plus courte que la normale. Au centre du Golfe, la glace est aussi apparue tard pour partir plus tôt, alors que l'inverse a été observé dans le sud-ouest et au nord-est. Le volume de la CIF sur les plateaux de Terre-Neuve et du Labrador a diminué en 2001 par rapport à 2000, mais a légèrement augmenté sur les Grands Bancs. Cependant, les températures au fond sur les Grand Bancs ont été généralement plus élevées au printemps de 2001. Les moyennes mensuelles de températures de surface au printemps dans le golfe du Maine étaient au-dessus de la normale suivant la tendance observée ces dernières années. Cependant, en juillet 2001, les températures de fond sur le plateau néo-Écossai étaient plus froides qu'en 2000. Dans le golfe du Saint-Laurent, le débit d'eau douce est demeuré faible toute l'année. La température minimale de la CIF a chuté de 0.6°C pour rejoindre le minimum de –0.42°C observé en 1997 et l'épaisseur de la CIF a augmenté de 30 m en 2001.

**2. L'environnement biologique en 2001** : Cinq documents ont été présentés sur les conditions biologiques. Sur le plateau de Terre-Neuve, l'amplitude du bloom printanier en 2001 était comparable à celle de 2000 mais le début avait été plus tôt et le bloom avait duré plus longtemps en 2000. En 2001, l'abondance des principaux groupes de zooplancton à la Station 27 était comparable à celle observée en 1999 et 2000. Sur le plateau néo-Écossai, des concentrations de chlorophylle plus basses qu'en 2000 ont été observées au printemps, mais le relevé tardif de 2001 par rapport à 2000 pourrait expliquer la différence. Les concentrations de sels nutritifs et de chlorophylle étaient plus basses dans le sud du Golfe à l'automne 2001 par rapport à 2000. En général, le zooplancton était plus abondant en 2001. Dans l'estuaire du Saint-Laurent, le bloom printanier est survenu 6 à 8 semaines plus tôt et la biomasse de phytoplancton était beaucoup plus faible que la moyenne pour la période 1995 à 1999 (mais comparable aux années 1992-1994). Sur tout le Golfe, les observations par satellite ont montré que le bloom est survenu à la fin avril. La diatomée *Neodenticula seminae* dominait la communauté de phytoplancton en 2001. Il s'agit d'une première occurrence pour cette espèce dans le Golfe. Au nord-ouest du Golfe, l'abondance totale de zooplancton en 2001 était comparable aux années 1999 et 2000. Cependant, des changements significatifs sont observés dans l'abondance de certaines espèces. Par exemple, il y a une relation négative entre l'indice de la température au cœur de la CIF et l'abondance de l'amphipode *T. libellula* dans l'estuaire du Saint-Laurent pour la période de 1994 à 2001.

**3. Recrutement** : Pour la deuxième année consécutive, les indices de recrutement pour une sélection de stocks de poissons et d'invertébrés ont été présentés ainsi que les progrès dans le développement d'une fiche standard du recrutement pour chaque région. Quelques cas d'indices de recrutement ont été présentés mais il reste encore beaucoup de travail à faire pour uniformiser les indices entre les régions. En plus, pour beaucoup de stocks, il n'y a pas de données provenant de relevés de recherche ou de données sur l'âge ou même sur la structure des stocks. Le taux de recrutement (R/S) est jugé un indice adéquat mais l'utilisation de ce paramètre soulève aussi beaucoup de questions. L'approche à prendre pour lier l'environnement à la variabilité du recrutement a aussi été discutée au cours de la réunion. Le groupe de travail formé en 2000 continuera ses activités en 2001.

**4. Session générale sur l'environnement** : Quatre présentations ont été faites au cours de la session. Deux documents ont traité de différents aspects de méthodologie : 1) le problème de la non-indépendance des observations dans les séries de données océanographiques ou sur les pêches et les méthodes à utiliser pour tenir compte de l'auto-corrélation dans les analyses de régression; 2) l'impact de l'utilisation de la période de référence 1971-2000 (par rapport à 1961-1990) sur l'interprétation des conditions océanographiques récentes.

**5. La session thématique** : La session thématique sur l'incorporation de l'information environnementale dans les évaluations de stocks a été un succès avec 11 présentations. Cinq documents ont présenté des cas où l'information environnementale est incorporée aux évaluations ou montrant comment l'incorporation pourrait être réalisée. Les autres présentations traitaient de comment l'environnement peut influencer la distribution, la capturabilité ou la survie. Une bonne discussion a suivi les présentations. Une recommandation importante a été que l'on devrait trouver une façon de promouvoir plus d'échanges entre les scientifiques des pêches et les scientifiques travaillant sur les questions environnementales.

**6. Affaires courantes du Comité** : Le comité a discuté des activités des différents groupes de travail. Le *Groupe de travail sur les indices de recrutement* continuera ses activités pour le développement des fiches et présentera les résultats à la réunion de 2003. Le *Groupe de travail sur le monitorage des écosystèmes pélagiques* continuera aussi ses activités pour une autre année afin de présenter au Comité les termes de référence et une proposition sur le monitorage. Le *Groupe de travail sur l'incorporation de l'information environnementale dans les évaluations des stocks* se poursuivra aussi pour une autre année. Le groupe sera entre autre impliqué dans l'organisation de l'atelier de travail « FOC-AZMP » prévu à l'automne 2002 sur les stratégies pour accroître les interactions entre le programme de monitorage et les évaluations de stocks. Le Comité a aussi convenu que les données physiques, biologiques et chimiques de la mer du Labrador seront incorporées dans la revue de l'environnement physique à chaque année.

**7.** En 2003, la réunion annuelle aura lieu à l'Institut Maurice-Lamontagne tard en mars. La session thématique sera une discussion des événements environnementaux qui pouraient expliquer les forts taux de recrutement observés en 1999 pour plusieurs stocks.

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## 1. Introduction

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans (DFO) met at the Bedford Institute of Oceanography (Bedford, Nova Scotia) on March 25 to 28, 2002, to review (1) the environmental conditions in the Northwest Atlantic during 2001, (2) review other paper on the environment or fisheries-environment linkages, and (3) conduct the annual FOC business meeting and review progress of working groups of the FOC. A theme session on incorporating environmental information into fisheries stock assessments was convened during the meeting. 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 and the lists of working papers and meeting participants appear in the Appendices.

## 2. FOC core-membership

While participation in the activities of the FOC is 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. At the time of 2002 annual meeting, the FOC core-members were:

| Name | Region | Location/lab |
|---|---|---|
| John Anderson | Newfoundland | NWAFC |
| Denis D'Amours | DFO Headquarters | Ottawa |
| Martin Castonguay | Quebec | MLI |
| Eugene Colbourne | Newfoundland | NWAFC |
| Ken Drinkwater | Maritimes | BIO |
| Ken Frank | Maritimes | BIO |
| Denis Gilbert | Quebec | MLI |
| Glen Harrison | Maritimes | BIO |
| Savi Narayanan | DFO Headquarters (MEDS) | Ottawa |
| Patrick Ouellet, Chairman | Quebec | MLI |
| Fred Page | Maritimes | SABS |
| Dave Reddin | Newfoundland | NWAFC |
| Doug Swain | Gulf | GFC |
| John Tremblay | Maritimes | BIO |

## 3. 2001 Environmental Overviews

As part of the FOC mandate, the Committee provides an annual review of environmental conditions in the Northwest Atlantic. A total of 10 papers were reviewed, five on the physical environment and five on the biological environment. Each environmental overview paper was assigned a reviewer 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. The principal conclusions from the physical environment review are summarized in a physical environmental scorecard for the entire Zone.

3.1 *Overview of Meteorological, Sea Ice and Sea-Surface Temperature conditions off Eastern Canada (K. Drinkwater et al.)*

The meteorological (temperature trends, atmospheric sea level pressures, winds) and sea ice (ice coverage and iceberg drift) conditions during 2001 off eastern Canada were presented. Annual mean air temperatures throughout most of the northwest Atlantic were warmer-than-normal. They generally increased relative to 2000 but were below the record-setting temperatures of 1999 (Fig. 1).

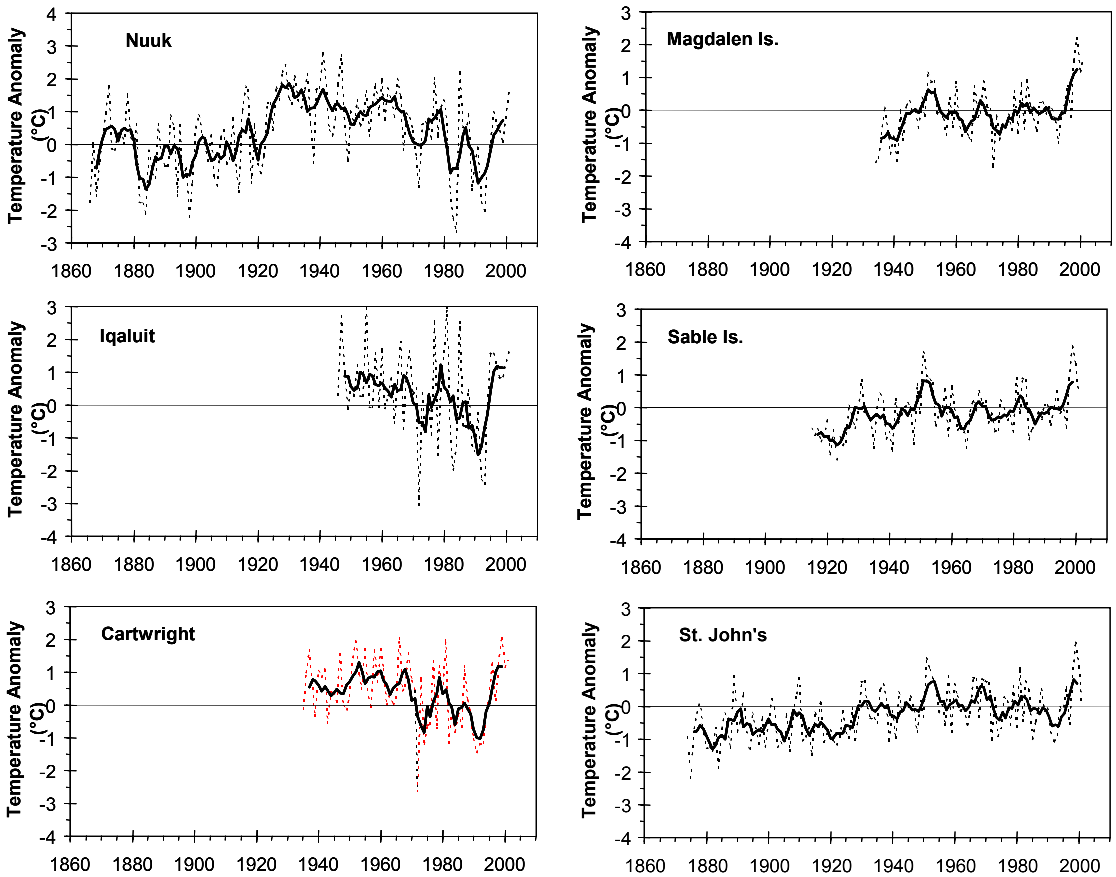


Figure 1. Annual air temperature anomalies (dashed line) and 5-yr running means (solid line) at selected sites.

The North Atlantic Oscillation (NAO) index was below normal and fell compared to its 2000 value. It was similar to the values of 1986-1998 and well below the levels seen in the cold period of the early 1990s (Fig. 2). The low index means that the large-scale atmospheric circulation, including the Icelandic Low and Azores High, weakened in 2001. The Labrador Sea experienced predominantly more easterly winds than usual throughout most of the year.

Sea ice in the southern Labrador and Newfoundland shelves generally appeared late and left early, resulting in a shorter duration of ice than usual.

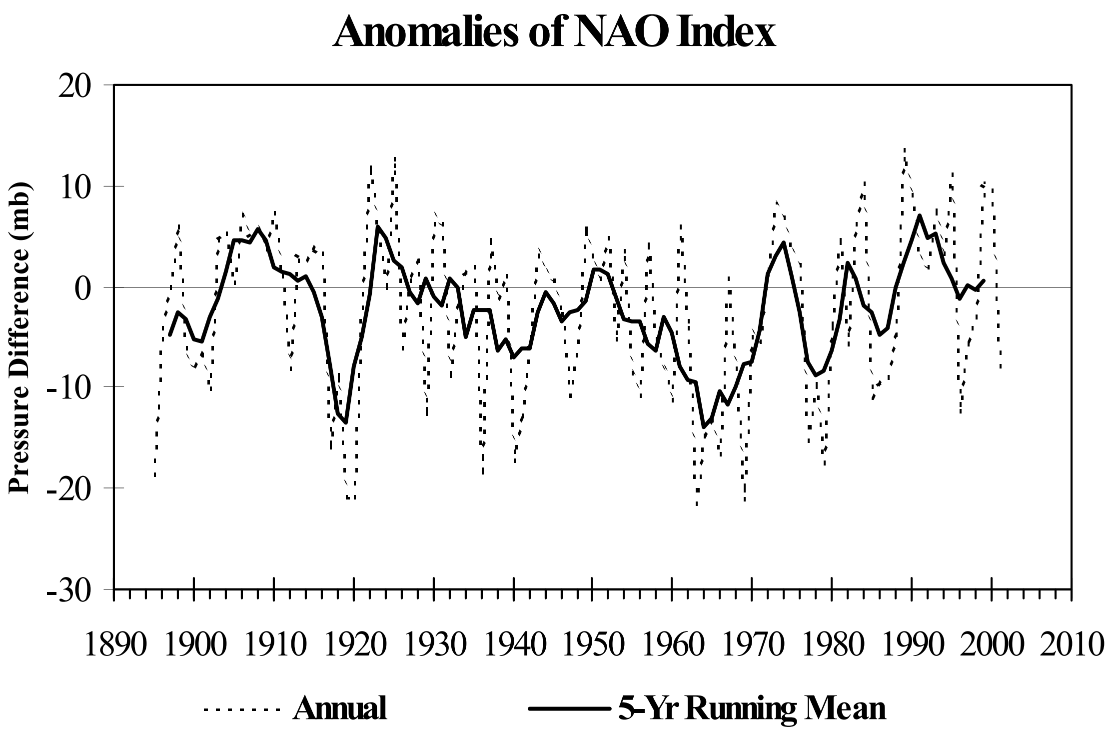


Figure 2. Anomalies of the North Atlantic Oscillation Index, defined as the winter (December, January, February) sea level pressure difference between the Azores and Iceland, relative to the 1961-90 mean.

The ice coverage in these areas was lower than average (Fig. 3). The number of icebergs reaching the Grand Banks in 2001 was only 89, almost a 10-fold decrease from the 843 icebergs observed in 2000. In the central Gulf of St. Lawrence, sea ice appeared late and disappeared early while the opposite (early arrival and late departure) was observed in the southwestern (inner Magdalen Shallows) and northeastern (Strait of Belle Isle) Gulf. Less ice than usual reached the Scotian Shelf while the areal coverage of ice in the Sydney Bight area off eastern Cape Breton was normal to less-than-normal. Sea-surface temperature anomalies throughout eastern Canadian waters were positive in 2001.

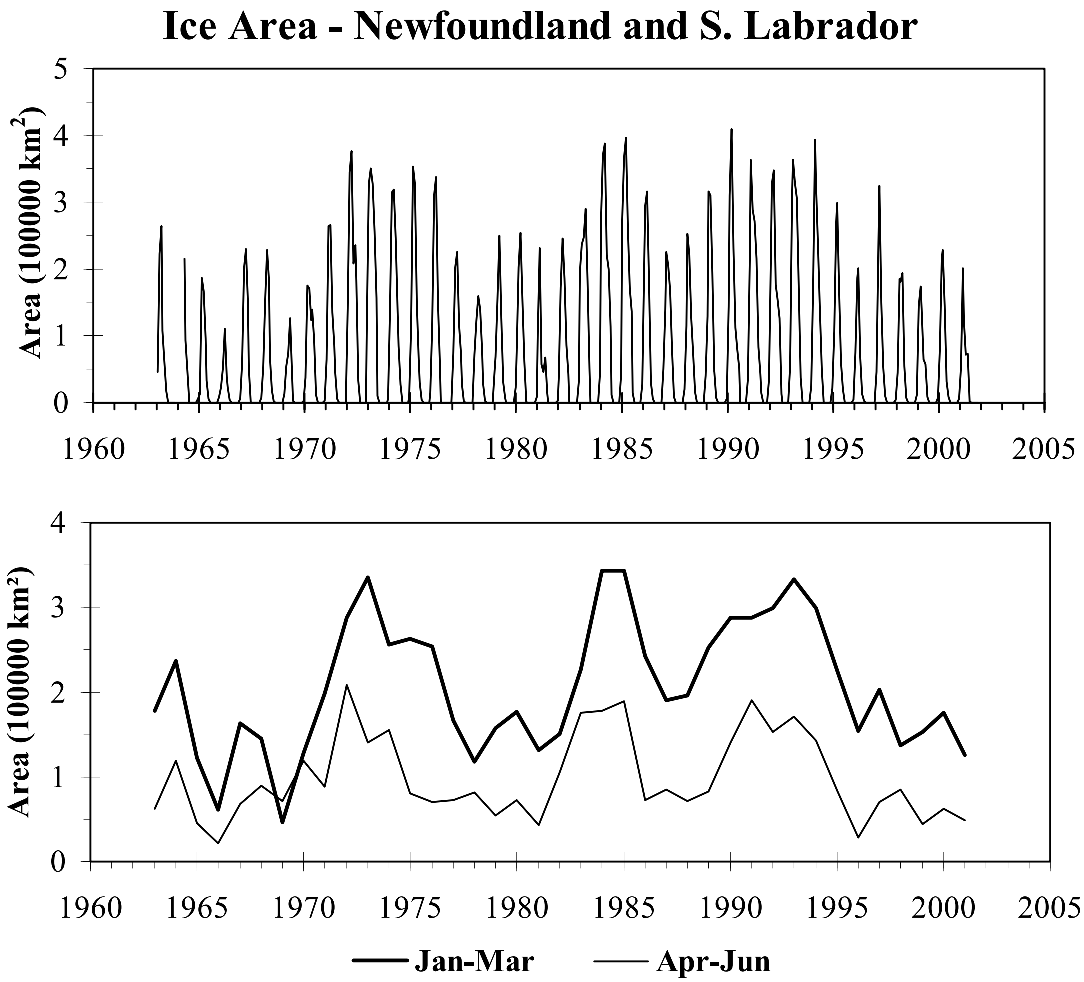


Figure 3. Time series of the monthly mean ice area off Newfoundland and Labrador between 45°N-55°N (top panel) and the average ice area during the normal periods of advancement (January-March) and retreat (April-June) (bottom panel).

3.2 *Physical Oceanographic Conditions*

3.2.1 Newfoundland Shelf and Labrador, and southern Newfoundland *(E. Colbourne)*

The annual water column averaged temperature at Station 27 remained above the long-term mean in 2001 and warmed slightly compared to 2000. Surface temperatures were below normal in spring (April to May) but were above normal for 9 out of 12 months with anomalies reaching a maximum of near 1.6°C in October (Fig. 4). Bottom temperatures at Station 27 were above normal by 0.5°C during all 12 months of the year. Water column averaged summer salinities at Station 27 decreased below normal values in 2001 compared to the near-normal conditions of 2000. Annually, salinities at Station 27 were above normal during the winter months, below normal from spring to early fall and slightly above normal during late fall below the surface layer (Fig. 4).

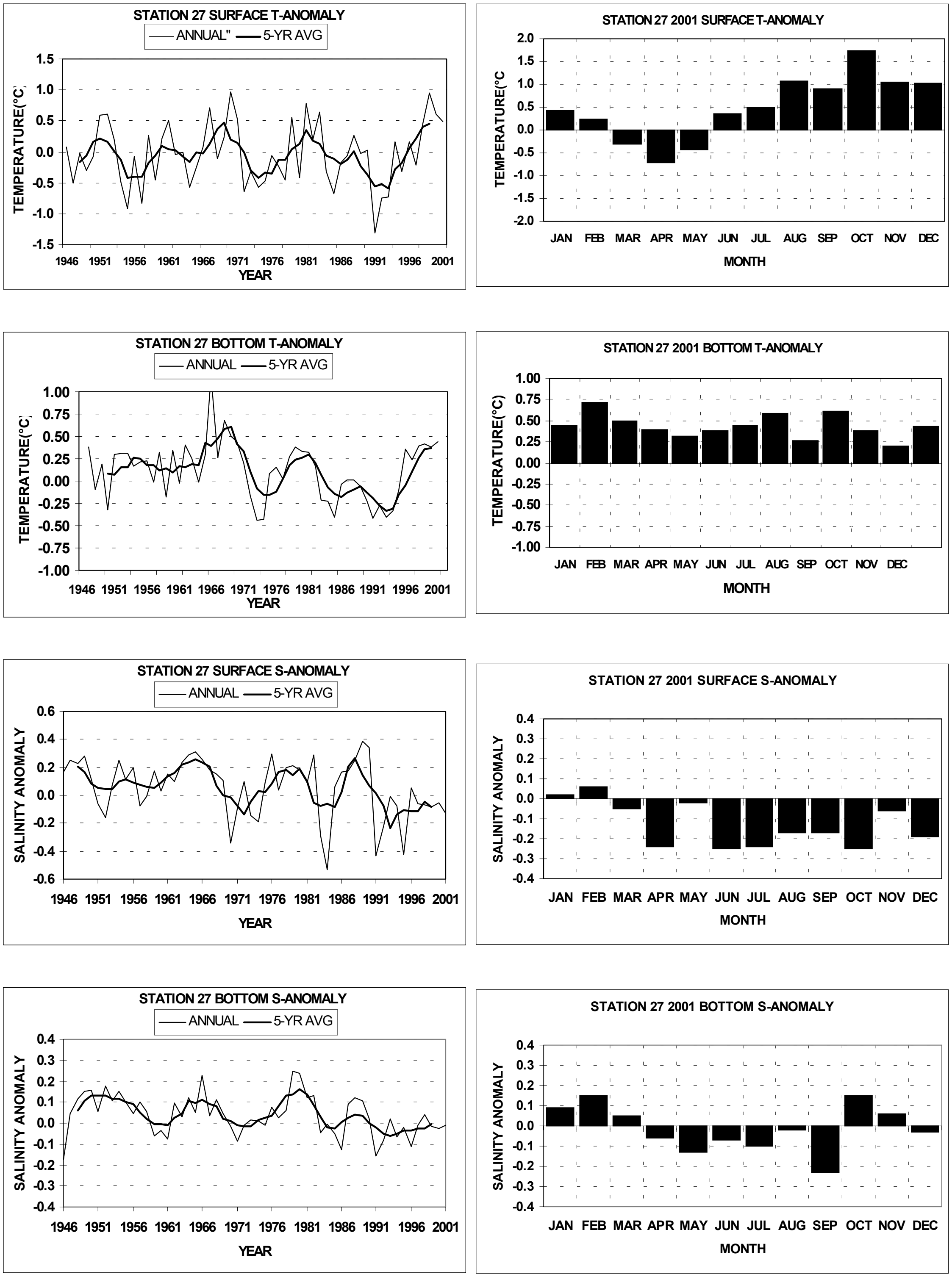


Figure 4. Station 27 surface and bottom annual temperature and salinity anomalies and their 5-years running means (left) and monthly temperature and salinity anomalies (right).

The cross-sectional area of sub-zero °C water (Cold Intermediate Layer - CIL) on the Newfoundland and Labrador shelves during the summer of 2001 decreased relative to 2000 values except on the Grand Bank where there was a slight increase. The CIL areas were below normal along all sections from the Grand Bank (Flemish Cap transect) to the Seal Island section off southern Labrador. Off Bonavista Bay, the CIL area decreased to the lowest value observed since 1978. The total volume of sub-zero °C water on the shelf during the fall decreased compared to 2000, continuing the trend of below normal values observed since the mid-1990s (Fig. 5). Minimum CIL core temperatures along the standard sections during the summer of 2001 increased over 2000 values except off White Bay, and were all above normal.

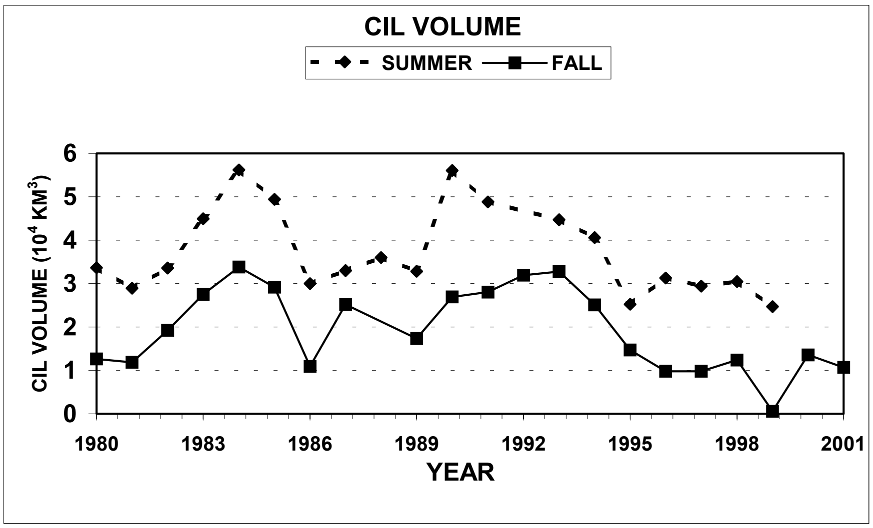


Figure 5. Time series of summer and fall Cold-Intermediate-Layer (CIL) volumes with temperatures <0°C over the 2J3KL areas. There were insufficient data to calculate the summer 2000 and 2001 values.

Bottom temperatures on the Grand Banks during the spring of 2001 were generally above normal by up to 0.5°C over most areas except the southeast shoal of the Grand Bank where temperatures were slightly below normal. During the fall, bottom temperatures were above normal on the northern Grand Bank (3L) but in 3NO they were quite variable fluctuating by ±1°C around the normal in most regions. Fall bottom temperatures in Divisions 2J and 3K were above normal in most areas and up to 2°C on Hamilton Bank. Except during the spring on the Grand Bank, mean bottom temperatures in all regions increased slightly relative to 2000 values. Correspondingly, the area of the bottom covered by warmer water increased slightly except on the Grand Bank during the spring. In general, over all areas of the Newfoundland Shelf the near-bottom thermal habitat continued to be warmer than that experienced from the mid-1980s to the mid-1990s.

In summary, during 2000 and 2001, ocean temperatures were cooler than in 1999 but remained above normal over most areas continuing the trend established in 1996. Salinities during 2001 were generally fresher than normal in the inshore regions, which is a continuation of the trend observed during most of the 1990s.

Off southern Newfoundland, time series of temperature anomalies in Division 3Ps (St. Pierre Bank) area show anomalous cold periods in the mid-1970s and from the mid-1980s to late 1990s. During the most recent cold period, which started around 1985, temperatures were ca. 1°C below average over all depths and ca. 2°C below the warmer temperatures of the late 1970s and early 1980s in the surface layers. Temperatures in deeper water off the banks during all years show significant variations, but remain relatively warm with temperatures in the 3-6°C range compared too much colder values (often sub-zero °C) on St. Pierre Bank. Beginning around 1996 temperatures started to moderate, decreased again during the spring of 1997 and returned to more normal values during 1998. During 1999 and 2000 temperature continued to warm reaching above normal values over most of the water column. During the spring of 2001 however, temperatures cooled significantly over the previous two years to values observed during the mid-1990s (Fig. 6).

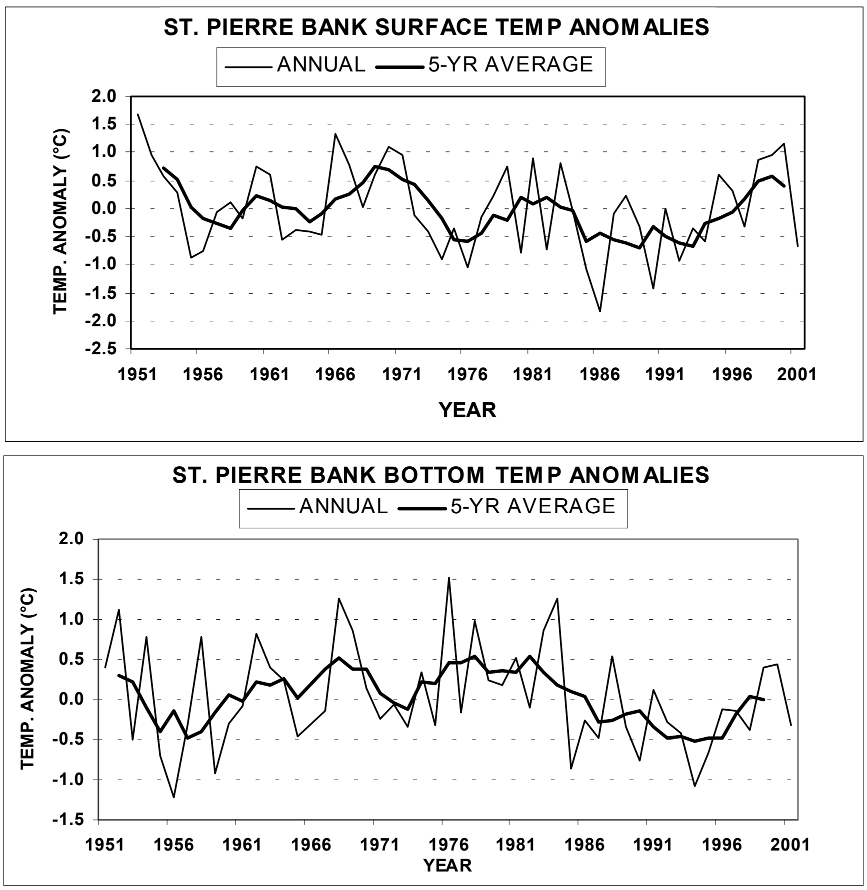


Figure 6. Annual near-surface and near-bottom temperature anomaly (°C) time series for the St. Pierre Bank constructed from all historical data. The heavy solid line represents the 5-year running mean.

The areal extent of <0°C bottom water increased significantly from the mid-1980s to mid-1990s but decreased to very low values during 1998-2000. During 2001 however, the area of <0°C returned to values observed during the mid-1990s (Fig. 7). During 2001 the area of warmer water decreased significantly compared to the pervious 3-years. On St. Pierre Bank sub-zero °C water completely disappeared during 1999-2000 but increased to near 30% during 2001. The area of near-bottom water on the banks with temperatures >1°C was about 50% of the total area during 1998, the first significant amount since 1984. This subsequently increased to about 70% during 1999 and to 85% during 2000 but decreased to very low area in 2001.

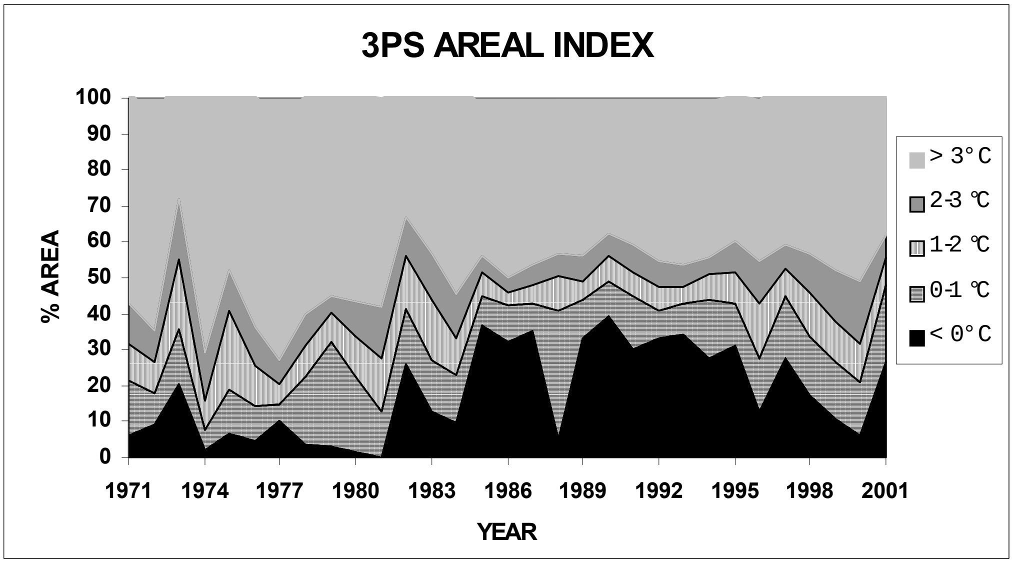


Figure 7. Spring time series of the percentage area of the bottom in NAFO Subdivisions 3Pn and 3Ps covered by water with temperatures ≤0°C, 0-1°C, 1-2°C 2-3°C and ≥3°C.

During the mid-1980s up to 1997 a cold near constant salinity water mass influenced most of the upper 100-m of the water column. This changed to much warmer and saltier conditions during 1998 and 1999 and to fresher but still warm conditions during 2000. During 2001 salinities increased to above normal values while temperatures generally decreased to below normal values.

3.2.2. Scotian Shelf and Gulf of Maine *(K. Drinkwater et al.)*

Annual mean air temperature over the Scotian Shelf, Bay of Fundy and eastern Gulf of Maine were warmer-than-normal in 2001. This was due mostly to warm conditions in June and the last four months of the year. The maximum monthly anomaly was in December (>2°C; Fig. 8). July and August matched their long-term averages (zero anomalies) while February through May were slightly below normal. Although 2001 was warm, the annual mean temperature declined for the second consecutive year after the record setting high in 1999.

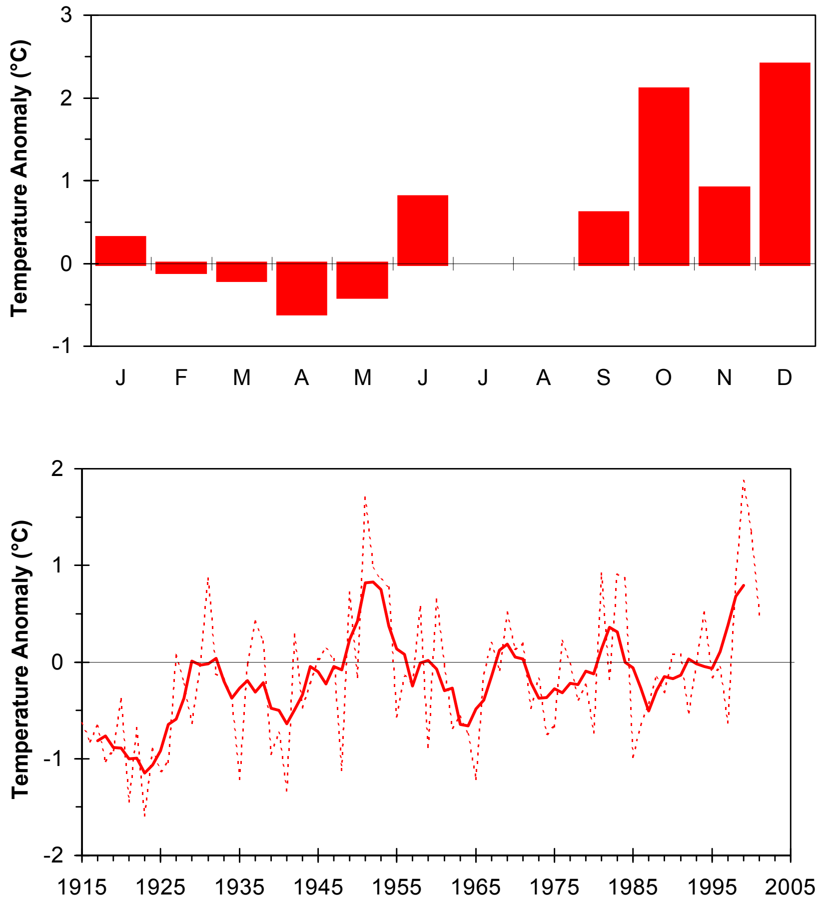


Figure 8. Sable Island air temperature 2001 monthly anomalies (top panel) and annual time series (bottom panel).

Monthly mean coastal sea surface temperatures in the Gulf of Maine during 2001 were warmer-than-normal continuing the general trend of positive temperature anomalies that persisted through the 1990s. At Halifax, monthly mean temperatures were mostly colder-than-normal reversing the warming trend of the past decade and the warmer-than-normal conditions of 1999 and 2000. In 2001, the waters in Emerald Basin were warmer-than-normal at the surface and near bottom (250 m) throughout the year resulting in positive annual temperature anomalies. At mid-depth (50 to 175 m), however, negative annual temperature anomalies were observed, principally to cold conditions in the second half of 2001.

Near-bottom temperatures over most of the Scotian Shelf during the July groundfish survey in 2001 were below normal, in some regions by greater than -2°C (Fig. 9). In the northeast, most of the bottom was covered by temperatures ranging from >1° to 4°C. These represented cooling relative to 2000 and a change from the general warming trend observed since the early 1990s. Emerald and LaHave Basins in the central shelf were covered by near-bottom temperatures >8°C, indicative of the influence of Warm Slope Water from offshore. Temperatures at 50 m and 100 m from the July survey also showed colder-than-normal temperatures, similar to the pattern near-bottom.

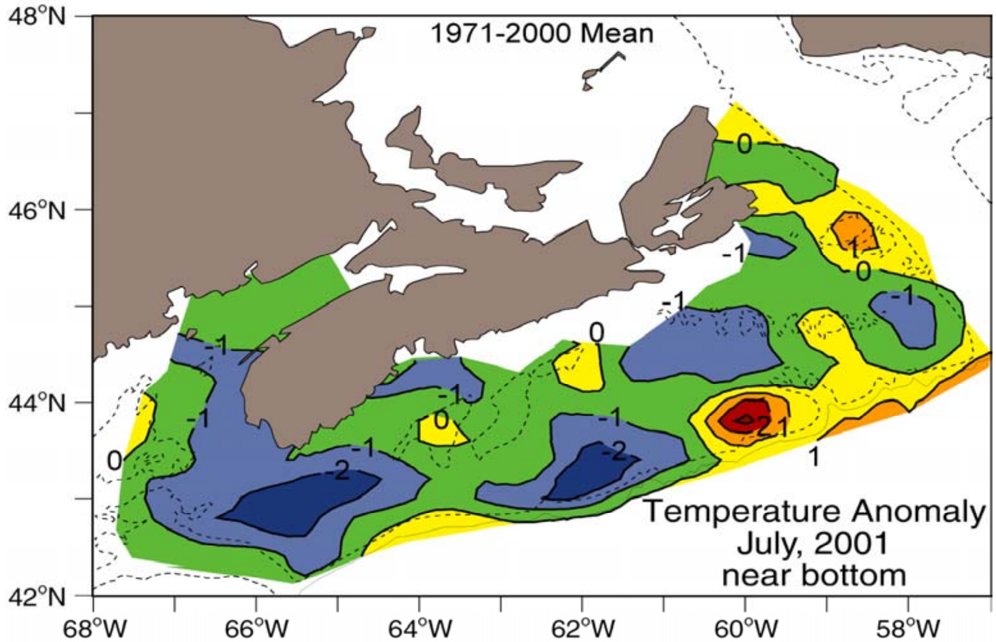


Figure 9. Near bottom temperature anomaly from July groundfish survey of 2001.

Through the 1990s, the vertical density stratification in the top 50 m over the Scotian Shelf increased significantly. Since the mid-1990s, it has been at or near its maximum in the approximately 50-year record. However, no increase in density stratification has been observed in the Gulf of Maine. The primary cause of changes in the Scotian Shelf stratification has been a freshening of the near surface waters. In 2001, stratification remained high although it has been decreasing slightly during the past two years.

In 2001, the thermal boundaries between the shelf waters and the slope waters (the Shelf/Slope front) as well as the slope waters and Gulf Stream (the north wall of the Gulf Stream) moved further offshore by approximately 20 km relative to their mean annual positions in 2000. For the Shelf/Slope front it moved to a location seaward of its long-term mean position whereas the Gulf Stream front remained shoreward of its long-term mean.

### 3.2.3 Gulf of St. Lawrence *(D. Gilbert)*

Air temperatures over the Gulf were 1°C to 2°C warmer than normal during the spring, summer and fall of 2001. In the winter of 2001, air temperatures were below normal by about 0.5°C in the eastern half of the Gulf and were essentially normal in the western half of the Gulf. As a result, there was less ice than normal except in the Strait of Belle Isle where it was near normal. Sea ice appeared earlier than normal over large sections of the Magdalen Shallows and in the north-eastern Gulf but it disappeared earlier then normal in the central region of the Gulf, by up to 15 days in south-western Newfoundland. The freshwater runoff index from the St. Lawrence River at Quebec City was below normal throughout the year.

The largest negative runoff anomaly (-4000 $m^3\ s^{-1}$) occurred in May due to earlier than normal snow melting. Relative to the 1971-2000-reference period, the annual mean freshwater discharge at Quebec City was about 2100 $m^3 \cdot s^{-1}$ below normal in 2001 (Fig. 10).

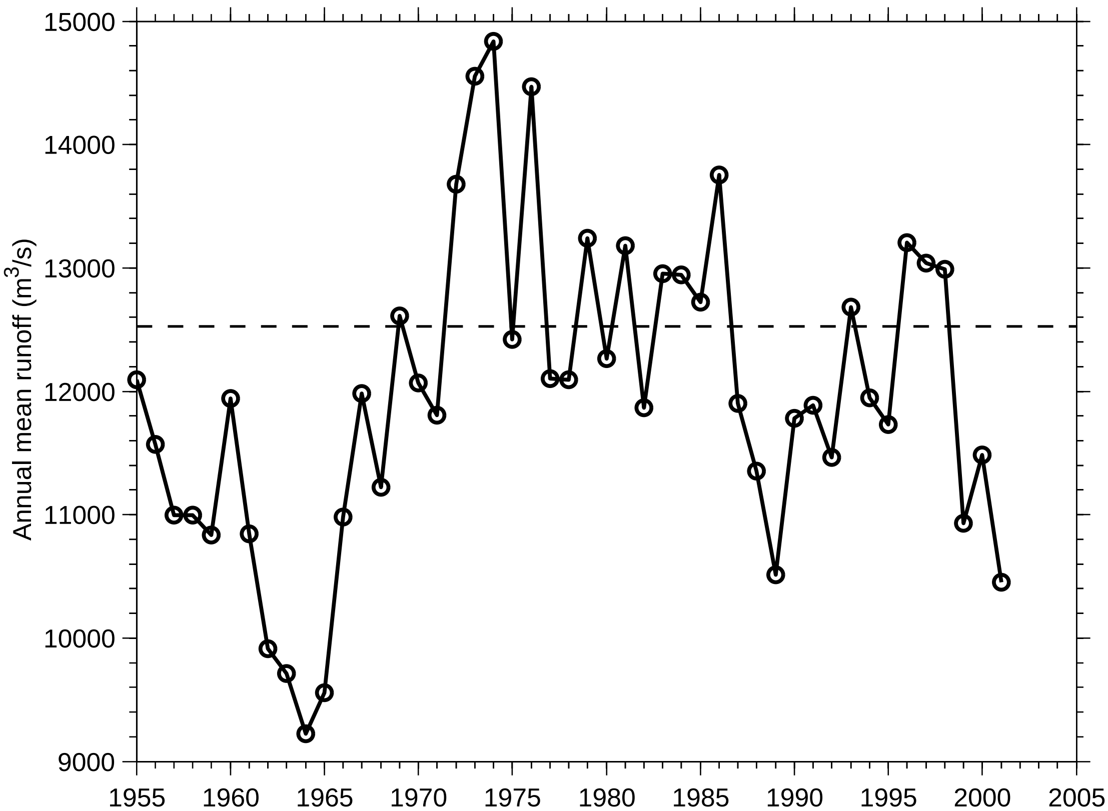


Figure 10. Yearly averaged freshwater discharge of the St. Lawrence River at Quebec City (line with circles) compared with the 1971-2000 climatological values (dashed line).

The minimum temperature within the cold intermediate layer (CIL) unexpectedly dropped by 0.6°C relative to 2000, thus returning to the 1997 value of –0.42°C. Moreover, the thickness of the CIL increased by 30 m relative to 2000. In the southern Gulf, the bottom area with temperature lower than 0°C decreased by 7500 $km^2$ whereas the bottom area with temperature lower than 1°C increased by 8000 $km^2$ compared to 2000 (Fig. 11). In the 100-200 m layer and the 200-300 m layer, the 2001 temperatures were close to their 1971-2000 normal.

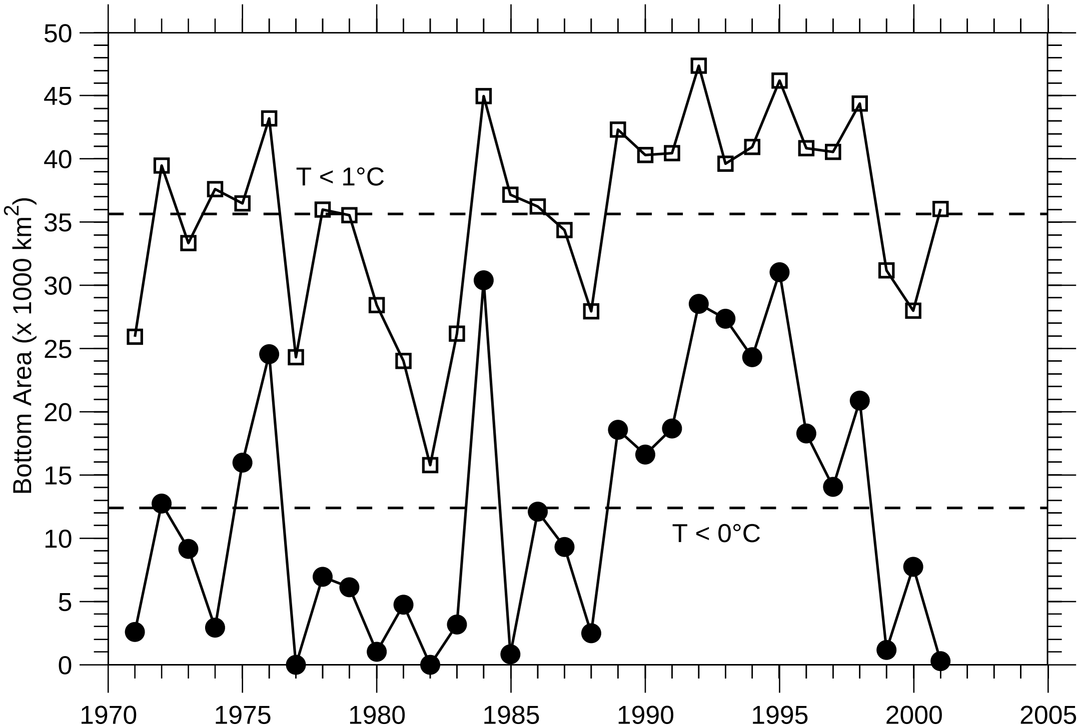


Figure 11. Bottom area with T <0°C (filled circles) and T <1°C (empty squares) in September in the southern Gulf of St. Lawrence. The dashed horizontal lines represent the 1971-2000 averages.

### 3.2.4 Labrador Sea *(R. Hendry)*

The upper layers of the Labrador Sea were observed to be warmer, saltier, and less dense in the summer of 2001 compared with conditions in 2000. These changes seem to be due largely to advection: there is no evidence for convective overturning during the winter of 2000-2001 to depths greater than 500 m.

### 3.2.5 Physical Environment Scorecard

In 2001, the physical environment scorecard was modified and shows the 2001 anomalies (in standard deviations from the 1971-2000 reference period) in relation with anomalies for the last five years (Table 1). The new format should facilitate the identification of recent trends in the various indices.

Table 1 Environmental scorecard for 2001.

| Area | Index | Region | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|
| NW Atlantic | NAO | | -0.63 | -0.34 | 1.18 | 1.1 | -0.96 |
| Newfoundland/ Labrador | Annual Air Temperature | Labrador (Cartwright) | 0.125 | 1.103 | 1.841 | 1.007 | 1.218 |
| | | Newfoundland (St. John's) | -0.69 | 1.14 | 2.52 | 1.56 | 0.78 |
| | Sea Ice | Lab/Nfld (Area) | -0.58 | -0.99 | -1.21 | -0.88 | -1.28 |
| | Surface Temperature | Station 27 | -0.4 | 0.85 | 1.81 | 1.15 | 0.93 |
| | Integrated Temp | Station 27 (0-50) | 0.05 | 0.18 | 1.25 | 0.96 | 1.73 |
| | | Station 27 (0-176) | -0.03 | -0.03 | 1.34 | 1.1 | 1.21 |
| | Near-Bottom Temperature | Station 27 | 0.83 | 1.35 | 1.45 | 1.31 | 1.52 |
| | | Nfld. Grand Bank | -0.54 | 0.24 | 0.61 | 0.59 | 0.05 |
| | | St. Pierre Bank | -0.36 | -0.18 | 0.61 | 0.65 | -0.72 |
| | CIL | Eastern Nfld Shelf | -1.03 | -0.35 | -0.93 | -0.17 | -1.24 |
| | | Grand Bank | 0.26 | -0.73 | -1.38 | -1.26 | -0.55 |
| | | Hamilton Bank | -1.46 | -0.64 | -1.91 | 0.25 | -0.52 |
| | Salinity | STATION 27 (SURFACE) | -0.26 | -0.3 | -0.39 | -0.22 | -0.57 |
| | | STATION 27 (BOTTOM) | -0.1 | 0.4 | -0.2 | -0.3 | -0.1 |
| | Stratification | STATION 27 | 0.4 | 0.9 | 1.3 | 0.5 | 1 |
| Gulf of St. Lawrence | Annual Air Temperature | Gulf St. Lawrence (Magdalen Islands) | -0.264 | 1.917 | 2.777 | 1.468 | 1.947 |
| | Integrated Temp | Cabot Strait (200-300 m) | 0.069 | -0.81 | 0.629 | 0.137 | 0.57 |
| | | Gulf of St. Lawrence (30-100 m) | -0.303 | -0.81 | 0.356 | 0.927 | -0.281 |
| | | Gulf of St. Lawrence (100-200 m) | -0.253 | -0.3 | 0.533 | 0.533 | -0.026 |
| | | Gulf of St. Lawrence (200-300 m) | 0.302 | -0.31 | -0.13 | 0.027 | 0.302 |

**Cold/Fresh Conditions**

>2
>1.5 to 2
>1 to 1.5
>0.5 to 1
-0.5 to 0.5

**Stn. Devs.**

**Warm/Salty Conditions**

>2
>1.5 to 2
>1 to 1.5
>0.5 to 1
-0.5 to 0.5

| Area | Index | Region | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|
| | Near-Bottom Temperature | Magdalen Sh. Area with T < 0 | -0.04 | 0.61 | -1.27 | -0.65 | -1.36 |
| | | Magdalen Sh. Area with T < 1 | 0.49 | 0.94 | -0.62 | -1.00 | -0.4 |
| | CIL | Gulf St. LawrenceMinimum Temp. (1948-1999) | -0.38 | -1.03 | 0.22 | 0.90 | -0.38 |
| Scotian Shelf/ Gulf of Maine | Annual Air Temperature | Scotian Shelf (Sable Island) | -0.923 | 1.283 | 2.77 | 1.984 | 0.714 |
| | | Gulf of Maine (Boston) | -0.769 | 1.325 | 0.941 | -1.01 | 0.926 |
| | Sea Ice | Scotian Shelf (Area) | -0.298 | -1.37 | -1.31 | -1.20 | -1.17 |
| | Surface Temp | Halifax (SST) | -0.299 | | -0.03 | 0.44 | -0.952 |
| | | Bay of Fundy (St. Andrews SST) | 0.341 | 0.962 | 2.307 | 2.002 | |
| | | Gulf of Maine (Boothbay SSTs) | 0.344 | 0.538 | 1.993 | 2.38 | 2.283 |
| | Near-Bottom Temperature | NE Scotian Shelf (Misaine Bank - 100 m) | -0.428 | -0.02 | 0.797 | 1.406 | -0.27 |
| | | Emerald Basin (250 m) | 0.331 | -1.69 | -0.22 | 0.191 | 0.274 |
| | | Georges Basin (200 m) | 0.345 | -2.57 | 0.985 | 1.036 | 0.181 |
| | | Prince 5 (90 m), Bay of Fundy | -0.46 | -0.85 | 1.893 | 1.596 | -0.544 |
| | Salinity | Prince 5 (90 m) | -0.095 | -1.07 | 0.799 | 0.483 | -0.157 |

3.2.6 Questions and Discussion

Questions and discussions followed the presentations on the physical environmental conditions. The substantial decline seen in recent years in the NAO index was noted. In general, low NAO index results in increased southeasterly winds, but that may depend where the low and high-pressure cells are located in Iceland and the Azores areas. In 2001, the increased easterly flow along the western north Atlantic region could be related to the low NAO. Another issue was the possibility that the stronger onshore flow, related to the low NAO, in recent years may be related to the intrusion of Labrador seawater into the Gulf of St. Lawrence through the Strait of Belle Isle. It was indicated that wind forcing by increasing pressure gradients could also create higher sea level along the coast creating a pressure gradient sufficient to increase flow through the Strait. A closer look at the wind direction more specifically will be needed to fully address the question. Concerning the areal extent of ice cover and the availability of data on ice thickness, it was mentioned that data on ice thickness are not normally collected in AZMP region but some data are available in the Gulf of St. Lawrence. Also, Environment Canada Ice Service does provide some qualitative data regarding average thickness of ice and volume calculations but, at present, they are not quantitative enough to include in the time series.

Concerning the low salinity observed during the recent years along coastal and eastern Newfoundland Shelf areas, although detailed analyses have not been conducted to address this specifically, more ice melt upstream is the preferred explanation. Moreover, there is a good correlation between ice cover and salinity at Station 27 and fresh conditions in southern waters over the past few years. Aliasing of the observations due to differences in the timing of the cruises among years should not have affected the pattern as the timing of the cruises is normally within a week or two of each other. However, another possibility was proposed; that above normal precipitations in Hudson Bay area may be related to low salinities observed along southern Labrador and northeast Newfoundland Shelf. Questions were also raised on the possibility that Southern Newfoundland waters may be the source of the CIL in the Gulf of St. Lawrence and the eastern Scotian Shelf, but it was generally concluded that to answer such questions circulation across the zonal region needs further investigation.

An increase in the CIL volume and a cooling in the eastern Gulf were noted in 2001, but the colder conditions were not observed in the southern Gulf. The intrusion of Labrador seawater (via Belle Isle Strait) may explain these observations but large-scale atmospheric circulation might also play a role in explaining the differences between the northern and southern Gulf. A detailed analysis of winds together with modelling efforts would be helpful also. It was mentioned that calculation of heat flux would help in distinguishing between atmospheric effects versus circulation and intrusions of Labrador seawater in Gulf of St. Lawrence. However, the presence of ice cover in the Gulf creates difficulties in calculations of heat flux in this region.

The issue was raised of the Magdellan Shallows area showing different air temperature conditions between Denis Gilbert (suggesting cooler conditions) and Ken Drinkwater (suggesting warmer conditions) analyses. One interpretation of these differences is related to the problems of contouring data and the different average periods (1951-80) and (1971-2000).

Denis Gilbert indicated that Environment Canada is still using older averaging period versus the current standard oceanographic convention of 1971-2000.

The causes of the observed cooling along the Halifax Section transect in June extending to 250 m were discussed. Intrusions of waters from further north was a likely possibility but examination of the T/S characteristics of the water sources would be needed to identify the main contributing (inshore or offshore branch of the Labrador current) sources of cooler waters. Moreover, the general circulation patterns in the Labrador Sea was discussed and it was indicated that the gradient in sea level can be used to estimate the strength of boundary currents (cyclonic gyres), and may have general validity for surface, and deeper, flow estimation. The question was raised about the relation between the strength of the inshore-offshore flow in Labrador Current (from E Colbourne presentation) and the results from the AR7W line. However, it was mentioned that higher flows were generally observed in the inshore branch of the Labrador Current along the Newfoundland Shelf.

The Environmental Overview Scorecard was specifically discussed. All scorecard values presented for this year and recent years have been adjusted for the newer (1971-2000) 30-year averaging period. The trend back to cooler periods in the early to mid-90's was apparent during the recent shift in 30-year averaging periods from 1961-1990 to 1971-2000. Several ameliorations were discussed. Consistency in color codes should be applied to detect trends and patterns in environmental scorecard and consideration for biological variables of interest as well (Glen Harrison). Stratification indices to all areas, ice index for the Gulf will be added and, also, work is considered to include wind indices. Labrador Sea information should be included each year in environmental overviews since that may provides useful information on boundary conditions. However, work is needed to decide what indices would be useful; e.g., some index of convection.

***Recommendation****: FOC recommends that Labrador Sea physical and chemical/biological information should be included to the physical environment overview each year.*

Finally, some methodological issues were discussed. One question was about possible ways to illustrate the relative changes further back in time (scorecard just show the last five years), maybe by using multivariate techniques (e.g., MDS) to summarize over the whole time series. It was noted that the 5 years perspective is short and that it is difficult to inter-relate the different scorecards (among regions). However, it is to remember that the scorecard was not designed for this purpose of multivariate (e.g., physical oceanography – recruitment) comparisons but to provide a visualization of the recent perspective. However, it was agree that the multidimensional approach should be tried despite the concern that these multidimensional techniques assume linearity but many of these processes are not.

### 3.3 *Biological Oceanographic Conditions*

#### 3.3.1 Newfoundland Shelf and Labrador *(P. Pepin and G. Maillet)*

Information were presented concerning the seasonal and interannual variations in the concentrations of chlorophyll a, major nutrients, rates of primary production, as well as the abundance of major taxa of phytoplankton and zooplankton measured from Station 27 and standard oceanographic transects on the Newfoundland Shelf. Temporal and spatial series of the different biological, chemical, optical, and physical measures during 2001 were presented and contrasted with previous information from earlier periods when data are available. Variations in optical conditions including attenuation and euphotic depth were comparable to the previous year. The magnitude of the spring bloom was comparable between 2001 and 2000, but the timing and duration of the bloom occurred earlier in 2000 and persisted longer by nearly two-fold compared to 2001 (Fig. 12).

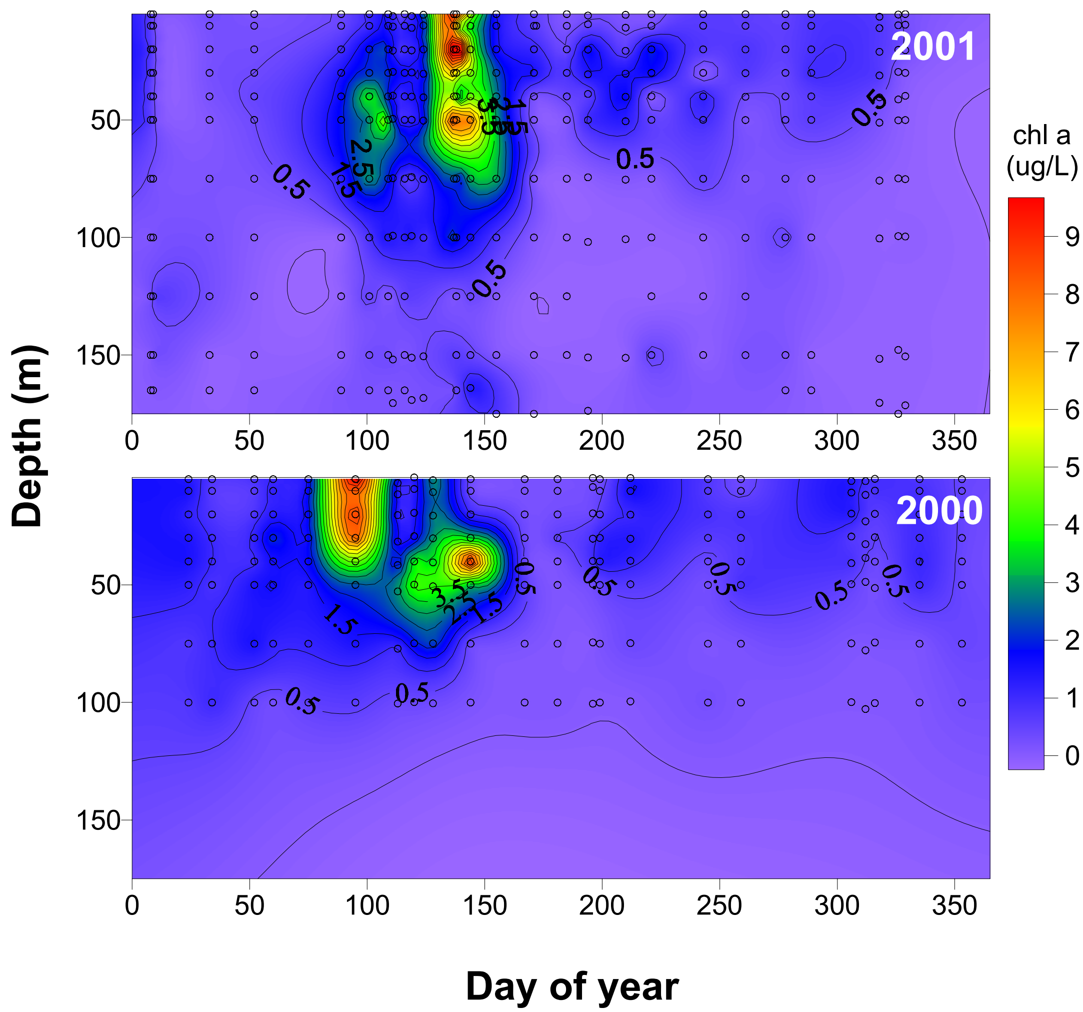


Figure 12. Vertical profiles of chlorophyll a concentrations versus day of year at Station 27. Sample locations are shown as small open cycles.

Time series of major nutrient pools at Station 27 showed differences between years. Silicate and nitrate pools in the upper mixed layer showed expected seasonal trends during 2000 and 2001. Depletion of nitrate was more prominent in 2000 during the production cycle in contrast to 2001. Integrated deep nutrient pools were nearly two-fold higher in 2000 compared to 2001.

The magnitude, timing, and duration of stratification were similar during 2000 and 2001, although the rate of onset in stratification appears too have been somewhat higher in 2001 compared to 2000. A prolonged maximum in mixed layer depth was observed during late winter-spring 2001 and may have contributed to the delay in the formation of the spring bloom. Major groups of phytoplankton were enumerated seasonally at the fixed station and along standard AZMP transects. The most notable difference observed between recent years was the widespread reduction in flagellates and diatoms in the coastal and Shelf areas during 2001.

The numerical abundance of major zooplankton groups at Station 27 was generally similar to that previously observed in 1999 and 2000, although densities were generally lower in the fall of 2001 (Fig. 13).

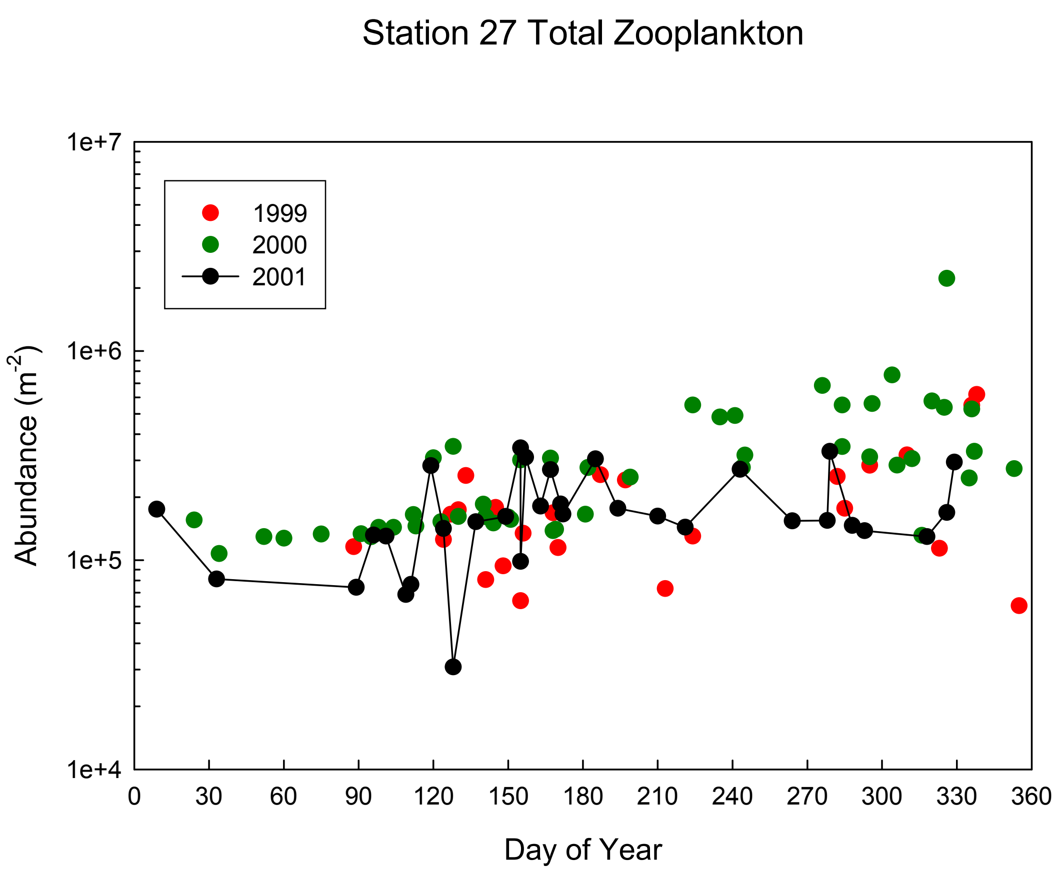


Figure 13. Seasonal combined abundance of all major zooplankton groups at Station 27.

The most notable exception was found in the abundance of *Calanus finmarchicus* in the winter of 2001, when a strong cohort of young stages from the previous fall dominated. There was evidence of a delay in the peak production of *C. finmarchicus* stage l copepodites by approximately 30 days in contrast to the two previous years. The density of large calanoid nauplii also showed a similar delay and peak concentrations was approximately 50% of that observed in the previous year although overall levels were comparable to those observed in 1999 (Fig. 14). Overall, the zooplankton community was similar in composition to that observed in 1999 and 2000 although the relative abundance of pelagic gastropods remained high for an extended period in contrast to the two previous years. Overall zooplankton abundance on the Newfoundland Shelf was similar to previously observed densities throughout the spring and summer periods, with the exception of the coastal areas along the Bonavista Bay transect where densities of all major taxa were lower during the summer observation period. In contrast, densities of all major taxa along the coast of Labrador appeared to be elevated during the July research vessel survey.

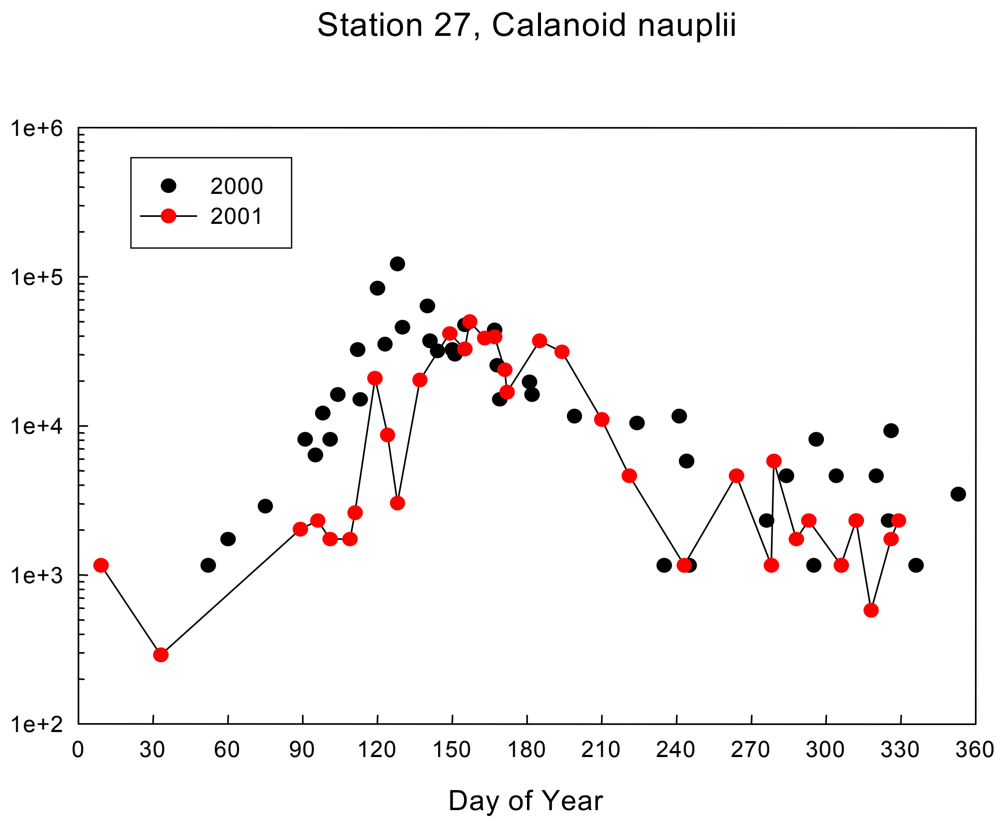


Figure 14. Seasonal abundance pattern of large (> 200 µm) calanoid nauplii at Station 27 in 2000 and 2001.

3.3.2 Scotian Shelf, Gulf of Maine, Southern Gulf of St. Lawrence *(G. Harrison et al.)*

The mean optical, chemical and biological oceanographic conditions in the Maritimes Region and adjacent waters in 2001 with the conditions in 2000 and over the long-term was presented. Many of the oceanographic properties observed in 2001, based on the core Atlantic Zonal Monitoring Program (AZMP) measurements (fixed stations, seasonal sections, groundfish surveys, remote sensing), were similar to properties observed in 2000. Nitrate concentrations at the fixed stations and the summer Scotian Shelf groundfish survey did not change significantly between 2000 and 2001. On the other hand, concentrations observed during the section surveys were substantially lower in spring and higher in fall 2001 than in 2000. However, the timing of the 2000 and 2001 surveys may explain these differences. In 2001, the surveys were later (by as much as a month) than in 2000. Since nutrient concentrations decrease in surface waters in spring, reach minimum values in late summer and increase again in the fall as vertical mixing intensifies, the later surveys in 2001 would be expected to sample lower nutrient waters in the spring and higher nutrient waters in the fall than in 2000. A similar explanation can be used to reconcile the lower chlorophyll concentrations observed on the 2001 spring section survey compared with the 2000 survey, i.e. chlorophyll levels would be expected to be lower in May (2001) than in April (2000). Thus, adjusted for sampling time, survey nutrients and chlorophyll were likely not different between years.

Nutrients and chlorophyll differences between the 2000 and 2001 fall Southern Gulf groundfish could not be explained by sampling bias; concentrations of both properties were lower in 2001. Phytoplankton community composition, where assessed (fixed stations), was essentially the same in 2001 as in 2000. Only for a few selected properties can yearly conditions be compared with the long-term climatological mean. Sufficient nutrient and chlorophyll data exists to generate the climatology; in 2001, nitrate and chlorophyll concentrations were similar to the long-term mean on the Scotian Shelf. The longest continuous biological (plankton) record in the Maritimes Region comes from the CPR. CPR-phytoplankton data for the Scotian Shelf are not yet available for 2001 but trends over the past few years have shown declining abundance, although levels remain well above the long-term mean. A shift in the timing of the spring bloom (earlier in more recent years) has also been evident. Similar long-term patterns in phytoplankton were observed outside the AZMP region.

Some of the observed differences in zooplankton between 2000 and 2001 could be attributed to survey timing as described above (i.e. zooplankton were higher in May, 2001 than in April, 2000 because populations usually do not peak until summer), however, most differences appear to be real. Feeding/reproducing zooplankton were somewhat more abundant in the region in 2001 than in 2000 but over-wintering populations (Emerald Basin) were generally lower. Community composition (fixed stations) was generally comparable between the two years although *Calanus finmarchicus* contributed considerably more to the zooplankton at P-5 (Bay of Fundy) in 2001 than seen previously. The decade-long record of over-wintering zooplankton (Emerald Basin) indicates that abundances in 2001 were significantly lower than the long-term mean in this deep-water basin. In a similar way, the multi-decade CPR data record suggests that the abundance of some components of the zooplankton (*Calanus* sp., euphausiids) were on a declining trend in 2001, and well below the climatological mean, while others (*Paracalanus* sp, *Pseudocalanus* sp.) have been increasing and are currently above the climatological mean. As in the case of phytoplankton, the CPR data (Scotian Shelf) suggest that the zooplankton peak abundance is now occurring earlier in the year than in the past.

3.3.3 Gulf of St. Lawrence *(M. Starr and M. Harvey)*

Information were reviewed concerning the seasonal and interannual variations in the concentrations of chlorophyll a, nitrates, and silicates as well as the abundance of the major species of phytoplankton measured from three fixed stations and six sections crossing the Estuary and Gulf of St. Lawrence. The conditions during 2001 are presented and compared with previous information from the period of 1992-2000. In 2001, the initiation of the spring phytoplankton bloom at Station Rimouski in the Lower St. Lawrence Estuary occurred in early May, that is, 6-8 weeks earlier than usual. This continued a trend that began in 1998 (Fig. 15). This major shift in the timing of the phytoplankton cycle is believed to be due to the below-normal spring freshwater runoff observed in the St. Lawrence basin since 1998.

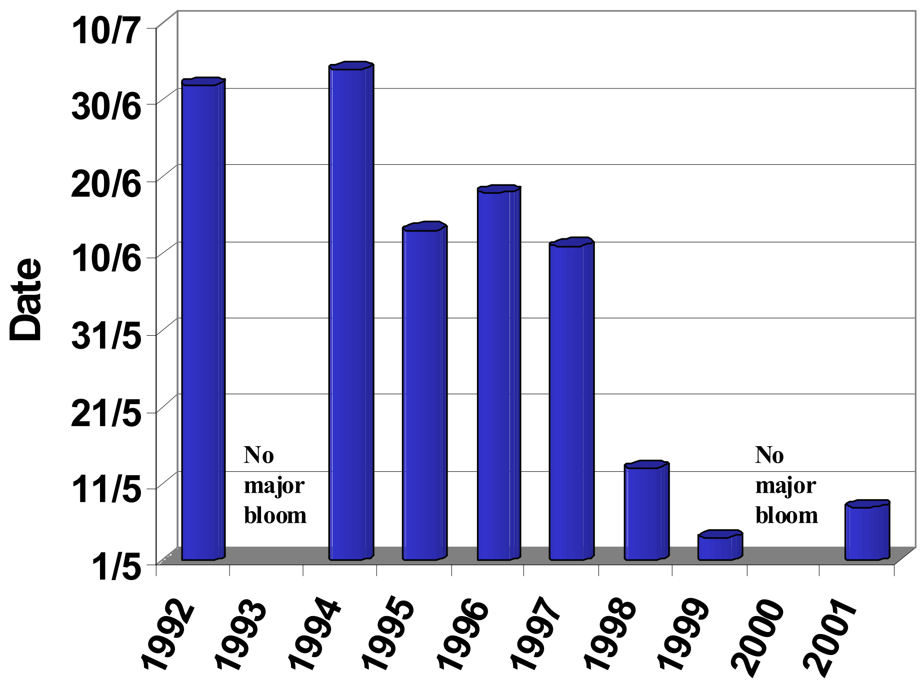


Figure 15. Date of onset of the primary bloom defined by the first incidence of chlorophyll concentrations greater than 100 mg of chlorophyll *a* per $m^2$ at Station Rimouski, 1992-2001.

For the second consecutive year, the average phytoplankton biomass at Station Rimouski during spring-summer 2001 was much lower compared to the 1995-1999 period (except for 1998) but comparable to the 1992-1994 period (Fig. 16).

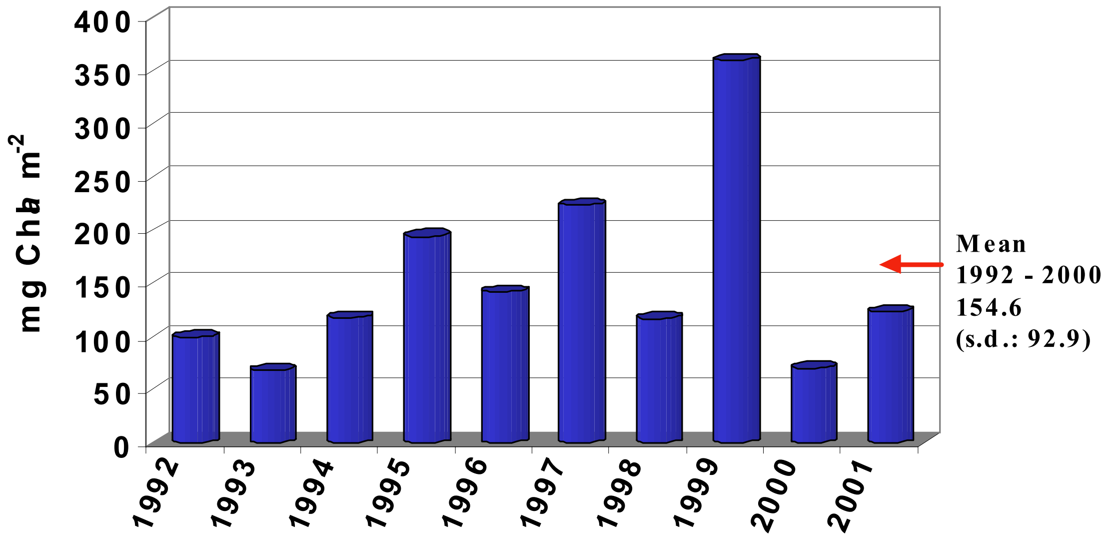


Figure 16. Mean integrated (surface to 50m depth) chlorophyll *a* levels at Station Rimouski from May to August, 1992-2001.

In particular, the phytoplankton biomasses in July 2001 were much lower compared to previous observations. This is believed to be due to a more intense mixing period in the Lower St. Lawrence Estuary in July 2001.

In the Anticosti Gyre and the Gaspé Current, the reduction of nutrients in the surface layer during spring-summer-fall 2001 was much less pronounced compared to the 1996-1999 period (except for 1998). In the Gaspé Current, near-surface chlorophyll levels were also generally lower in 2001 compared to the previous two years. On the other hand, summertime chlorophyll levels in the Anticosti Gyre were higher in 2001 compared to those observed in 1997-2000. Satellite observations of sea surface chlorophyll concentrations indicate that the 2001 spring bloom occurred in late April for most areas of the Gulf of St. Lawrence. This contrasts with previous observations showing a greater spatial variability in the timing of the bloom. In late spring 2001, the chlorophyll levels were extremely low for most areas of the Gulf of St. Lawrence. The highest levels were observed in the nutrient-rich waters of the St. Lawrence Estuary and Gaspé Current system. In the eastern and southern part of the Gulf, the chlorophyll and nitrate levels in the surface layer in late spring 2001 were not notably different than those observed in 1999-2000.

The analysis of community composition showed that the 2001 spring bloom over most of the Gulf was principally dominated by the diatom *Neodenticula seminae* (Fig. 17). This is the first occurrence of this species in the Gulf of St. Lawrence; this species is usually found in North Pacific waters. This unusual event is consistent with recent observations indicating a greater influx of Pacific waters into the Atlantic Ocean (via the Bering Strait) and with hydrographic evidence of a major intrusion of Labrador Slope Water into the Gulf of St. Lawrence in 2001.

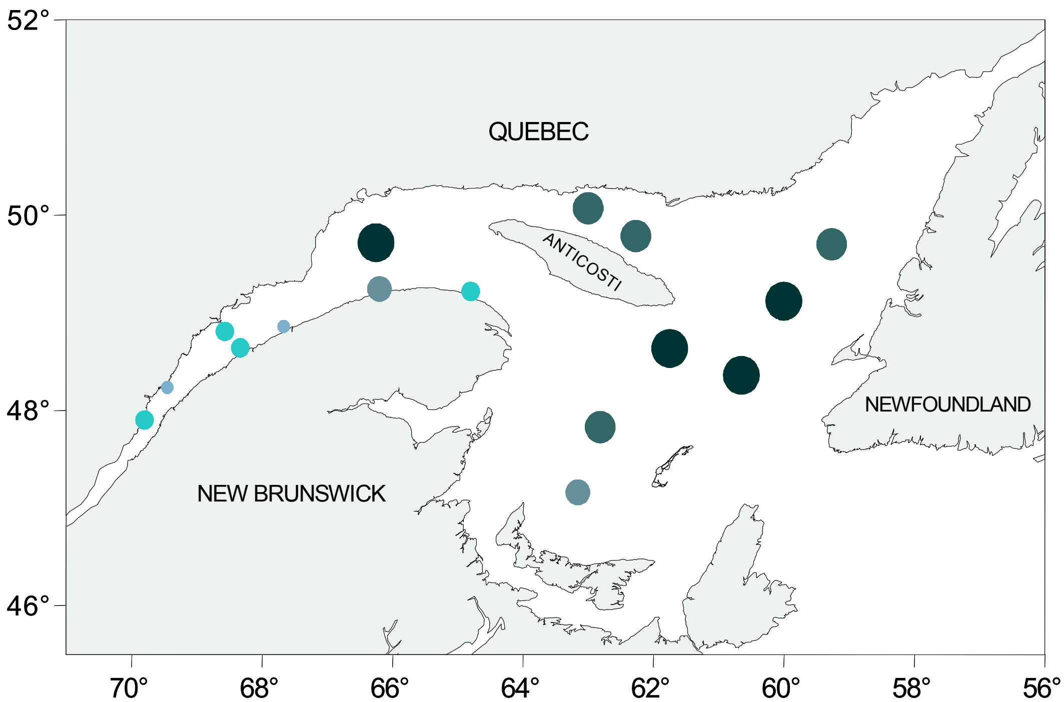


Figure 17. Abundances (cells/L) of the diatom *Neodenticula seminae* in late April 2001 in the Estuary and Gulf of St. Lawrence.

For zooplankton, the temporal variability of the biomass, abundance, and species composition at two fixed stations and six transects of the AZMP (Anticosti Gyre and Gaspé Current) in 2001 we reviewed. In addition, an overview of the interannual variability of the macrozooplankton species composition, abundance, and biomass in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence as measured in September in each year between 1994 and 2001 was presented.

*AZMP fixed stations and transects*: The annual minimum and maximum zooplankton biomasses occur in April in the Anticosti Gyre and the Gaspé Current, respectively. This difference in the timing of the maximum and the minimum observed biomasses at the two stations seems to be typical since the same situation was observed in 1999 and 2000. Both the mean integrated zooplankton biomass and abundance observed in 2001 in the Anticosti Gyre and the Gaspe Current were on par with what we observed in 1999 and 2000 (Fig. 18).

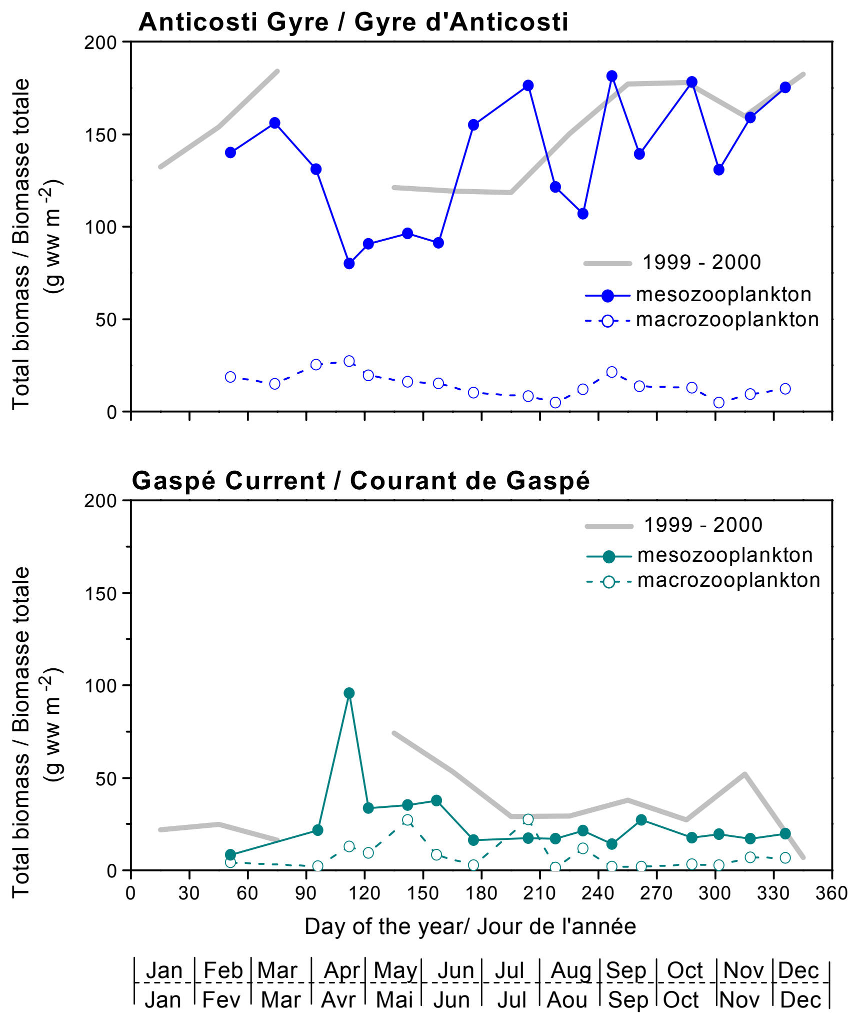


Figure 18. Monthly variations of the total zooplankton biomass in the Anticosti Gyre and the Gaspé Current in 2001.

The total abundance of zooplankton in 2001 varied between 22,000 and 317,000 ind.•m$^{-2}$ in the Gaspé Current and between 28,500 and 213,000 ind.•m$^{-2}$ in the Anticosti Gyre. At both stations, the total abundance of zooplankton observed in 2001 was on par with observations made in 2000 (Fig. 19).

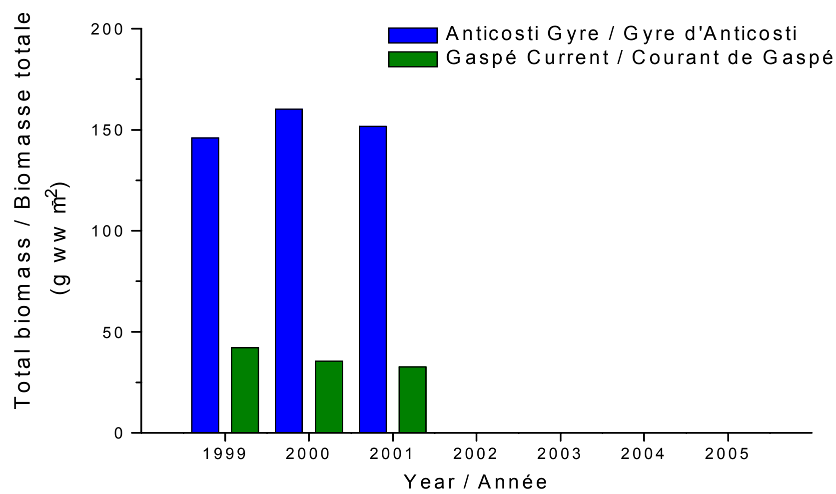


Figure 19. Mean integrated zooplankton biomass in the Anticosti Gyre and the Gaspé Current in 2001.

Copepod eggs, juveniles, and adults were clearly dominant, accounting for more than 80% of the zooplankton community for all sampling dates in the Anticosti Gyre and the Gaspé Current except in May and July in the Gaspé Current. In the Anticosti Gyre, the minimum and the maximum copepod abundances occurred in May and November respectively and were synchronized with the minimum and the maximum values observed in 2000; the minimum and the maximum copepod abundances were observed in June and September in the Gaspé Current, ca. 1.5 months earlier than in 2000.

The total zooplankton biomass varied between 3 and 208 g ww•m$^{-2}$ along the six transects sampled in June and December 2001 in the Lower Estuary and the Gulf of St. Lawrence. The highest biomasses were found along transects located over the Laurentian Channel (St. Lawrence Estuary, Sept-Iles, Anticosti, and Cabot Strait) and the lowest were in the northern (Bonne Bay) and the southern (Magdalen Island) regions. The zooplankton biomass observed in 2001 along all transects for both seasons (spring and fall) was on par with observations made in 2000 except along the Magdalen Island transect, where the zooplankton biomass was three and two times higher in spring and fall 2001 than in spring and fall 2000, and along the Cabot Strait transect, where the biomass was two times lower in fall 2001 than in fall 2000.

The overall abundance of zooplankton was generally lower in 2001 than in 2000 for all regions and for both seasons except for fall in the southern Gulf (Magdalen Island transect), where the inverse was true. Globally, in both the Lower Estuary and the Gulf of St. Lawrence, the overall abundance of zooplankton was 64% and 41% lower in spring and fall 2001 than in 2000. This difference in abundance between the two years was due to the lower abundance of both copepod and invertebrate eggs in 2001.

Macrozooplankton species composition, abundance, and biomass for 1994-2001: There were no significant changes in the macrozooplankton and the mesozooplankton biomasses in 2001 compared to 2000 (Fig. 20).

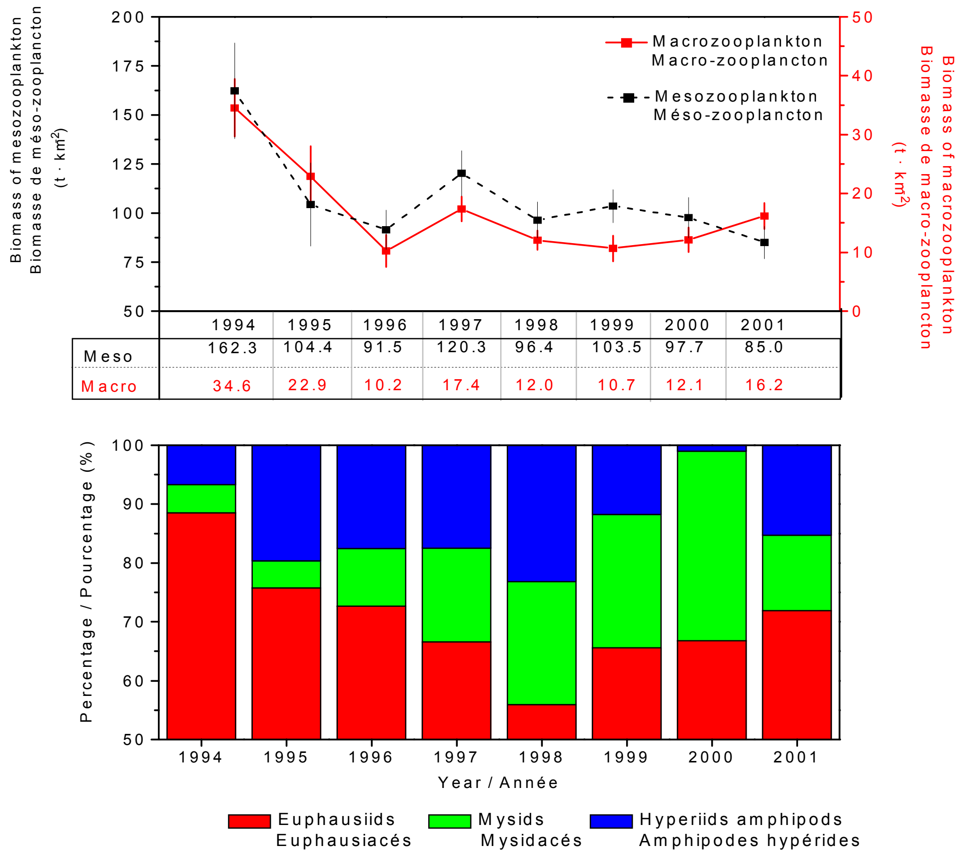


Figure 20. Mean biomass (± SE) of mesozooplankton and macrozooplankton in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2001 (upper panel) and relative abundance of the three most important macrozooplankton groups in term of biomass (lower panel).

However, there were significant changes in the mean abundance in some macrozooplankton species: 1) decreases in the euphausiid *Thysanoessa raschii*, 2) increases in the euphausiid *Meganyctiphanes norvegica*, the chaetognath *Sagitta elegans*, the gelatinous zooplankton *Aglantha digitale*, *Obelia* sp. and *Boreo* sp., and the pelagic amphipod *Themisto libellula*. The mean abundance of the latter species increased from 1.7 ind.•10 $m^{-2}$ in 2000 to 92.3 ind.•$10^{-2}$ in 2001. There was a significant negative correlation between the annual CIL core temperature index and the abundance of *T. libellula* in the Lower St. Lawrence Estuary and the northwest Gulf from 1994 to 2001 (Fig. 21).

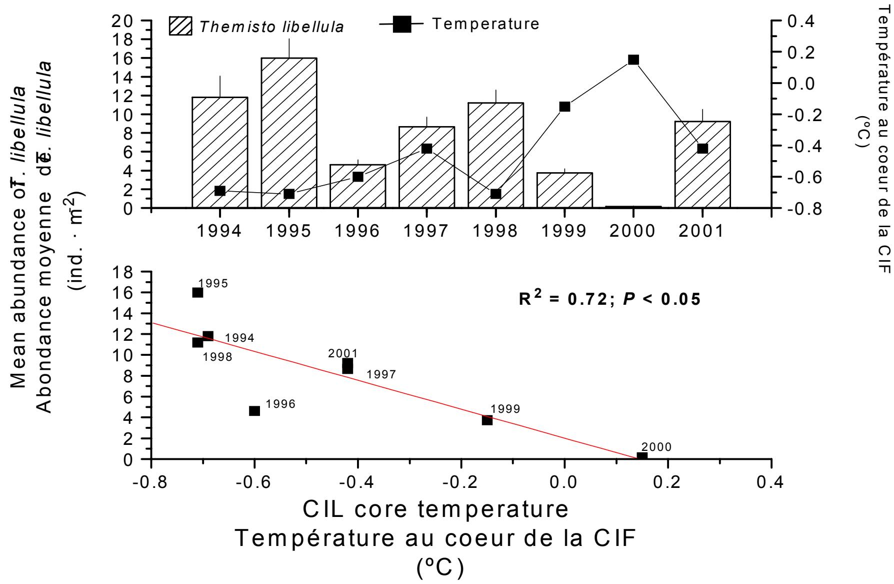


Figure 21. Relationship between the annual CIL core temperature index and the abundance of *T. libellula* abundance in the Lower St. Lawrence Estuary and the northwest Gulf from 1994 to 2001.

Based on this relationship, this species could be considered as an index of the intrusion of cold Labrador Current water into the Gulf of St. Lawrence. If this hypothesis is true, 2001, 1998, and 1995 would be years when there where important intrusions into the Gulf of St. Lawrence.

### 3.3.4 Northwest Atlantic Plankton trends *(D. Sameoto)*

The 1990s appear to be a unique period in the CPR time series in the region of the western North Atlantic between Iceland and North America since at no other time in the data series were observed that such large and persistent changes in abundance and timing of the blooms. The most striking changes occurred in the phytoplankton abundance, which is reflected in the phytoplankton color index. The color index values in the 1990s increased markedly between October and March in the region west of longitude 45° W, but it did not change from values seen in the earlier years east of longitude 45° W. The yearly mean values of the phytoplankton color index showed a large increase in the 1990s on all the three regions west of 45° W, with the greatest relative increase occurring on the Scotian Shelf.

The diatom and dinoflagellate abundance changes were independent of one another even though both showed increases in the 1990s. Diatoms increased during the months of January to March on all regions west of longitude 45° W. Dinoflagellates increased primarily on the Grand Banks and eastern Scotian Shelf regions during October to March, with the greatest increase occuring on the Grand Banks. Increases in these two taxa did not occur in the eastern North Atlantic region.

A significant decrease in abundance of *C. finmarchicus* stages 1 to 4 occurred after 1991 in all regions west of longitude 45° W. The abundance of *C. finmarchicus* stages 5 to 6 also decreased below the climatological mean in 1994 and remained low into 2000. The decrease in abundance of both stage groups occurred in July to September. There were no consistent decreases in abundance of these taxa on the eastern Atlantic region in the 1990s. *Pseudocalanus/Paracalanus* spp. increased on the Grand Banks and eastern Scotian Shelf regions during the months of January to March but deceased in abundance during July to September in the 1990s. Total euphausiids abundance decreased after 1991 in regions west of longitude 45° W. But, there was no evidence that any significant change occurred in the total euphausiids east of longitude 45° W.

The bloom periods for diatoms and dinoflagellates occurred progressively earlier in the 1990s than in the years prior to the 1990s on the regions west of longitude 45° W. There was no shift in the timing of the bloom periods for these two taxa on the eastern Atlantic region in the 1990s. The *C. finmarchicus* stages 1 to 4 bloom on the Scotian Shelf occurred approximately a month earlier in the 1990s than in the earlier years. But the bloom occurred about a month later on the regions of the Grand Banks and western Atlantic. In the eastern Atlantic there was no change in the timing of the bloom in the 1990s compared to the earlier years. The bloom period of *C. finmarchicus* stages 5 to 6 did not change significantly in any of the regions during the time series.

The CPR data provided evidence that significant changes in the abundance and the timing of blooms occurred during the 1990s in some of the major phytoplankton and zooplankton taxa. These changes occurred in the regions west of longitude 45° W that includes the Grand Banks, Scotian Shelf and Gulf of Maine/Georges Bank, all of which are influenced by the Labrador Current. An increase in the phytoplankton color index after the mid-1980s was also reported in the central northeast Atlantic and central North Sea. The reasons for this increased color index are uncertain, but it was suggested it maybe related to a large export of fresh water from melted ice and permafrost in and around the Arctic Seas as a response to the high positive temperature anomalies in northern Eurasia and Alaska.

Most of the changes in abundance appeared to start in the earlier 1990s and persisted until 2000. There was a change in the direction of the trend of the annual means of a number of taxa, *C. finmarchicus* stages 1 to 4, *C. finmarchicus* stages 5 to 6, *Pseudocalanus/Paracalanus* spp. and total euphausiids on the Scotian Shelf. The trends of these taxa in 1997 switched direction from negative to positive and it remained positive until 2000, the last data year. The total euphausiids in the western and eastern Atlantic did not reverse the downward trend in the 1990s; both areas remained below the climatological mean. There was no indication that the patterns of high values seen during the 1990s for phytoplankton color index, total diatoms or total dinoflagellates were decreasing in 2000.

3.3.5 Questions and Discussion

A discussion followed the presentations on the biological and chemical environmental conditions. The lower nutrient and chlorophyll concentrations on the Scotian Shelf in the spring of 2001, relative to 2000, was debated but it was clear from the SeaWiFS composites (satellite data) that this was mostly due to a delay in the spring survey so that it missed much of the spring bloom. However, the later bloom at Station 27 appears related to delay in stratification. Much interest was raised by the report on the presence and the dominance of an unusual diatom species in the Gulf of St. Lawrence in 2001. An intrusion from the Pacific via the Arctic was proposed as a probable explanation; however, alternatively, an origin from ballast water could be another possibility for the (new) diatom. Erica Head also remarked that in 2000 they observed a large phytoplankton spp they have never seen before but it was found after examination of CPR data that the species was very common on Scotian Shelf in the 1990s but not in April (i.e., it just appeared earlier than usual in 2000), and perhaps something similar happened in the Gulf in 2001. The answer however was that in earlier years the species has never been seen in samples from other time of the year in Gulf.

The question was raised about a possible relationship between the delayed copepods production at Station 27 and the delayed phytoplankton bloom. The answer was that it is not possible to determine if the pattern is due to delay in production or survival of the nauplii. It was also inquired if the influx of St-Lawrence runoff influences the zooplankton community structure at the Shediac station (southern Gulf), but apparently not. The possible consequences of Labrator Current water intrusion in the northern Gulf of St. Lawrence were discussed further. It was mentioned that another clue of Labrador water influx could be an increase in abundance of the copepode *Calanus glacialis*. However, that species was not seen in the Gulf, although that maybe due to the time that sampling is done (i.e., June).

Questions were raised by the zooplankton trends in the Northwest Atlantic presented by Doug Sameoto. It was asked if the CPR data were compared with other (e.g. AZMP) data. It seems that for *C. finmarchicus* parallel trends are seen in the CPR data and independent indices for the Scotian Shelf. For chlorophyll data, it is not possible to compare early (before 1975) and recent (1990s) abundance indices with the satellite data. It was also mentioned that the deep over-wintering Euphausiid populations on the Scotian Shelf do not show the recent increase evident in CPR data. Possible explanations may be changes in ship tracks or changes in pelagic fish biomass (e.g. predation). Similarly, phytoplankton increase could be related to reduced grazing (i.e. lower zooplankton abundance). For the years the data sets overlap, similar patterns are observed in data from the USA. Off Eastern US, *Calanus* abundance was high until the late 1980s and then dropped. In the Gulf of Maine specifically, *C. finmarchicus* was highest in the 1980s.

More general comments were made on the Biological environment presentations. It was noted that time series for the biological data are short but as some series are getting longer it may be worth to start looking for patterns between the various physical and biological indices, and between areas. This should be done on a rigorous basis, rather than fishing for correlations. One suggestion was that maybe a working group could be formed to look at the issue. The discussion also addressed the issue of producing appropriate indices given the type of sampling. For example, from fixed stations: indices to characterize the temporal cycle, to characterize peak and duration of spring bloom, etc. From groundfish surveys, spatial indices should be identified and calculated uniformly for all regions to allow comparisons. Moreover, it was mentioned that it may be time trying to make connections between the physical and biological indices, but a simpler approach (or beginning) might be to have more co-ordination in producing the physical and biological overviews.

One particular point of methodology raised was that when some abundance data are plotted on the linear scale, there is a lot of structure at low values that can be missed, in comparison to the logarithmic scale.

### 3.4 *Recruitment trends*

At the AZMP annual meeting in 2000 it was agreed to compile recruitment data across the four regions within the Atlantic zone for review and presentation at FOC. A preliminary report was prepared for the 2001 FOC meeting and an updated report was presented at this year meeting. The primary work activity associated with this initiative is compilation of a recruitment time-series database for finfish and invertebrates in the NW Atlantic. Eventually, the database will be expanded to include spawning stock biomass and possibly growth, however the latter will be restricted to commercial species with ageing data. The other objective is to develop a scorecard along the lines of the physical/biological environment scorecards that have been develop and now presented to FOC annual meetings.

#### 3.4.1 Newfoundland Shelf and Labrador *(J. Anderson, E. Dalley - presented by E. Colbourne)*

The selected stocks for which recruitment indices were compiled in the Newfoundland region include 2 stocks of American plaice (2J3K and 3M), capelin (2J3KLNO), 4 stocks of cod (2J3KL, 3NO fall, 3NO spring and 3PS), and 3 herring stocks (Bonavista - Trinity Bay, St. Mary's - Placentia Bay, and White - Notre Dame Bay). Most fish populations included in this analysis changed very little for the most recent year-classes. The largest change occurred for 3Ps cod, which increased at the highest rate for the 1998 year-class. The remaining cod populations all indicated positive increases but at a low rate of change for the 1997 year-classes. Capelin declined at a relatively high rate for the 1999 year-class. American plaice on the Northeast Newfoundland Shelf (2J3K) and Flemish Cap (3M) both declined at small rates for the 1996 year-class. Finally, herring all indicated declines for the 1997 and 1998 year-classes.

#### 3.4.2 Scotian Shelf *(K. Frank)*

Progress on the development of the database was reported for the Maritimes region and time-series of the indices (recruitment, recruitment rate, residuals from the S-R relationship) were presented. Where multiple stocks of a given species occurred, inter-stock comparisons were made. For example, the three haddock stocks distributed across the Scotian Shelf/Georges Bank region appear to be responding in unison to environmental effects, based on the high degree of coherence in the temporal series of S-R residuals. In contrast, cod stocks distributed over the same geographic areas appear to be responding independently to environmental forcing. In summary, although many species are assessed in the Maritimes region (> 100), the number of stocks with recruitment estimates is much lower and this applies to other regions as well. A systematic examination of the survey data for both commercial (not aged) and non-commercial species might result in an increasing number of species with recruitment estimates if evidence for poly-modality exists in length composition that is suggestive of cohort development. This shortcoming of having recruitment data for only the most common, commercially exploited species does not, however, severely limit the utility of this exercise.

3.4.3 Southern Gulf of St. Lawrence *(D. Swain et al.)*

Recruitment trends were summarized for selected groundfish, pelagic fish and invertebrates in the southern Gulf of St. Lawrence. Where possible, three indices were presented: recruitment *R* (number of recruits), recruitment rate (*R*/*S* where *S* is spawning stock biomass), and residuals ($\log_e$ scale) from a Ricker stock-recruit model. It was argued that the most appropriate index for analyses of environmental effects on recruitment is recruitment rate (which can be thought of as an index of pre-recruit survival rate) or stock-recruit residuals (if pre-recruit survival is density-dependent). The fit of the stock-recruit model and the residuals from it may change dramatically when additional covariates are included in the model. For this reason, it was argued that the best approach for testing effects on recruitment is to include the potential explanatory variables as covariates in the stock-recruit model. An example was given using southern Gulf cod. Evidence for density-dependent pre-recruit survival increased dramatically and stock-recruit residuals changed greatly when an index of pelagic fish biomass was included in the model.

Recruitment of southern Gulf cod was high from the mid 1970s to the mid 1980s and low throughout the 1990s. The high recruitment from the mid 1970s to the early 1980s reflected an unusually high recruitment rate whereas the low recruitment throughout the 1990s was due to low *S* rather than a poor recruitment rate. Early estimates of the strength of the 1999 year-class indicate that it is very weak, the lowest in the time series. Recruitment rate appeared to be low in 1999, and the 1999 *S-R* residual was also the lowest in the 50-yr time series.

Plaice recruitment has been low throughout the 1990s, but recruitment rate has been average or better. The recruitment rate of white hake has been relatively high since the mid 1990s. The recruitment rate of southern Gulf herring was exceptionally high in the early 1980s for both spring and fall spawning components; recent recruitment rates have been high for fall spawners but low for spring spawners. The abundance of snow crab pre-recruits declined in the mid 1990s.

3.4.4 Northern Gulf of St. Lawrence *(M. Castonguay)*

Recruitment trends of selected fishes (3Pn4RS cod, Unit 1 redfish, 4RST turbot, spring-spawning 4R herring, fall-spawning 4R herring, and Canadian mackerel) and invertebrates (Estuary snow crab, Baie Sainte-Marguerite snow crab, Iles-de-la-Madeleine lobster, and Iles-de-la-Madeleine scallop) were presented. Recruitment rate (R/S), which provides a survival index of recruits, was also calculated for those species where S is measured (cod, turbot, herring, and mackerel). This presentation showed that overall, except for turbot; groundfish recruitment is at a low level, although recruitment rate is not. In contrast, pelagic fish and invertebrate recruitment is average or high, except maybe for scallop.

3.4.5 Recruitment scorecard

The scorecard indices include recruitment (which depends on spawning stock), recruitment rate (R/S) and the residuals from stock-recruitment relationships. All of the indices are expressed as anomalies from the average in the baseline period, expressed in standard deviation units. An example scorecard was presented for the southern Gulf of St. Lawrence cod (Div. 4TVn) using both model and survey-based indices and presenting anomalies for the most recent year-class (1999) relative to a baseline (1950-1999), relative to the previous year, and relative to the previous five year-classes. The intention is to apply this methodology to a wide variety of stocks throughout Atlantic Canada and, possibly, to include commercial species that are not aged and non-commercial species in addition to those stocks for which there are model-based estimates of stock and recruitment in order to complete the scorecard. The ultimate goal is that the database will provide more than just a scorecard but could be used to provide a description of the "State of Fishery Production" for analysis and evaluation in relation to data products from AZMP, environmental monitoring from research vessel surveys, continuous plankton recorder, ships of opportunity, atmospheric monitoring, model output, etc.

3.4.6 Questions and Discussion

In general, it was observed that the information presented consisted principally of recruitment time series with the hope that in the future, both spawners and recruit data could be provided for most stocks. Although there are numerous stocks in the (Maritime) region, (30 groundfish, 10 pelagic, and 70 Invertebrate species), the majority of stocks have no recruitment indices. The greatest level of information was from the region of Georges Bank. Moreover, many of the stocks have no survey data, and no age information (most flatfish and minor groundfish stocks). In many instances there is limited or no knowledge of stock structure. Additional difficulties include mixing or other behaviors that may prevent the accurate estimation of true production patterns over time. This issue can yield very different recruitment patterns depending on the models used and the assumptions underlying relationship of fish to environment.

There were questions about the reasons why the approach relied on estimates of recruitment rate based on SPA/RV surveys (model based) rather than exclusively based on RV survey, which may have fewer assumptions. It was pointed out that restricting analysis to data surveys would likely have shortened time series substantially. However, it was agreed that in the future it was generally good to rely both on model-based and RV-based analyses. RV surveys provide more current information in contrast to model-based information since model (SPA) may not include the younger ages.

It was also pointed out that there are recruitment indices for some invertebrates stocks that were not included in presentation. Apparently, the information is available and the S/R relationship is good but data was not currently available for evaluation when presentation was being prepared.

There were concerns that regressions of recruitment rate against stock size represented confounding relationships. However, it was pointed out that this approach is the one generally used and that this approach may be a suitable one for further analysis. However, despite the general application of the approach throughout the field, there may be questions about information of such a relationship - the overall value will depend on the underlying variability of the two series. It was pointed out that the use of R vs S and the application of a slope based even on a nonlinear model would be useful in establishing the pattern of variation in recruitment. Environmental relationships should be contrasted using this approach rather than a potentially confounding function.

It was noted that the effect of herring (as "pelagic predators") was notable in one particular case. The question that remains to be addressed is whether this is important for other species. The reviewer replied that the case in question (cod) is the only one with a strong relationship. For most other species or stocks, the basic biology is not quite as well understood to establish the potential for interaction between herring predation and deviations from a stock-recruitment relationship. What may be needed is a reasonable and rationalized relationship to explain the effect of environmental variables if they are to be included as part of the S/R model.

There appears to have been some substantial events in 1999 in many species and trophic levels. It may be worth returning to investigate if that year had particularly different environmental conditions. There was also evidence that growth rates for many species were high during that year. It was pointed out that recruitment to the hake population was apparently high, as was recruitment to the Scotian Shelf haddock stock.
As a contrasting pattern, it was pointed out that recruitment levels for many species in the southern Gulf of St. Lawrence represented the worst year on record. One possible hypothesis is that the low general recruitment levels in most species were due to the possible the impact of high predation resulting from the production of a strong mackerel year class in 1999.

There were several comments about the uniformity of presentations among regions. The general scorecard should include a standardized color scheme to present good and poor year classes. The meaning of the reported change from previous year was ambiguous for participants. In contrast, the trend relative to long term and recent 5 years is fairly clear.

A number of methodological issues were discussed further. The issue of ln(R/S) vs S has still to be resolved, as it remains a potentially confounding factor in the interpretation of patterns of variation in recruitment. There may be other methods to fit the S-R relationship and the Committee may have to consider a different approach to fitting the underlying relationship. There was considerable discussion about the approach that should be taken to investigate the potential relationship between environmental variations and recruitment. The apparent pattern or relationship may be substantially different if the independent variable used in the analysis represents the residuals from a S-R relationship. The presentation of such relationships should determine if the raw and normalized time series show similar trends. There were also questions about how additional independent variables can be incorporated into S/R relationships: What happens if the two indices (SSB and environment) are serially and cross-correlated? Should the trends be considered separately? The inclusion of several variables may be difficult to disentangle because of the effects of serial correlation. Furthermore, the manner in which environmental variables are included may affect the interpretation of variations in recruitment. Depending on spawners abundance (and the underlying S/R relationship) high recruitment may not always represent a substantial variation in overall survival rates. Finally, should the Committee concentrate on the trends in terms of more long-term fluctuations or are "events" the issue to be considered?

### 3.5 *Coastal monitoring*

The physical, biological and chemical data reviewed during the annual FOC meetings are mainly products from AZMP and are focused on the shelf and/or offshore environments. However, there is also an important and ongoing effort on coastal monitoring in the Atlantic Zone (e.g., Long-Term Temperature Monitoring [LTTM], toxic algae). Although some coastal monitoring data are currently included in the physical oceanography overviews, the Committee felt the need to discuss the issue of incorporating more information from inshore monitoring programs. At this year meeting, two presentations were given on that subject.

*The coastal component of the Global Ocean Observing System* - John Cullen (Dalhousie University)
An overview of the planned Coastal Ocean Observing Panel (COOP) of GOOS was presented. The general objectives and priorities of the coastal aspect of GOOS are: 1) the preservation of healthy coastal environments (prevent habitat loss; nutrient enrichment; algal blooms; pollution; etc.), 2) to promote the sustainable use of marine resources (ecosystem-based management; aquaculture; etc.), 3) to mitigate coastal hazards (storm surges; tropical storm damage; coastal erosion; sea-level rise; etc.), and 4) to ensure safe and efficient marine operations (navigation; spills; ballast water; etc.). The planned coastal GOOS observing elements are: 1) beach and near-shore zone observations (tide gauges, fixed/drifting platforms, buoys, ships including ferries), 2) remote sensing (space and aircraft), and 3) remote sensing from land. The current horizon for the full implementation of the coastal elements of GOOS is 2010.

*Phytoplankton abundance on the Scotian Shelf, the Labrador Sea and the Bay of Fundy: comparisons with a time series (1993-2001) in Bedford Basin* - W.K.W. Li (BIO)

Biological variability exists in the domains of both space and time. To monitor the ecosystem state over a large geographic region, a sampling strategy must be devised whereby the variability in each of the two aspects are measured. Logistic considerations usually limit high frequency sampling to a few fixed sites that are easily accessible, and highly-resolved spatial sampling to a few occasions per year that are constrained by weather conditions. A first step towards an integrated view of the Atlantic zone ecosystem must arise from reconciling the measurements of high temporal resolution and high spatial resolution. This is the aim of the present paper. Phytoplankton, being the major primary producers in all the waters studied, are a crucial component in the ecosystem. Here, an examination is made of the numerical abundance of phytoplankters, and the following question is addressed. Do the seasonal and secular trends of phytoplankton at an inshore site provide a basis to evaluate the time-aliased measurements at other locations?

Phytoplankton were sampled in the course of 4 ongoing research opportunities: the Bedford Basin plankton monitoring program, the Atlantic zone monitoring program, the southwest Bay of Fundy phytoplankton monitoring program and the WOCE-JGOFS study of the Labrador Sea AR7W transect. In summary, most of the phytoplankton (by numbers, not biomass) are picoplankters and nanoplankters. They display consistent seasonal patterns, marked by a fall maximum each year. At any time of year, abundance is relatively uniform across the entire region, much more so at smaller scales such as an area comprising Bedford Basin and the adjacent continental shelf. Although there is statistical evidence that phytoplankton abundance has increased in Bedford Basin during the observation period, there is yet insufficient data to discern a secular trend in any of the other areas.

## 4. General Environment Session

At this year meeting, the committees reviewed only four papers not directly related to the annual environmental overviews or the Theme session.

*Early life stages in fisheries research: A perspective from the larva's point of view* – P. Pepin (NWAFC)

Despite laboratory evidence that the growth and survival of larval fish are strongly affected by variations in prey and predators, there is limited field evidence, which concurs with those observations. This discrepancy may be due partly to the mismatch in the scales at which manipulative and observational studies are conducted. However, our fundamental approach to describe the environmental variability faced by larvae as well as the larva's potential to respond to it may also contribute to difficulties in matching lab-derived predictions with field data. Information from several field studies dealing with the growth and mortality of radiated shanny (*Ulvaria subbifurcata*) larvae were used to illustrate some limitations of past approaches used to study the dynamics of the early life history stages of fish. Patterns in growth histories show how differences among individuals may lead to varying responses to fluctuations in prey availability. The issues concerning the level of variability in environmental conditions that may be described by standard surveys methods used in the study of larval fish were also discussed. The examples served to illustrate the need to better describe the stochastic (i.e. probabilistic) structure of environmental conditions in order to understand early life dynamics.

*Accounting for serial correlation in fisheries oceanography regression analysis studies*.- D. Gilbert (IML)

In standard statistical methods, critical values of a given test statistic are commonly used by investigators in order to search for empirical evidence against some null hypothesis. Such critical values are convenient for many reasons, not the least of which being that we can readily find them in textbook tables or commercial software. However, investigators should not use these tables of critical values or their accompanying standard confidence interval formulae when the data sets at hand do not meet the statistical assumptions upon which the tables and formulae were based. In the case of correlation and regression analysis, textbook formulae assume that the two input data sets (predictor and predictand) come from normal distributions, and that each data pair is independent from the other data pairs. Testing for normality is easily done and most often performed by investigators. However, testing for independence among the data pairs is usually not performed.

When the variables consist of time series, statistical tests exist to verify whether successive measurements are independent of each other or else are serially correlated (e.g. Zar 1999). More often than not, it turns out that oceanographic and fisheries time series are strongly autocorrelated due to the dominance of low frequencies in their periodogram, something oceanographers commonly refer to as a red spectrum. Such time series fail the 'independence' test, and we must then accept the alternative hypothesis that they are serially correlated. Under such conditions, the effective number of independent pairs of observations is usually much less than our original number of data pairs. For fisheries oceanography interannual time series that are 20 to 50 years long, the number of effectively independent data pairs is typically 3 to 5 times less than in the original time series, leading to a drastic reduction in the number of degrees of freedom and a drastic increase in the critical value at which we would reject the null hypothesis of zero correlation between the two time series.

Various techniques exist in the literature to correct for the 'serial correlation' problem in regression analysis. Most of these originate from the econometrics and the meteorological literature, but there are a growing number of papers dealing with these issues in oceanography and fisheries journals as well. A quick overview of these techniques was provided together with a useful list of references.

*A comparison of the 1961-1990 and the 1971-2000 means for selected oceanographic data sets in the Newfoundland region* – E. Colbourne, C. Fitzpatrick, and J. Craig (NWAFC)

During the past several decades' ocean climate conditions on the Newfoundland Shelf have been characterized by several extremes. Most of the 1960s were very warm and salty. Cold-fresh ocean conditions prevailed during the early 1970s, mid-1980s and early 1990s and the very warm but generally fresh conditions occurred during the latter half of the 1990s. The annual time series of temperature, salinity, CIL and other oceanographic and meteorological indices clearly show these near-decadal oscillations in the physical environment in the Northwest Atlantic. The 30-year time period of 1961-1990 included the warm, salty 1960s and the two cold-fresh periods of the early 1970s and mid-1980s, whereas the new standard will include three cold-fresh periods of the past three decades. As a result, ocean temperatures in Newfoundland waters were generally colder over 1971-2000 time period compared to 1961-1990. The most significant temperature anomalies occurred in the upper water column where some of the largest monthly mean differences were observed. The deeper waters of the CIL (>75 m) were also colder over the 1971-2000 time period during all months of the year. Salinities were generally lower during 1971-2000 compared to the 1961-1990 base period.

The most significant salinity anomalies and monthly mean differences over the two time periods were restricted to the upper water column, where the freshening effects of sea ice melt dominate. In conclusion, the net result of the changing standards for computing long-term means will be that the time series of temperature and salinity anomalies during the past several decades will appear warmer and saltier referenced to the new base period compared to the previous.

*Trends in stratification on the inner Newfoundland Shelf* – J. Craig and E. Colbourne (NWAFC)

The time series of the stratification at Station 27 shows a continuation of the increasing trend first seen in the early 1990s, reaching near record levels in recent years. The increase in stratification appears to be in response to reduced salinity. Increased stratification over the last decade of the new (1971-2000) reference period resulted in a higher mean stratification than that for the old (1961-1990). As a result, the anomalies are about 0.002 $kg/m^4$ lower with respect to the new reference period. The mean annual signal for this period was broader and about 7 percent higher than the previous one. Increased stratification over the past year was a result of almost equal contributions of reduced salinity and increased temperatures during the summer and fall of 2001.

## 5. Theme Session

### 5.1 *Introduction*

The dynamics of fish and shellfish populations result from interactions with their physical and biological environment. The fishery is an important component of this environment, but so too are other predators, prey and physical oceanographic conditions. Annual overviews of environmental conditions, both physical and biological, often accompany assessments of stock status, however, environmental data are rarely incorporated into stock assessments in a quantitative way. It has long been recognized that this should be attempted but to date there has been little progress. The FOC asked the following questions. Are assessment models and fisheries management strategies robust to changes in environmental conditions or is there a need to quantitatively incorporate environmental variability in stock assessments? If the latter, how should environmental variability be incorporated into the assessment process? To promote discussion of ideas on this subject, the FOC convened a special theme session on the application of environmental data in stock assessment. Contributions on all aspects of environmental impacts on fish and shellfish stocks, both physical and biological, were invited. Papers were sought on the following and related topics:

- Incorporating environmental effects in the estimation of population size, e.g. oceanographic effects on catchability in fish and shellfish surveys.
- Environmental effects on population dynamics and stock production, e.g. effects on growth, mortality, fecundity, spawning stock biomass and its characteristics, stock-recruitment relationships, migration, distribution, etc.

- Forecasting environmental conditions and population parameters such as rates of growth, mortality and recruitment.
- Development and application of environmental indices characterizing the “state of the ecosystem”.
- Compilations of recruitment, distribution and growth data on finfish and invertebrate stocks across the three regions within the Atlantic zone for use in examining relationships with environmental indices.
- Development of tools (e.g., bioenergetics’ growth models, and methods for nowcasting or forecasting recruitment) for incorporating environmental information in stock assessment.
- Incorporating environmental variability and its consequences in a precautionary approach to fisheries management.

A total of 11 presentations were made, 4 of which were accompanied by working papers and another 4 were based on, or updates of, previously published CSAS Res. Docs.

5.2 *Presentations*

The following papers were presented with the name of the presenter underlined. Talks for which there were working papers are marked with an * and those based on already published Res. Docs are denoted by **.

*Ecosystem variability and fisheries* - T. Platt, C. Fuentes-Yaco and K. Frank (BIO)

Using remotely-sensed data on ocean colour, a time series of the distribution of chlorophyll-a concentration in the Atlantic Zone has been developed with a resolution of one week and roughly 1 km in space. From these, the timing of the initiation of the spring bloom, the timing of the maximum concentration, its amplitude and the duration of the bloom were estimated for each year from 1997 to the present for each of the 1.5 million pixels in the Atlantic Zone. These data were used to examine the match/mismatch hypothesis of Cushing. The test was made on the eastern Scotian Shelf Atlantic haddock (*Melanogrammus aeglefinus*) fishery, for which annual survey data are available. Approximately 90% of the variance in abundance of 0-group haddock can be accounted for by a linear regression with timing of bloom initiation and timing of maximum as independent variables. The results are not regarded as definitive, because of the shortness of the data set; nevertheless it is suggestive that haddock recruitment may be dependent upon the timing of the spring bloom. The analysis was extended back in time using the CZCS data for 1979-1981. With the combined data some 60% of the variance in haddock survival can be accounted for by variations in the timing of the spring bloom. Haddock have had two very strong year classes since 1970, both occurring in years with abnormally early spring blooms.

*Recent trends in bottom temperatures and distribution and abundance of cod (Gadus morhua) in NAFO Subdivisions 3Pn and 3Ps from the winter/spring multi-species surveys** - E. Colbourne and E. F. Murphy (NWAFC)

Near-bottom temperatures in NAFO Div. 3P during winter and spring surveys were compared to the spatial distribution and abundance of Atlantic cod for the years 1983 to 2001. There was a significant shift in the near-bottom thermal habitat with a dramatic increase in the extent of <0°C over the Bank from the mid-1980s to the mid-1990s. During this time, zero catch rates of cod dominated the survey sets on St. Pierre Bank and in the eastern regions of 3Ps. Beginning in 1996, the area of <0°C over the Bank decreased significantly reaching very low values in 1998 and a complete disappearance in 1999 and 2000. The areal extent of bottom water with temperatures >1°C was about 505 of the total area during 1998, the first significant amount since 1984 and it increased to about 70% during 1999 and 85% in 2000. During 1999 and 2000 larger catches of cod became more wide spread in the region. In 2001, as the cold water returned to the region, there again were many zero catches of cod from the survey sets. During all surveys most of the larger catches occurred in warm waters (>2-3°C) along the slopes of St. Pierre Bank or to the west of the Bank. An examination of the cumulative distributions of temperature and catch indicates that cod are associated with the warmer portion of the available temperature range, with a slight warmer preference based on weight than on numbers.

*The effects of temperature on the catchability of lobster* - K. Drinkwater (BIO), M. Comeau (GFC) and J. Tremblay (BIO)

The relationships among wind, temperature and daily catch rate were presented. Lobster landings (in kg) and trap haul data were obtained from fishermen through a voluntary logbook program. Data were collected in 1994 to 1996 at 6 sites in the Baie des Chaleurs and one on the eastern shore of New Brunswick to the south of the Bay. On Cape Breton Island, there were 5 sites on the eastern coast and 3 on the southern coast. From the landings and trap haul data, the catch per trap haul (CPTH) in kg was calculated and compared to temperature data were obtained at or near the traps. The landings and temperatures were first-differenced to remove any linear trends in the time series and the analysis was restricted to the first 4 weeks of lobster season in the case of the Baie des Chaleurs and 5 weeks for Cape Breton, which reduced the complicating effect that molting may have on catch. Results show that at both Baie des Chaleurs and Cape Breton, temperature has a statistically significant effect upon catchability of lobsters. These were established using correlation analysis and also by using the binomial test based on the scattergrams of the first-differenced temperatures and CPTH where coordinates of the paired variables located in the upper right (+/+) or the lower left (-/-) quadrant indicated a good correlation. Both methods produced similar results. In the Baie des Chaleurs region 6 of the 7 sites were significantly correlated with the temperature variability accounting for from 15 to 60% of the variance in CPTH, depending upon site. On the eastern shore of Cape Breton, changes in CPTH were significantly correlated with temperature variability in 4 of the 5 sites (changes in temperature accounting for from 5 to over 80% of the CPTH variance). None of the sites along the Atlantic coast produced significant correlations. Differences in the strength of the correlations between sites are in part associated with the amplitude of the temperature fluctuations. Higher temperature variability tends to result in higher correlations with changes in lobster landings. The temperature variability in both locations was related to wind in the classical Ekman sense, i.e. wind-induced downwelling (warming) when the coast is on the right of the wind and upwelling (cooling) when the coast is on the left.

*A rare example of quantitative incorporation of environmental information in a stock assessment: mixed layer temperature and the egg production model used to assess mackerel spawning stock biomass*** – F. Gregoire and M. Castonguay (IML)

For the past several years, IML has been using temperatures in the estimate of spawning stock biomass of Atlantic mackerel (*Scomber scombrus* L.) through the total egg production method. An egg sampling survey has been conducted in the southern Gulf of St. Lawrence for mackerel since the beginning of the 1980s. Most of the surveys have been in June and since 1994 have been conducted every two years. The eggs are used to estimate the abundance of the spawning stock biomass using the Total Egg Production Method (Gregoire and Girard, 2000; Chapter 5 in CSAS Res. Doc. 2000/021). During the surveys, temperature data were also collected. The number of eggs spawned is estimated from the number of different stage eggs observed during the survey after correction for natural mortality and incubation times. The latter is related to water temperature from work by Ouellet (1987; CAFSAC Res. Doc. 87/62). Since most of the eggs are found near surface, the average water temperature of the top 10 m is used in the equation. The size of the spawning stock is then estimated from the total number of eggs produced. The use of temperature in the equation for the number of eggs produced improves the estimates compared to methods when temperature is not included.

*Area of ice over the northern Newfoundland and southern Labrador shelves as a variable to reduce the variance of in-season forecasts of Atlantic salmon at Morgan Falls, LaHave River*** - C.J. Harvie and P.G. Amiro (BIO)

Based upon cumulative counts during the year, an end-of-season estimate of the population of Atlantic salmon (*Salmo salar*) can be made as the season progresses. This method requires that the portion of the population observed at any chosen date can be estimated with a known error. In-season estimates provide valuable information to managers for adjusting in-river exploitation rates in order to meet conservation targets. The value of these adjustments is increased when performed earlier in the season and particularly when conducted without loss of accuracy or precision. It was found (Harvie and Amiro; 1998, Canadian Stock Assessment Secretariat Res. Doc. 98/57) that the mean monthly ice areas over the northern Newfoundland and southern Labrador shelves can explain a significant portion of the variation in run time of Atlantic salmon counted at Morgan Falls, LaHave River. An end-of-season population estimate, based on cumulative counts to a date, are made as the season progresses using a linear regression model with ice area as the independent variable. An estimate can be made as early as June 30 while maintaining an approximate minimum level of precision of 25% coefficient of variation. Inclusion of the mean March ice area in the model allows an end of season population estimate to be made as early as June 15, with a 31% loss of precision over the June 30 estimate. Inclusion of the mean May ice area improved the proportion of variation explained by the regression from $R^2_{adj} = 0.84$ to $R^2_{adj} = 0.92$ and increased the precision by 33% using cumulative counts to July 6. Ice areas have been used during the past 5 years for in-season forecasts with improved accuracy over previous in-season forecasts although there is a bias towards over estimating the final population numbers. The ice is considered to have an effect on the time that the salmon reach the mouth of the river, perhaps not directly but indirectly. The Newfoundland and Labrador ice affects the salmon since they spend their winters in the Labrador Sea area.

*Incorporating an environmental index in the assessment of Pacific Cod*** - A. Sinclair (PBS) and W. Crawford (IOS) [Presented by J. A. Gagné (IML)]

Tyler and Crawford (1991; Can. J. Fish. Aquat. Sci. **48**: 2240-2249) tested several possible environmental stock recruitment functions for the Pacific cod (*Gadus macrocephalus*) stock in Hecate Strait including transport, temperature, herring as prey for young cod, and herring as prey for spawners. They concluded that transport was the most effective in accounting for recruitment anomalies for the stock. Sea level at Prince Rupert during the spawning period (January-March) was used as an index of transport. High sea levels indicated high transport through Hecate Strait and this resulted in low recruitment success due to removal of cod eggs and larvae from the area. Their analysis of alternative hypotheses was repeated using data from the original time period along with new data for the late 1980s and 1990s. The original conclusions held and the transport hypothesis continues to be the best predictor of recruitment anomalies. Based on these results, an index of sea level height in Prince Rupert was incorporated as an environmental covariate in the stock assessment model for pacific cod in Hecate Strait (Sinclair et al. 2001; CSAS Res. Doc. 2001/159). Inclusion of the sea level series significantly improved the fit of the assessment model. Sea level conditions have been unfavourable for recruitment through most of the 1990s; however, sea levels have declined in the past two years and recruitment may be improving. High fishing mortality and unfavourable conditions for recruitment have resulted in very low stock biomass and production in 2001. The implications of prolonged periods of favourable and adverse sea level conditions on production and management targets are shown in Figure 1. High sea levels are associated with lower production, lower target stock biomass, and lower target fishing mortality.

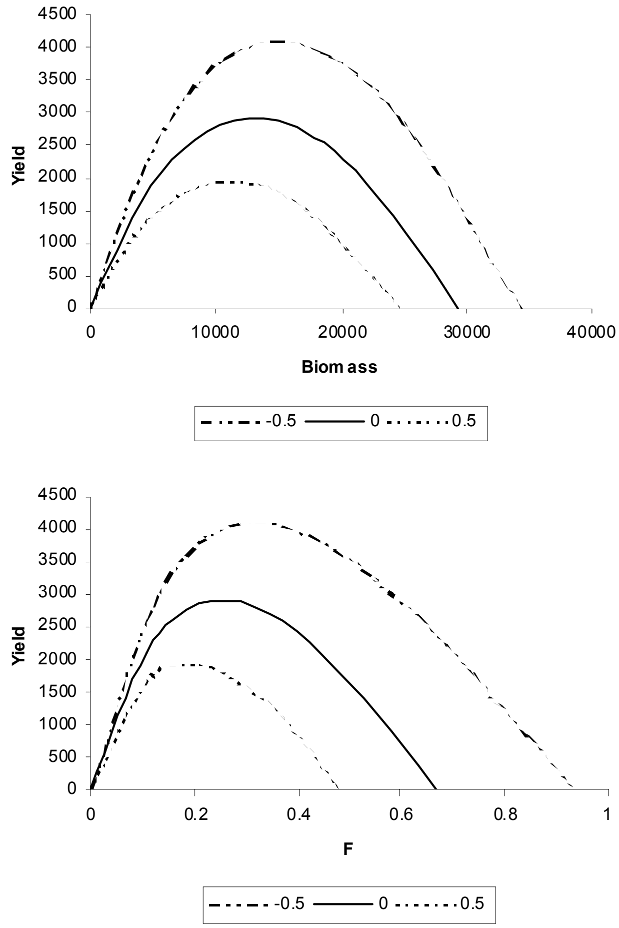


Figure 21. Predicted effects of variation in sea level height on production of area 5CD Pacific cod. Equilibrium yield curves are presented for +- 0.5 standard deviation of sea level height.

*Development of model-based indices of the drift, growth and survival of cod eggs and larvae in the southern Gulf of St. Lawrence** - J. Chassé (BIO/GFC), G. Chouinard (GFC), D. Swain (GFC), M. Castonguay (IML) and K. Drinkwater (BIO).

There is increasing evidence that recruitment of fish and invertebrate stocks is affected by environmental variability. While relationships between recruitment and temperature indices have been explored, few indices of drift, growth, retention and export of the early life stages have been developed. The larval drift and survival are often highly nonlinear functions of the currents and other related physical variables, such as stratification and temperature. These need to be quantified and arranged in a format suitable for inclusion in stock assessments. On-going work was presented towards the development of simple model-derived indices of the drift, growth and survival of Atlantic cod (*Gadus morhua*) eggs and larvae in the Gulf of St.

Lawrence. A generic biophysical semi-Lagrangian model with an Individual-Based Model (IBM) that includes stage and temperature-dependent growth and mortality of eggs and larvae has been developed. This is incorporated into a prognostic full 3-D hydrodynamic model of the Gulf of St. Lawrence and northeastern Scotian Shelf. Indices being developed include: a survival index based on the total number of larvae that survive to settlement within the model domain; a settlement index based on the number that settle within a given area, with and without mortality; a retention index based on the percentage of the total eggs released that settle within a given area; an export index based upon the number that settle outside of a given area; a drift index that measures the mean distance a larvae travels between spawning and settlement; and a temperature index obtained by averaging the ambient temperature of the larvae during its drift. These indices will be estimated in the near future covering the period from 1950 to present.

*Top-down versus bottom-up control in Oceanic Food Webs: A meta-analysis of cod-shrimp interactions in the North Atlantic** - B. Worm and R.A. Myers

Field experiments have demonstrated that predator control of lower trophic levels or "top-down control" is an important structuring force in terrestrial, freshwater and coastal marine food webs. Because oceanic webs typically cannot be studied using powerful experimental techniques, there is only weak and isolated evidence that "top-down" control is important in the open ocean. Consequently, many marine scientists believe that changes in productivity ("bottom-up control") or ocean temperature ("climate control") represent the predominant structuring forces in the open ocean. A meta-analytic approach to analyzed population interactions across the North Atlantic was carried out. Available biomass time series for Atlantic cod (*Gadus morhua* L.) and northern shrimp (*Pandalus borealis* Kroyer) were assembled to test whether the temporal dynamics of these populations are consistent with the "top-down" or "bottom-up" hypothesis. Eight out of nine regions showed inverse correlations of cod and shrimp biomass, supporting the "top-down" view. Exceptions occurred only close to the southern range limits of both species. Random-effects meta-analysis showed that shrimp biomass was strongly negatively related to cod biomass but not to ocean temperature in the North Atlantic Ocean. In contrast, cod biomass was positively related to ocean temperature. The strength of the cod-shrimp relationship, however, declined with increasing mean temperature. Based on the results, it was proposed that changes in predator population have strong effects on prey populations in oceanic food webs.

*Some don't like it hot: The shrimp-temperature connection on the Scotian Shelf** - P. Koeller, M. Covey and M. King (BIO)

Growth and sexual development of northern shrimp (*Pandalus borealis*) on the Scotian Shelf were determined during two periods of low and high population abundance, using deviation and modal analysis. Growth rates were higher during the period of low abundance, probably due to density-dependent effects and higher temperatures. Faster growth during the first period was associated with a smaller size at transition ($L_t$) from male to female and a smaller maximum size ($L_{max}$), while slower growth during the later period was associated with a larger size at transition, and a larger maximum size (and older age). Results are consistent with Charnov and Skuladottir's (2000; Evol. Ecol. Res. 2: 1067-1071) theory of invariance in the ratio of *Pandalid* $L_t/L_{max}$ and its implications, i.e. that growth can be determined from measurements of $L_t$ or $L_{max}$ alone, and the *P. borealis* undergoes a terminal molt, which is determined by $L_t$. $L_t$ was not a good indicator of short-term changes in population abundance, consequently $L_t$ or $L_{max}$ should only be used as measures of growth in stock assessment or population models. The theoretical and practical implications of the results were discussed. In particular, decreased fecundity, resulting from an increased growth rate, decreased size at transition and maximum size, is responsible for the negative lagged relationships between temperature and the stock abundance at the southern limit of their distribution. Measurements of $L_t$ and/or $L_{max}$ could be used in quantitative assessment models and to develop harvest limit reference points.

*The Traffic Light Method*** - P. Fanning, B. Mohn and R. Halliday (BIO)

The Traffic Light method has been investigated as a framework for stock assessment and fishery management planning in a precautionary approach within the Maritimes Region. It allows for inclusion of environmental information into the assessment. The original work on the Traffic Light by Caddy (1999; NAFO Sci. Coun. Studies 32: 55-68) proposed three lights (red indicating “poor” conditions, yellow indicating “average” conditions, and green indicating “good” conditions) to categorized multiple indicators of the state of a fishery and ecosystem in relation to defined reference points. This method has been adopted by the Maritimes Region and is being used as part of the assessment process (Halliday et al., 2001; CSAS Res. Doc. 2001/108). It allows the inclusion of more indicators into assessment decisions than in the more traditional methods, including the environment. However, instead of the three colours, the traffic lights are being allowed to be a combination of the three colours with the amount of each determining where the particular indicator is relative to some acceptable reference. This avoids the problem of sharp changes from one state to another (e.g. for going between “average” conditions to “poor” conditions) by indicating two colours that shows that it is in transition from one state to another. Much work has been carried out to determine what indicators should be used. These must be shown to have links to the fish or the fishery. For example, in the case of environmental variables, the indicator should be based upon published relationships. Difficulties arise in weighting the importance of the various indicators, the establishment of the reference points in order to determine when conditions should be considered red, yellow or green, and combining the indicators to come up with an overall status of the stock. Some examples of the Traffic Light method were provided. For 4VsW haddock, temperature has been shown to affect growth with larger fish found under warmer conditions. Thus, temperature is being used as an indicator for this haddock stock.

*ICES Study Group on Incorporation of Process Information into Stock Recruitment Models* - P. Pepin

An ICES Study Group on Incorporation of Process Information into Stock Recruitment Models (SGPRISM) was struck by the Working Group on Recruitment Processes (WGRP) to explore ways of integrating biological knowledge, including responses to physical forcing, into stock assessment methods and techniques. They held 3 annual meetings beginning in

2000 with the first meeting concentrating mainly on environmental issues as drivers of recruitment variability and the second considering environmental and biological causes for recruitment fluctuations. A third and final meeting was held in January 2002 to consider 2 case studies, the North Sea cod and the Bay of Biscay anchovy and to summarize the results of the SG (2002; ICES CM 2002/C:01, http://www.ices.dk/reports/OCC/2002/SGPRISM02.pdf). One of its major conclusions was that the low accuracy of the environmental indices as recruitment predictors makes it impossible at present to estimate the population abundance one year in advance. They suggested that the use of such indices should be postponed as far as provisional forecasts for managers are concerned until better predictive power on the environmental stock recruitment models is achieved. They did, however, find important effects of growth, condition and maturity on stock projections. They also considered medium-term (up to 5 year projections) which ICES is presently requesting for most stocks. Before this can be accomplished, the SG felt that a thorough collation and evaluation of the appropriate data available for each stock in the ICES area, along with analyses of which process models would be most suitable for incorporation in stock projections. They therefore have recommended that a new SG on Growth, Maturity and Condition Indices in Stock Projections (SGGROMAT) be formed to undertake this work. This recommendation will be taken forward to ICES by the WGRP. The SGPRISM was held up as a great example of biologists and fisheries assessment scientists working together on a common goal.

**6 Discussion of Theme Session and FOC Business meeting**

The committee was generally pleased with this year's theme session and the quality of the talks. Five papers gave case studies where environmental information is presently being incorporated into the assessments or offered ways in which it could be achieved (traffic light approach). Other talks provided potential examples, showing how the environment affected distribution, survival or catchability. It was noted that several new indices (associated with plankton blooms and thermal habitat) are being developed and models offer the potential for developing many more. Such indices can be used in statistical analyses to determine, what if any, is the relationship between the environment and fisheries.

The AZMP is tasked to provide a basic description of the environment in eastern Canadian waters and these are presented annually to the FOC for review. The committee felt that further dissemination of the information is required beyond the research documents and the SSRs. It therefore focused much of the discussion on how to improve communications of the results of the AZMP and FOC activities to fisheries assessment biologists.

While some fisheries biologists were involved with the design of the AZMP, it was felt that discussions with the broader fisheries community are now required to ensure that they know what AZMP is doing, the scientific questions AZMP is attempting to address, and the indices or products they are now producing. There is a further need to obtain their opinions on what products they would like to see generated from the present suite of measurements that might be useful for their assessments. Also, what additional data might they like to see collected as part of the program, within the present logistic and financial constraints? There is a need to focus on what questions are most important from a fisheries perspective and to determine where the present effort of AZMP and FOC should be concentrated. It was noted, however, that the AZMP mandate is broader than just fisheries for it also has to address concerns regarding search and rescue, transportation, contaminants, etc.

Paul Fanning, as an assessment biologist, felt that the key was in understanding processes. Also, there is a need to identify environmental shifts that might explain major changes in the underlying fisheries biology. An example of 4VsW cod was given from a period when their was density dependence as measured by the negative relationship between condition factor and spawning stock biomass (pre 1989) to a period (1989 to present) when this dependency no longer held. He further felt that fisheries biologists need guidance in the application of environmental effects. Put in the language of the traffic light approach, fisheries indicators (or indices) need to be developed, ones where specific relationships can be established, e.g. affects of temperature on growth. Because of the possibilities of "regime shifts", environmental indicators that have been shown in the past to be related to some aspect of fish stocks should be included in the traffic light approach. He gave an example of freshwater discharge from the St. Lawrence (RIVSUM) that had previously shown an association with Scotian Shelf cod recruitment but recently this relationship has failed. While fisheries are especially concerned about recruitment, Paul felt that more progress might be made in terms of environmental effects by examining production factors such as growth, condition, and reproduction. He noted the work of J.-D. Dutil and Y. Lambert's work at IML. Also, distribution (what are the environmental cues that determine distribution?) and catchability (both on the research vessel surveys and the fishery) are areas where environmental information may help a great deal in explaining observed variability in some fish stocks. Paul suggested the establishment of a website where indices are posted so assessment biologists would be able to access them if they wished to explore environmental relationships.

The question arose of how some of the issues raised by Paul could be achieved. One suggestion was that the regional RAP coordinators be asked to request their RAP chairmen to identify key environmental questions that arose during the RAP and to pass these onto the FOC.

***Action**: The **Chairman** will write a letter to the RAP coordinators and the division managers to this effect.*

Critical is the need for greater direct discussion between the fisheries assessment people and those working on environmental issues. This could be achieved by more AZMP and FOC members attending the RAPs and also more fisheries assessment biologists attending the FOC. It was also suggested that more FOC and AZMP members should become involved in the working group meetings held prior to the RAPs, such as those held in the Maritimes and Quebec regions. This would facilitate dialogue and possibly lead to greater consideration of environmental information within the assessment process than might be achieved by attendance at the RAP meetings themselves, when the final scientific advice is given. The working group meetings certainly would allow for more discussion, perhaps generate more questions pertaining to the environment and allow consideration about what should be done in the long term. The FOC endorsed this proposal and asked that the FOC members be informed when such working groups would be meeting.

***Action***: *The **Chairman** will ask divisional managers to inform him and local FOC members when such working group meetings will take place. FOC members should make an effort to attend these working group meetings*.

Another method to encourage discussion is through workshops. The recent workshop that Trevor Platt held on Satellite Imagery and the ICES Cod and Climate workshop on cod growth held a couple of years ago were held up as examples of focused workshops whose format could be used. The Workshop on how the AZMP information could be used by assessment people planned for the autumn of 2002 on the basis of recent SSF funding is an excellent opportunity for such interaction (see further description below). It is planned to invite several fisheries assessment biologists to this meeting.

***Action:*** *The **Chairman** to ensure that fisheries assessment biologists receive invitations to the workshop and that the dates for the workshop be chosen to enable as many of them as possible to attend.*

FOC working groups can also provide opportunities to address the major questions of linkages between fisheries and the environment. Indeed, the FOC established a Working Group on incorporating environmental information into the assessment process a couple of years ago (see report on working groups below). While some of its members were involved in the theme session, this working group has not been very active due to other commitments. The working group was still felt by the committee to be an opportunity to help focus FOC on environment-fisheries linkages and should continue.

The committee felt that the development of new indices would help in the search to find more linkages between fisheries and environment. Such linkages are required before the environment can be incorporated into the assessment process. Some of this work can be done by FOC members and the scientific community at large, although input from the assessment biologists could help to focus the search. This is especially true in customizing data products to obtain stock specific indices. Attendance at RAP meetings also would help FOC members understand the assessment problems and perhaps be able to aid their search for stock-specific indices.

The use of multivariate analyses to describe the environment and their relationship with fish stocks was encouraged. This would help in the determination of regime shifts, based not just upon one variable but a multitude of variables, i.e. the ecosystem as a whole.

Committee members also noted that the biological component of the AZMP is new and that most of the datasets began only 2 years ago. Also, because of the large variability and non-stationarity of the biological data, we are presently at the stage of attempting to understand the signal and noise relationship. How much does the biology change? What is a significant change? When do we set up alarm bells?

It was noted that different fish respond differently to the same environmental change. Also there was a call to match the environmental time series to the fisheries management units. It was noted however, that in some instances this latter request might not match well with the environment. For example, bottom temperatures in 4VsW span different water masses, varying spatially from the colder northeast to the warmer southwest. Averaging temperatures over such gradients may not make much sense.

It was noted that the theme session made a start on widening the dialogue between scientists working on environmental issues and the fisheries assessment biologists. The autumn Workshop should continue this.

Workshop on Strategies for Strengthening the Link between the Atlantic Zonal Monitoring Program (AZMP) and Stock Assessments

The Chairman informed the Committee that in the autumn of 2001, the Atlantic Directors suggested to examine the issue of how AZMP data products are or should be used in stock assessments. They asked that the FOC spearhead the effort and in co-operation with the AZMP a proposition for a workshop to discuss ways in which the AZMP could be more closely linked to fisheries assessment n was submitted for funds through the SSF. The Chairman together with Pierre Pepin (AZMP), Doug Swain and Ken Drinkwater put together the proposal. It was recently announced that funds were allotted to the workshop, which will most likely be held in the autumn of 2002. The workshop team will finalize the Terms of Reference for submission to the Atlantic Directors, put together a list of potential participants and decide upon a date. Discussion centered on ensuring that members of the fisheries assessment community be involved.

***Action**: The **Chairman** to inform the RAP Coordinators of the Workshop and ask them who they felt should be involved.*

Reports of FOC Working Groups

There are presently three FOC Working Groups. These include the following.

The Working Group on Recruitment Indices (WGRI) reported their progress through 4 presentations at this year's meeting. They have assembled several time series of recruitment and recruitment-related indices and begun to develop a scorecard of these recruitment indices. Over the next year this working group will continue to develop the scorecard and present their results at the 2003 FOC annual meeting. In addition, they plan to perform statistical analyses to compare recruitment indices between stocks to determine evidence of synchrony or not. They also plan on undertaking multivariate analyses to examine relationships with environmental variables. Members include John Anderson, Martin Castonguay, Ken Frank and Doug Swain.

The Working Group on Monitoring of Pelagic Ecosystems (WGMPE) was formed last year. Due to other commitments it did not meet during the year. However, it was felt that the terms of reference of the group needed to be addressed and the committee decided to endorse this working group for another year. Paul Fanning will continue as chair with members John Anderson, Laurie Devine (IML Data Management), Jacques Gagne, Erica Head, and Doug Swain.

The Working Group on Incorporating Environmental Information into Stock Assessments (WGIEISA) will also continue for another year. This working group also has not been active although they did help in organizing the 2002 FOC theme session. Their terms of reference continue to be important and this coming year they will work towards pulling together a list of relationships between environmental variables and fish stocks and will report during the 2003 FOC meeting.

**Recommendation:** *That the WGRI, the WGMPE and the WGIEISA continue through 2002/2003 under their previous terms of reference.*

Increased activity of the latter two working groups was encouraged.

Stock Status Reports

A total of six SSRs were produced for the FOC meeting, 3 physical and 3 biological SSRs, one each per region. There was not enough time to go through these in detail for content and editorial suggestions. It was decided to read these over the coming week and then hold a conference call on Monday 8 April.

The committee discussed whether the Labrador Sea information should be included in the SSRs. The information should be written by the individuals working on the data and they should be included in the Zonal overviews. It was decided not to include it this year but to begin next year.

**Recommendation**: *The Labrador Sea biological and physical data and time series to be incorporated into the environmental overviews for next year.*

The committee discussed the Zonal overview for the biology. Pierre Pepin put together one in 2001 for the AZMP Bulletin by combining information from the regional SSRs. However, after it was published, it was found not to be entirely consistent. Pierre's suggestion was putting together a Zonal overview of the biology should not be undertaken simply through e-mails but required a 2-3 day meeting of 3-4 of the major players. Such a meeting would be tasked with producing the Zonal SSR on the biology.

***Action***: ***Pierre Pepin*** *to make an outline and to arrange a meeting of the major contributors to the biological overviews in order to develop a template for future SSRs on the Zonal biology review. The AZMP will produce a Zonal report on the biology covering the review period 2002 for the 2003 FOC annual meeting or shortly thereafter.*

Interactions of FOC and FOWG of PSARC.

The Chairman reported that the National Directors suggested interaction between the FOC and its Pacific equivalent, the Fishery Oceanography Working Group (FOWG) of the PSARC, including an exchange of agendas for this year's meetings. He reported that PSARC operates differently from the FOC. They meet for only 1 day, the purpose being to produce an environmental status report. The Chairman sent the FOC agenda to the PSARC Chair. He also noted that it might be useful for the two chairs to meet at one of the National RAP coordinators meetings. FOC members noted that funds are being sought to set up a Pacific equivalent of AZMP.

***Action****: The* ***Chairman*** *to send the FOWG agenda to FOC core members. He will also put the PSARC and FOWG Chairs on the distribution list for our documents.*

Other Business

A discussion of the inclusion of inshore monitoring in the overviews and in the SSRs was held. Some of these data have been included in the physical oceanographic overviews. These include data from the long-term coastal monitoring sites in the Maritimes Region and some of the Long-Term Temperature Monitoring (LTTM) sites in Newfoundland. There has been no reporting of the LTTM program in the Gulf of St. Lawrence but some of the longer operating stations could be added. Such long-term records were felt to be useful but reporting all of the available LTTM records was not needed or desired. Reporting of those stations that show wide-scale temperature coherence is particularly encouraged. Questions of reporting of the inshore biological monitoring such as that in Bedford Basin was raised. Again it was felt that unless the changes can be shown to have wider application than within the particular embayment, these not be included. It was also noted that the AZMP is focused upon the shelf environment and not the coastal zone.

Scientists have developed several new instrumentation packages recently for monitoring, including some by J. Cullen for the nearshore and others by Memorial University.

**Recommendation**: *The FOC will be kept up to date on instrumentation that could help in monitoring the environment and individuals be invited to the FOC annual meeting to present talks on such developments.*

***Action****: The* ***Chairman*** *will request Pierre LaRouche to speak on the instrumentation being used for monitoring the Gulf of St. Lawrence during the 2003 FOC meeting.*

Doug Swain requested three indices be included in the Gulf environmental report that were not there this year. First was to include the time series of the CIL for the southern Gulf. This had been reported previously and only needs to be updated. Second, time series of surface temperature should be developed from the June mackerel surveys. Third, biological indices from the June mackerel surveys be developed. Jeff Runge and Martin Castonguay had developed some indices previous. In regards to the temperature indices in June it was suggested by some members of the FOC that satellite imagery could be used to develop such indices.

***Action**: **Denis Gilbert** will update the CIL southern Gulf time series. **Ken Drinkwater** will examine the time series of surface temperatures during June for the southern Gulf. **Michel Harvey** will determine possible biological indices from the mackerel surveys and report his findings at next year's meeting.*

Next Year's FOC Meeting

The Committee decided to tentatively schedule the 2003 FOC annual meeting for 10-14 March at Mont Joli in the IML.

***Action**: The **Chairman** to ensure that there will be no conflicts with the March break for students in any of the Atlantic Provinces and Quebec before confirming the date.*

After a brief discussion the Committee decided that next year's theme session will be *1999: an exceptional year in the environment and fisheries?* The study of events has in the past lead to insights into environmental effects on fisheries, e.g. the Cod and Climate Change Workshop on the Tilefish kill in the late 1880s. The year 1999 was unusual in several respects. Air temperatures and sea surface temperatures achieved long-term historic highs. Phytoplankton production was the highest on record based upon the available satellite imagery. Haddock on the Scotian Shelf had phenomenal recruitment, as did scallops (although these latter also had high recruitment in 1998 as well). It was a good year for mackerel recruitment in the Gulf of St. Lawrence but one of the lowest on record for 4T cod. Some exceptional events in fisheries also were also noted on the Grand Banks. The Theme Session will attempt to document the various changes that occurred in 1999 and to establish links between the environmental changes and the possible responses of the various fish stocks in eastern Canada.

# Fisheries Oceanography Committee

Annual Meeting, March 25-28, 2002
OSD Boardroom
Bedford Institute of Oceanography, Dartmouth, N.S.

**AGENDA**

## Monday, March 25

8:30 Introduction and administrative details
- Chairman

**Review of 2001 environmental conditions in the Northwest Atlantic.**

**Physical Environment**

8:45 Overview of meteorological, sea ice and sea surface temperature conditions off Eastern Canada during 2001. [**WP1]**
K. Drinkwater, B. Petrie, R. Pettipas and L. Petrie

9:15 Physical oceanographic conditions on the Newfoundland and Labrador Shelves during 2001. [**WP2**]
E. Colbourne

Oceanographic conditions in NAFO Subdivisions 3Pn and 3Ps during 2001 with comparisons to the previous year and the long-term (1971-2000) average. [**WP3]**
E. Colbourne.

10:00 BREAK

10:30 Physical oceanographic conditions in the Gulf of St. Lawrence in 2001. [**WP4**]
D. Gilbert.

11:00 Physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine during 2001. [**WP5**]
K. Drinkwater, B. Petrie, R. Pettipas, L. Petrie and V. Soukhovtsev

!1:30 Conditions in the Labrador Sea.
R. Hendry

12:00 LUNCH

13:00 Physical Environmental Scorecard – Discussion of physical overviews.

*Biological and Chemical Environment*

13:30 Biological and Chemical oceanographic conditions on the Scotian Shelf, in the Gulf of Maine and the Southern Gulf of St. Lawrence in 2001. [**WP6**]
G. Harrison, J. Spry, K. Pauley, H. Maass, V. Soukhovtsev.

14:00 Biological and Chemical oceanographic conditions on the Newfoundland Shelf during 2001 with comparisons with earlier observations. [**WP7**]
P. Pepin et G. L. Maillet

14:30 State of phytoplankton in the Estuary and the Gulf of St. Lawrence during 2001.[**WP8**]
M. Starr and L. St-Amant.

15:00 State of zooplankton in the Estuary and the Gulf of St. Lawrence during 2001.[**WP9**]
M. Harvey, J.-F. St-Pierre, G. Morrier

15:30 BREAK

16:00 Northwest Atlantic plankton trends 1960 to 2000. [**WP10**]
D. Sameoto

16:30 Zonal overview of biological and chemical environmental conditions in 2001: Discussion of biological overviews.

## Tuesday, March 26

*Recruitment trends*

8:30 Recruitment of selected fishes and invertebrates in the Southern Gulf of St. Lawrence. [**WP11**]
D. Swain.

8:50 Recruitment patterns of fishes and invertebrates from the Northern Gulf of St. Lawrence. [**WP12**]
M. Castonguay.

9:10 Recruitment of selected fishes and invertebrates on the Scotian Shelf [**WP13**]
K. Frank.

9:30 Recruitment of selected fishes and invertebrates from Newfoundland and Labrador.[**WP14**]
J. Anderson and E. Dalley (presented by E. Colbourne)

9:50 Recruitment Scorecard and Discussion

10:15 BREAK

*Coastal monitoring*

10:45 The coastal component of the Global Ocean Observing System.[**WP15**]
J. Cullen

11:15 Phytoplankton abundance on the Scotian Shelf, the Labrador Sea and the Bay of Fundy: comparisons with a weekly time series from 1993 to 2001 in the Bedford Basin.[**WP16**]
WKW Li

11:45 Discussion

12:00 LUNCH

**Miscellaneous**

13:00 Early life stages in fisheries research: A perspective from the larva's point of view. [**WP17**]
P. Pepin.

13:50 Accounting for serial correlation in fisheries oceanography regression analysis studies.[**WP18**]
D. Gilbert.

14:20 A comparison of the 1961-1990 and the 1971-2000 means for selected oceanographic data sets in the Newfoundland region. [**WP19**]
E. Colbourne, C. Fitzpatrick and J. Craig

15:00 BREAK

15:30 Trends in stratification on the inner Newfoundland Shelf. [**WP20**]
J. D. C. Craig and E. B. Colbourne

16:00 Environmental indices for Atlantic Canada. A fisheries Oceanography Committee (FOC) Working group report (E. Colbourne, K. Drinkwater, D. Gilbert)
E. Colbourne

Wednesday, March 27

**Theme Session: Incorporating Environmental Information into Fisheries Stock Assessments**

08:45 Introductory remarks
K. Drinkwater

09:00 Ecosystem variability and fisheries. [**WP21**]
T. Platt

09:30 Recent trends in bottom temperatures and distribution and abundance of cod (*Gadus morhua*) in NAFO Subdivisions 3Pn and 3Ps from the winter/spring multi-species surveys. [**WP22**]
E. Colbourne and E. F. Murphy

10:00 The use of environmental information to improve production estimates of Hecate Strait Pacific cod.
A. Sinclair (presented by J. A. Gagné)

10:30 BREAK

11:00 The effects of temperature on the catchability of lobster [**WP25**]
K. Drinkwater, M. Comeau and J. Tremblay

11:30 Meta-analysis of cod-shrimp-temperature interactions
R. Myers and B. Worm

12:00 LUNCH

13:00 A rare example of quantitative incorporation of environmental information in a stock assessment: mixed layer temperature and the egg production model used to assess mackerel spawning stock biomass. [**WP26**]
F. Grégoire and M. Castonguay

13:30 The use of environmental information to produce revised estimates of salmon returns.[**WP27**]
P. Amiro and C. Harvie

14:00 BREAK

15:15 Development of model-based indices of the drift, growth and survival of cod eggs and larvae in the southern Gulf of St. Lawrence. [**WP28**]
J. Chassé, G. Chouinard, D. Swain, M. Castonguay, and K. Drinkwater.

15:45 Some don't like it hot: The shrimp-temperature connection on the Scotian Shelf. [**WP29**]
P. Koeller

16:15 The traffic light approach. [**WP30**]
P. Fanning

16:45 ICES Study Group on Incorporation of Process Information into Stock Recruitment Models [SGPRISM]
P. Pepin

17:15 Discussion

## Thursday, March 28

8:30 – 12:00 **FOC Business Meeting**

1. Stock Status Reports
   - Discussion and approval of environmental overview SSRs
   - The need to produce a "biological/chemical" Overview
   - CSAS requirements for publication on WEB site.

2. Reports on FOC Working Groups:
   - WG: *Incorporation of environmental data into stock assessments*
   - WG: *Monitoring of pelagic ecosystems*
   - Others WGs?

3. The FOC sponsored workshop on AZMP – Stock assessments interactions

4. Implications/Interactions of FOC with other groups:
   - PSARC – Fisheries Oceanography Working Group (FOWG)
   -

5. Next year meeting: Location/Date
   Theme session

6. Other business

## Meeting Participants

| | |
|---|---|
| Patrick Ouellet | DFO-MLI |
| Martin Castonguay | DFO-MLI |
| Gary Maillet | DFO-NWAFC |
| Jeff Spry | DFO-BIO |
| Kevin Pauley | DFO-BIO |
| Joel Chassé | DFO-BIO, GFC |
| Joe Craig | DFO-NWAFC |
| Daniel Duplissea | DFO-MLI |
| Eugene Colbourne | DFO-NWAFC |
| Michel Harvey | DFO-MLI |
| Michel Starr | DFO-MIL |
| Denis Gilbert | DFO-MLI |
| Peter Koeller | DFO-BIO |
| Pierre Pepin | DFO-NWAFC |
| Jacques A. Gagné | DFO-MLI |
| Ross Hendry | DFO-BIO |
| Michel Mitchell | DFO-BIO |
| Doug Sameoto | DFO-BIO |
| Brian Petrie | DFO-BIO |
| Glen Harrison | DFO-BIO |
| Hugues Benoit | DFO-GFC |
| Doug Swain | DFO-GFC |
| Ken Frank | DFO-BIO |
| Erica Head | DFO-BIO |
| Amélie Rondeau | DFO-GFC |
| John Cullen | Dalhousie University |
| Ransom Myers | Dalhousie University |
| Travor Platt | DFO-BIO |
| Stephen Smith | DFO-BIO |
| Paul Fanning | DFO-BIO |
| Peter Amiro | DFO-BIO |
| Li Bill | DFO-BIO |