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Final Report of the Fisheries Oceanography Committee 2003 Annual Meeting

March 11 - 14, 2003
Maurice Lamontagne Institute
Mont-Joli, Québec

Patrick Ouellet, Chairperson (FOC)
Fisheries and Oceans Canada,
Québec Region,
Maurice Lamontagne Institute
850 route de la mer
Mont-Joli, QC G5H 3Z4

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Canada

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CSAS@DFO-MPO.GC.CA

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Executive Summary

The Fisheries Oceanography Committee of the Department of Fisheries and Oceans met in Mont-Joli, Québec, at the Maurice Lamontagne Institute on 11-14 March 2003. The Committee reviewed environmental conditions in the Northwest Atlantic during 2002, convened a theme session on the particular conditions of the year 1999 and their effects on some fish and invertebrate stocks, reviewed additional papers on physical and biological oceanography, and conducted its annual business meeting.

1- Physical Environment in 2002: Slightly warmer-than-normal air temperatures tended to dominate over most of eastern Canada during 2002. Annual mean air temperature declined substantially compared to 2001 for the northernmost sites but annual anomalies rose at southern locations (e.g., Gulf of Maine). The NAO index was still below normal but rose relative to 2001. Low NAO usually means warm air temperatures over Labrador Sea in winter and this is consistent with conditions observed in 2001 and 2002. Relative to the long-term mean, ice appeared later-than-normal over most of the Labrador and Newfoundland shelves and average ice area was also below the long-term mean. Sea surface temperature anomalies continued to be above normal as since the late 1990s, particularly in the Newfoundland and Scotian Shelf regions. The annual surface temperature at Station 27 was about normal in 2002 whereas bottom temperature remained above normal. However, summer salinities increased to reach the highest values in about 12 years. The cross-sectional area of the CIL on Newfoundland and Labrador shelves decreased in summer 2002. Bottom temperatures on the Grand Bank ranged near the normal in spring 2002 and were generally above normal in the fall. Warm and salty conditions tended to dominate the Scotian Shelf and Gulf of Maine regions in 2002. Near-bottom temperatures as observed in July increased relative to 2001 and were generally warm except in the northeast Scotian Shelf. Warm air temperatures in late 2001 slowed ice formation in the Gulf of St. Lawrence so that there was little ice at the beginning of 2002. Duration of ice was also shorter so that 2002 was a light ice year for the Gulf of St. Lawrence. However, the minimum temperature within the CIL declined slightly in 2002 in the deep part of the Gulf.

2- Biological Environment in 2002: The seasonality of chemical and biological variables at Station 27 and along major AZMP sections on the Newfoundland and Labrador shelves was similar to previous years. Since 2000, there has been a gradual intensification in the overall productivity and standing stock of phytoplankton in the spring. The overall abundance of zooplankton at Station 27 was somewhat similar to previous years except that fall and winter 2001-2002 concentrations of small copepod species (*Oithona* sp. and *Pseudocalanus* sp.) were higher. In addition, there was an increase in the abundance of cold-water species of copepods at Station 27. On the Scotian Shelf and in the southern Gulf of St. Lawrence, generally, the seasonal cycles of nutrients were similar to previous years. The most prominent feature in 2002 was the persistent high concentrations of chlorophyll *a* in the southern Gulf of St. Lawrence during the fall groundfish survey. The spring bloom was also earlier and shorter than in 2001 on the Scotian Shelf. Zooplankton biomass was lower in 2002 at all fixed stations (Halifax 2, Prince 5 and Shediac Valley) and *C. finmarchicus* abundance at Halifax-2 was the lowest on record. However, at Shediac Valley (southern Gulf), *C. finmarchicus* abundance was up from the previous years. In 2002, the initiation of the major phytoplankton bloom occurred in June in the Lower St. Lawrence Estuary, near the historical mean date. The average phytoplankton biomass during the spring 2002 was higher compared to the recent (2000-2001) years but much lower than the record level of 1999. Based on the evolution of the nutrients, phytoplankton production in the northwestern Gulf could have been higher in 2002 than the two previous years, but lower than in 1999. At the AZMP fixed stations, annual mean integrated zooplankton biomass was similar to previous year at Anticosti Gyre station but 1.5 times higher than in 2000 and 2001 at Gaspé Current station.

3- Recruitment: Summary tables of recent recruitment trends for selected stocks on Newfoundland Shelf and the southern Gulf of St. Lawrence were presented at the meeting. To go further however, the Committee agreed to concentrate the effort of the Working Group on Recruitment Indices on the establishment of a common database from which standardized annual reports would be produced.

4- General Environment Session: At this year meeting, five papers were presented and the session was greatly appreciated as judged by the discussion that followed the presentations. Three papers were particularly remarked: (1) a new automated buoy network to monitor environmental conditions and validate satellites data in the St. Lawrence ecosystem; (2) a presentation of model-based summer oceanic conditions in the southern Gulf of St. Lawrence in 2002; and (3) an analysis of recent changes in the marine fish community on the Scotian Shelf ecosystem.

5- Theme Session: Six papers were presented at the session. In addition, Ian Perry (DFO-Pacific region) who was at IML at the time of the meeting was invited to present a seminar on the recent change in oceanographic conditions in the northeast Pacific. Clearly, 1999 presented unique environmental conditions for the recent (5) years period. Thermal conditions in 2000 were also anomalously high and the timing of the bloom in the LSLE was also relatively early but not as early as in 1999. Mackerel and haddock had exceptional recruitment in 1999 and the spring bloom was unusually early. In the Gulf of St. Lawrence, the 1999 year-class was the highest of the last 10 years for turbot and the second best for shrimp. There was support for pulling the theme session information together for a primary publication. It was also agreed that a short article on the 1999 "event" will be produced for the AZMP Bulletin in the fall 2003.

6- Business meeting: There was a discussion about the continuation of the WG on incorporating environmental information into the assessment process. It was pointed out that recommendations were made at the FOC-AZMP workshop of November 2002 about the implication of the FOC in establishing case studies to aid in the exploration of environment-fish relationships and their possible use in assessment work. It was decided that the WG will be maintained and the Chairman is to examine possible activities that can be initiated in relation to its mandate. The WG on monitoring of pelagic ecosystems was discontinued. The issues at the origin of the WG were raised at the FOC-AZMP workshop and recommendations about how to enhance monitoring of nekton and the pelagic community were made to the AZMP. The FOC decided to wait for the results of the AZMP program review before to discuss future actions. The 2004 Annual Meeting will be held at the Northwest Atlantic Fisheries Centre (NWAFC) in St. John's, Newfoundland, in late March 2004.

Résumé

Le Comité sur l'océanographie des pêches du ministère des Pêches et des Océans s'est réuni à l'Institut Maurice-Lamontagne (Mont-Joli, Québec) du 11 au 14 mars 2003. Le Comité a revu les conditions environnementales dans le nord-ouest Atlantique en 2002, a tenu une session thématique sur les conditions physiques particulières de l'année 1999 et leur impact sur des stocks de poissons et d'invertébrés, a revu des documents sur l'océanographie en général et a discuté des affaires courantes du Comité.

1- L'environnement physique en 2002 : Des températures de l'air légèrement plus chaudes que la normale ont été plus fréquentes sur tout l'Est du Canada en 2002. Les températures annuelles moyennes ont diminué par rapport à 2001 aux sites les plus au Nord mais les anomalies annuelles ont augmenté au sud (ex. golfe du Maine). L'indice NAO était toujours sous la normale mais plus élevé qu'en 2001. Un faible NAO signifie généralement des températures de l'air en moyenne plus chaudes sur la mer du Labrador pendant l'hiver, en accord avec les conditions observées en 2001 et 2002. Relativement à la moyenne, la glace est apparue plus tard sur le plateau continental de Terre-Neuve et du Labrador et la surface du couvert de glace a été également au-dessous de la moyenne. Les anomalies positives des températures de l'eau en surface continuent la tendance observée depuis la fin des années 1990, particulièrement dans les régions de Terre-Neuve et du plateau Néo-Écossai. La moyenne annuelle de la température en surface à la station 27 était plus élevée que la normale en 2002 alors que la température au fond était comparable à la normale. Cependant, en été, la salinité a augmenté pour atteindre les plus hautes valeurs observées depuis 12 ans. L'aire de la section transversale de la CIF sur le plateau continental de Terre-Neuve et du Labrador avait diminué à l'été de 2002. Sur le Grand Banc, les températures de l'eau au fond étaient en général au-dessus de la normale à l'automne. Des eaux chaudes et plus salées dominaient sur le plateau Néo-Écossai et dans le golfe du Maine en 2002. Les températures au fond, observées en juillet, étaient plus élevées relativement à 2001 et elles étaient en général chaudes sauf au nord-est du plateau Néo-Écossai. Les températures de l'air chaudes à la fin de 2001 ont ralenti la formation de la glace dans le golfe du Saint-Laurent et il y avait peu de glace au début de 2002. La durée de la glace a été aussi plus courte de sorte que 2002 a été une année de faible abondance de glace dans le golfe du Saint-Laurent. Cependant, la température minimale de la CIF a diminué en 2002 dans les secteurs les plus profonds du Golfe.

2- L'environnement biologique en 2002 : Le cycle saisonnier des variables chimiques et biologiques à la station 27 et sur les lignes du PMZA du plateau continental de Terre-Neuve et du Labrador a été comparable aux années précédentes. Depuis 2000, il y a une augmentation graduelle de la productivité totale et de la biomasse de phytoplancton au printemps. L'abondance totale de zooplancton à la station 27 a été similaire aux années passées sauf pour la concentration d'espèces de petits copépodes (*Oithona* sp. et *Pseudocalanus* sp.) à l'automne et l'hiver 2001-2002. De plus, il y a une augmentation de l'abondance des espèces de copépodes d'eau froides aux stations fixes du PMZA. Sur le plateau Néo-Écossai et dans le sud du golfe du Saint-Laurent, en général, le cycle saisonnier des sels nutritifs a été similaire aux années précédentes. Un fait dominant de 2002 a été la persistance de fortes concentrations de chlorophylle dans le sud du golfe du Saint-Laurent

pendant le relevé de poissons de fond. La floraison printanière a débuté plus tôt et a duré moins longtemps qu'en 2001 sur le plateau Néo-Écossai. La biomasse de zooplancton a été plus faible en 2002 aux stations fixes du PMZA et l'abondance de *C. finmarchicus* à la station Halifax-2 a été la plus basse jamais enregistrée en 2002. Cependant, à la station Shediac Valley (sud du Golfe), *C. finmarchicus* était plus abondant que par les années passées. En 2002, le début de la floraison principale de phytoplancton est survenu en juin dans le Bas-estuaire du Saint-Laurent, soit près des dates normales. Au printemps 2002, la biomasse moyenne de phytoplancton a été plus élevée par rapport aux années 2000 et 2001 mais beaucoup plus faible que les valeurs records de 1999. En se basant sur l'évolution des sels nutritifs, la production de phytoplancton dans le nord-ouest du Golfe peut avoir été plus forte en 2002 par rapport aux deux dernières années mais plus faible qu'en 1999. Aux stations fixes du PMZA, la moyenne intégrée de biomasse de zooplancton a été comparable aux années passées à Anticosti mais 1.5 fois plus forte qu'en 2000 et 2001 à la station du courant de Gaspé.

3- Recrutement : Au cours de la réunion, des résumés des tendances récentes dans le recrutement de certains stocks ont été présentés pour les régions de Terre-Neuve et le sud du golfe du Saint-Laurent. Toutefois, le Comité a convenu que dans l'immédiat les efforts du groupe de travail sur les indices de recrutement seront dirigés vers l'établissement d'une base de données commune pour les régions à partir de quoi des indices standardisés seront préparés et présentés à la réunion annuelle.

4- Session générale sur l'environnement : Cinq documents ont été présentés lors de la réunion. Les discussions soulevées démontrent la qualité des présentations et l'appréciation du Comité. Trois présentations ont été particulièrement remarquées : (1) une nouvelle bouée automate pour le monitorage de données environnementales pour la validation des données de production des satellites pour l'écosystème du Saint-Laurent; (2) une présentation des conditions océaniques estivales pour 2002 obtenues par un modèle du sud du golfe du Saint-Laurent; et (3) une analyse de récents changements dans la communauté de poissons de l'écosystème du plateau Néo-Écossai.

5- La session thématique : Six présentations ont fait l'objet de la session. De plus, Ian Perry (MFO – région du Pacifique) en visite à l'IML pendant la réunion a été invité à présenter un séminaire sur les changements récents dans les conditions océanographiques dans le nord-est Pacifique. Sans aucun doute, les conditions environnementales de 1999 représentaient des conditions uniques pour les cinq dernières années. Les conditions de températures en 2000 ont été également anormalement élevées et le début de la floraison printanière relativement tôt mais moins qu'en 1999. Le maquereau et l'aiglefin ont eu un recrutement exceptionnel en 1999. Dans le golfe du Saint-Laurent, la classe d'âge de 1999 était la plus forte des 10 dernières pour le turbot et la deuxième plus importante pour la crevette. Une proposition a été appuyée à l'effet de produire une publication primaire à partir des présentations de la session. Également, il a été décidé qu'un article sur "l'évènement 1999"sera préparé pour le bulletin du PMZA pour l'automne 2003.

6- Affaires courantes du Comité : La poursuite des activités du groupe de travail sur l'incorporation de données environnementales dans les évaluations de stocks a été discutée. Il a été souligné qu'une recommandation avait été faite lors de l'atelier du COP-PMZA de novembre 2002 sur l'implication du COP dans l'établissement de projets type afin d'explorer les relations entre l'environnement et les stocks et l'utilisation possible de l'information dans les évaluations. Il a été décidé que le groupe de travail sera maintenu et que le président du Comite allait examiner quelles activités pourraient être initiées en relation avec le mandat du groupe de travail. Le groupe de travail sur le monitorage des écosystèmes pélagiques a été discontinué. Les questions à l'origine de la formation du groupe de travail ont été soulevées lors de l'atelier du COP-PMZA et des recommandations sur le besoin d'accroître le monitorage du necton et des communautés pélagiques ont été présentées au PMZA. Le COP a décidé d'attendre les résultats de la revue des activités du PMZA avant de poursuivre les discussions sur ce point. La réunion annuelle de 2004 aura lieu au Northwest Atlantic Fisheries Centre (NWAFC) à St. John's (Terre-Neuve) en mars 2004.

Table of Contents

1. Introduction

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans (DFO) met at the Maurice Lamontagne Isntitute (Mont-Joli, Québec) on March 11 to 14, 2003, (1) to review the environmental conditions in the Northwest Atlantic during 2002, (2) to review other papers on the environment or fisheries-environment linkages, and (3) to conduct the annual FOC business meeting and review progress of working groups of the FOC. A theme session on the particular physical conditions of the year 1999 and the effect on some fish and invertebrate stocks 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 2003 annual meeting, the FOC core-members were:

Name	Region	Location/lab
John Anderson[1]	Newfoundland	NWAFC
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. 2002 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

[1] Edgar Dalley replaced John Anderson at the 2003 Annual Meeting

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, sea ice and sea surface temperature conditions during 2002 were examined and compared with those of the preceding year as well as to the long-term means (30-yr base period – 1971 to 2000, when possible) in the Northwest Atlantic. Generally, slightly warmer-than-normal air temperatures tended to dominate over most of eastern Canada during 2002. In detail, predominantly cold air covered much of the Labrador Sea region from January through April whereas, during the same period, warmer-than-normal air temperatures covered areas from the Gulf of St. Lawrence to the Atlantic Bight. In June and July, the Labrador Sea region had above normal air temperatures while Newfoundland and more southern areas experienced cold conditions. During July and September, most areas off the East coast experienced slightly (positive anomalies of the order of 1°C or less) warmer-than-normal air temperatures. Cold conditions moved to southern regions in October and November while most of the Labrador Sea maintained warmer-than-normal air temperature. In December, warm temperature anomalies were again observed over the entire region.

The annual mean air-temperature anomalies for 2002 were also calculated at selected coastal sites (Fig. 1). Annual means in 2002 declined substantially (≥1°C) compared to 2001 from the northernmost site (Nuuk) to the Scotian shelf (Sable Island). However, the annual anomalies rose in the southern locations (e.g., Boston) relative to 2001 (Fig. 1). Interestingly, inter-annual variability in air temperatures since 1960 at Nuuk, Iqaluit, Cartwright, and St. John's, show a quasi-decadal (lows in early 1970s, mid 1980s and early 1990s – Fig. 1) fluctuations and the recent decline at these sites is consistent with the decadal period. During the 1990s, air temperatures at Boston and Cape Hatteras have been (generally) out of phase with the Labrador region, i.e., cold temperatures in Labrador occurred when temperatures are warm along the US seaboard (Fig. 1).

The North Atlantic Oscillation (NAO) index is the difference in winter (December to February) sea level atmospheric pressures between the Azores and Iceland and is a measure of the strength of the winter westerly winds over the northern North Atlantic. A high NAO index corresponds to an intensification of the Icelandic Low and Azores High. A high positive NAO index usually mean strong northwest winds, cold air and sea temperatures, and heavy ice in the Labrador Sea. In 2002, the NAO index was still below normal but rose relative to 2001 (Fig. 2). For both 2001 and 2002, the index was well below the high indices of 1998 to 2000 and similar to values observed during 1996 – 1997 (Fig. 2). Low NAO usually means warm air temperatures over the Labrador Sea in winter and this is consistent with the conditions observed in 2001 and 2002.

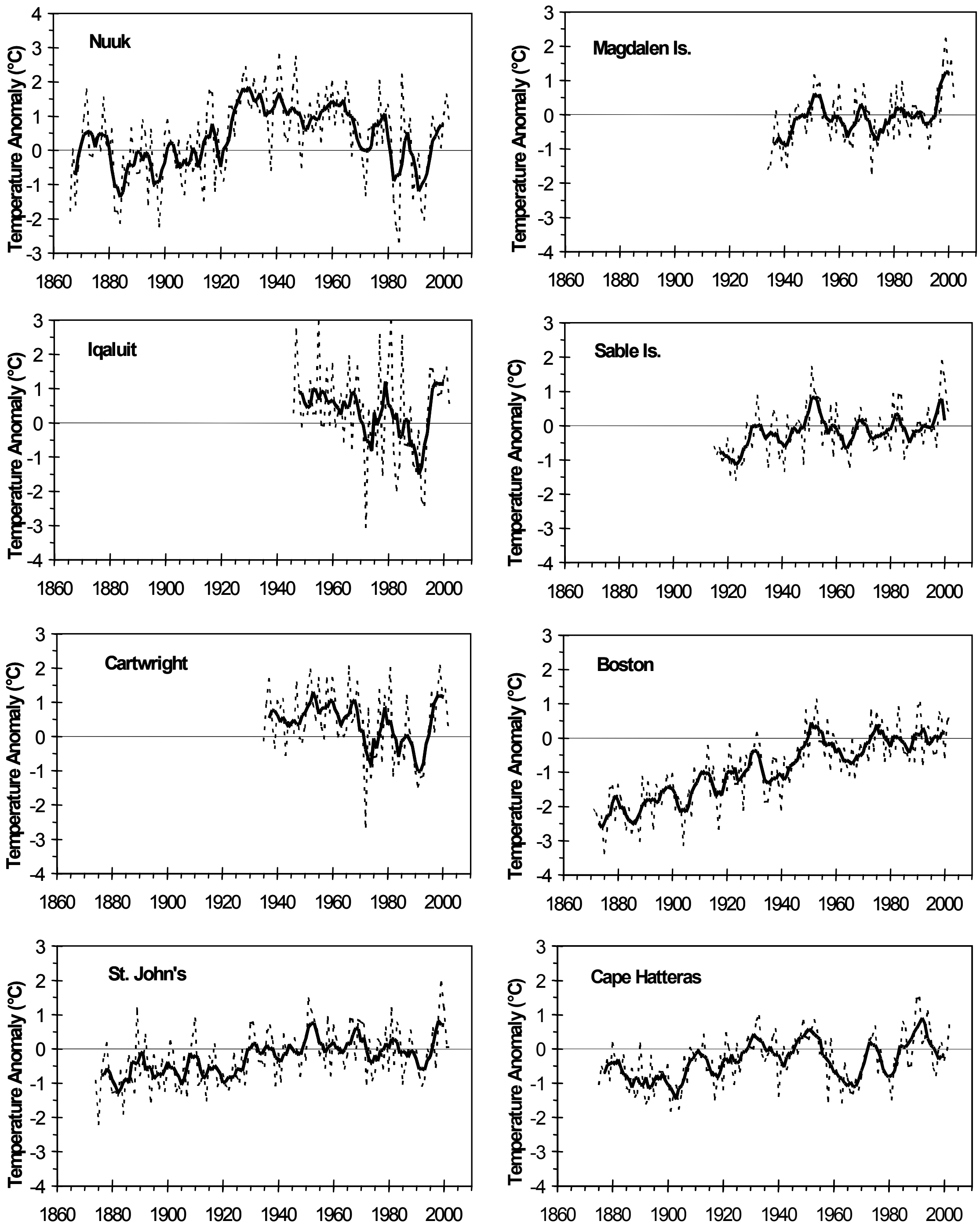

Figure 1. Time series of air temperature anomalies (dashed line) and 5-yr running means (solid line) at selected sites.

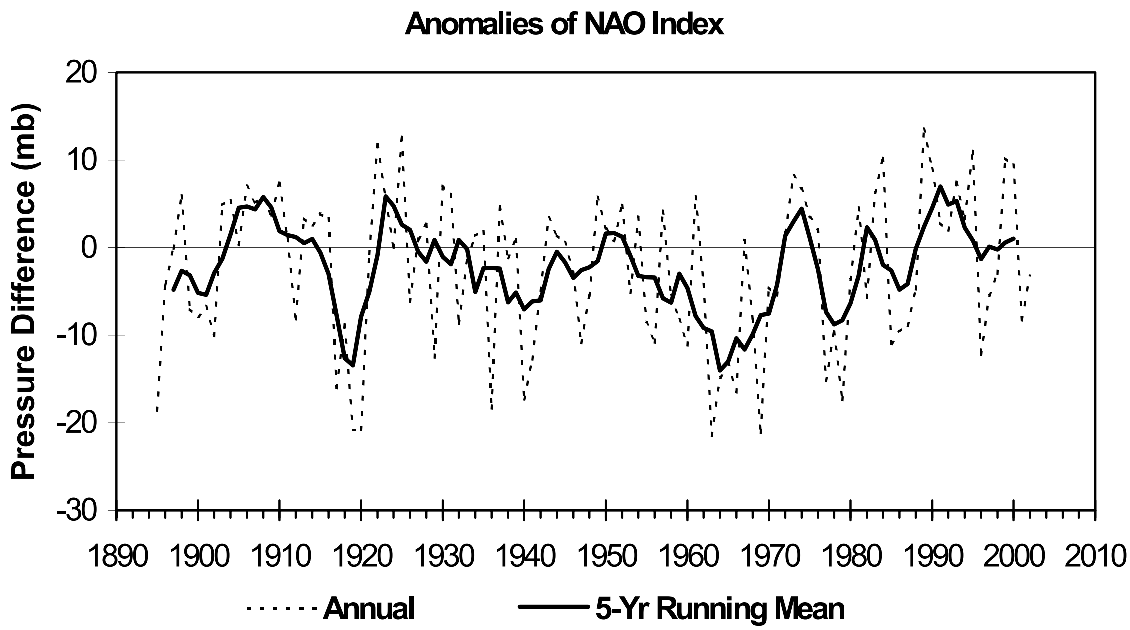

Figure 2. Anomalies of the North Atlantic Oscillation Index, defined as the winter (December, January, February) sea level pressure difference between the Azores and Iceland, relative to the 1961-90 mean.

This year new values for the long-term median, maximum and minimum positions of the ice edge were based on the 1970 – 2000 data available from the Canadian Ice Service. The areal coverage was less than the long-term median and close to the long-term minimum for the beginning of the year. At the beginning of 2002, sea ice was present only off the southern Labrador coast in vicinity of Hamilton Inlet. The expansion of the ice resulted in a distribution near the median values by February 1, but southward extension was slightly less than the median by March 1. In 2002, ice appeared along the southern Labrador coast in late December, and gradually spread southward to northeastern Newfoundland water by late-January. Only small quantities of ice reached the northern Grand Bank.

Relative to the long-tern mean, ice appeared later-than-normal over most of the Labrador and Newfoundland Shelves. Ice began to disappear from the offshore and southern sites in late March but not until mid-May from inshore northern Newfoundland and southern Labrador waters. However, over much of the region, ice disappeared later-than-normal. On Newfoundland and southern Labrador shelves, peak extent during 2002 was slightly above 2001. During both periods, the average ice area was below the long-term mean, and was much less than in the early 1990s.

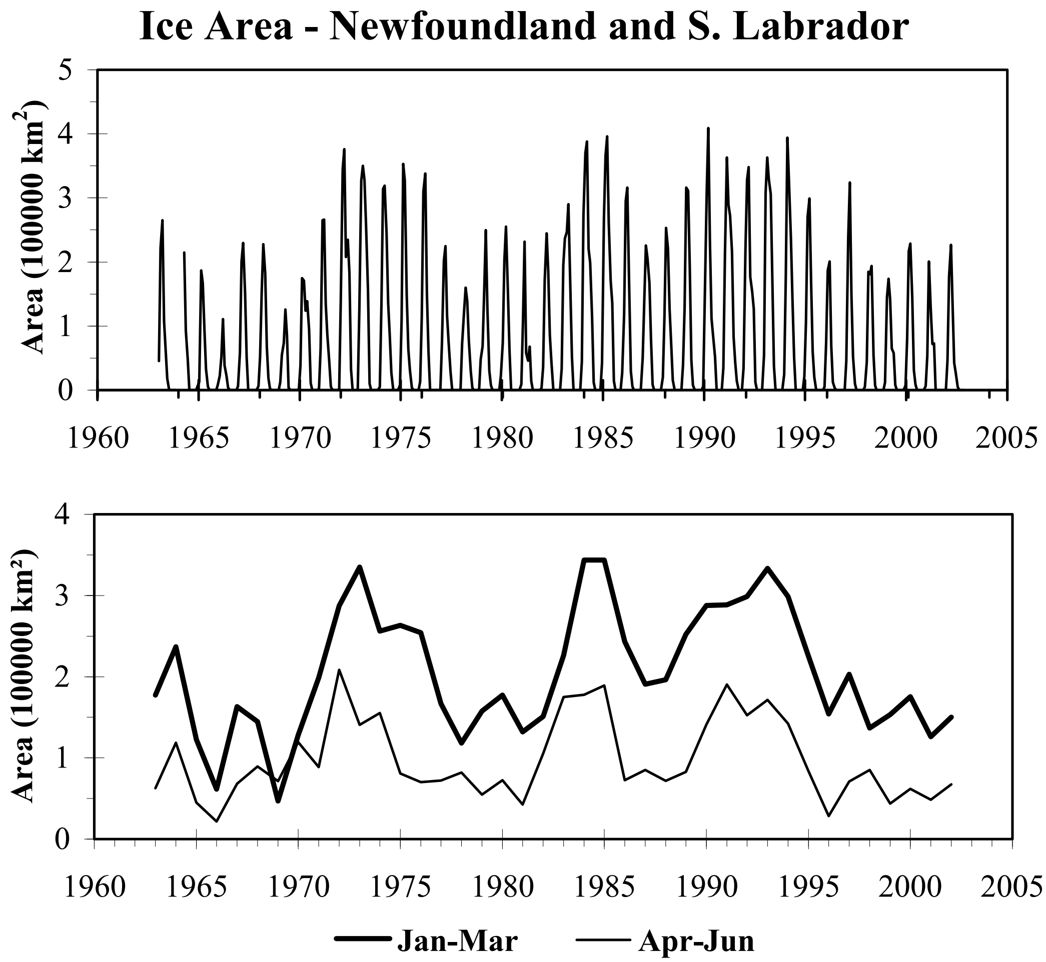

Figure 3. Time series of the monthly mean ice area off Newfoundland and Labrador between 45°N-55°N (top panel) and the average ice area during the normal periods of advancement (January-March) and retreat (April-June) (bottom panel).

Averages of monthly and annual sea surface temperature (from satellite-derived temperature data) anomalies were examined for 6 areas stretching from the Labrador Sea to the Gulf of Maine. Positive annual mean sea surface temperature anomalies were comparable between 2002 and 2001 for Labrador and Newfoundland shelves whereas the 2002 anomalies were lower relative to 2001 in the Gulf of St. Lawrence. Overall however, the anomalies showed continuation of a period of generally above normal temperatures that began in the late 1990s and is particularly well defined in the Newfoundland and Scotian Shelf regions.

3.1.1 Physical conditions in the Labrador Sea in 2002 (R. Hendry)

Since the winter of 1994-1995, mild winters have produced only shallow wintertime convection and this pattern persisted through the winter of 2001-2002. Wintertime (December-February) heat fluxes were nearly 60 W m^{-2} less than the winter normal but were balanced by higher than normal spring (March-May) heat fluxes. A July 2002 transect of the Labrador Sea showed evidence of vertical overturning during the previous winter to depths of 1200-1400m. This evidence consisted of remnants of a vertically mixed layer with high dissolved oxygen and relative minima of potential temperature and vertical density stratification.

In spite of a cooling and freshening near 1000m associated with the moderate 2001-2002 winter overturning, the upper layers of the Labrador Sea became warmer and saltier. This points to a greater influence of warm, saline waters carried north into the Labrador Sea by the offshore branch of the West Greenland Current. The 150-1000m mean temperature in the central Labrador Sea was the second highest observed in the thirteen-year period of annual surveys, surpassed only by 1999; the net effect was a small decrease in 150-2000m mean density. The salinity of the upper 1000m was greater than observed since the period of deep convection of the early 1990's when higher-salinity waters from deeper levels were entrained into the upper 1000m. The dissolved oxygen content of the warm, salty water observed in 2002 was lower than observed in the preceding two years.

Since the mid-1990's, a notable trend to higher temperature and salinity in the 1000-2000m layer has emerged. In spite of the effects of winter overturning noted above, the mean temperature of this layer in early-summer 2002 was the warmest observed at comparable seasonal times during the past thirteen years. Salinity in this depth range showed a very slight decrease from the record-high conditions of the previous year. The density of seawater decreases with increasing temperature and increases with increasing salinity. The 2002 survey revealed slightly less-dense waters in the 1000 - 2000m depth range compared with results from 2001.

3.2 Physical Oceanographic Conditions

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

The below-normal trends in temperature and salinity, established in the late 1980s reached a minimum in 1991. This cold trend continued into 1993 but started to moderate during 1994 and 1995. During 1996 temperature conditions were above normal over most regions; however, summer salinity values continued to be slightly below the long-term normal. During 1997 to 1999 ocean temperatures continued to warm over most areas, with 1999 one of the warmest years in the past two decades. During 2000 to 2002, ocean temperatures were cooler than 1999 values, but remained above normal over most areas continuing the trend established in 1996. From 1997 to 2001 the trend in salinities on the Newfoundland Shelf was mostly below normal; however, during 2002 there was a significant increase with surface values the highest observed in over a decade.

The annual water-column averaged temperature at Station 27 for 2002 decreased compared to 2001 values, but remained above the long-term mean over most depth ranges. The annual surface temperature at Station 27 was about normal during 2002, while the annual bottom temperature remained above normal by 0.2°C (Fig. 4). Water-column averaged summer salinities at Station 27 increased over 2001 values to above normal and to the highest in about 12 years. Surface salinities at Station 27 were above normal for 11 of 12 months, while bottom salinities were either near normal or slightly below normal. Farther east, the long-term trends in temperature and salinity anomalies on the Flemish Cap were similar to those at Station 27 (Fig. 4). Surface temperatures during 2002 (only three observations) decreased to below normal values, while values at deeper levels were similar to 2001. On the Labrador Shelf, temperatures on Hamilton Bank in 2002 were very similar to 2001 values; about normal at the surface and generally above normal at the deeper levels (Fig. 4).

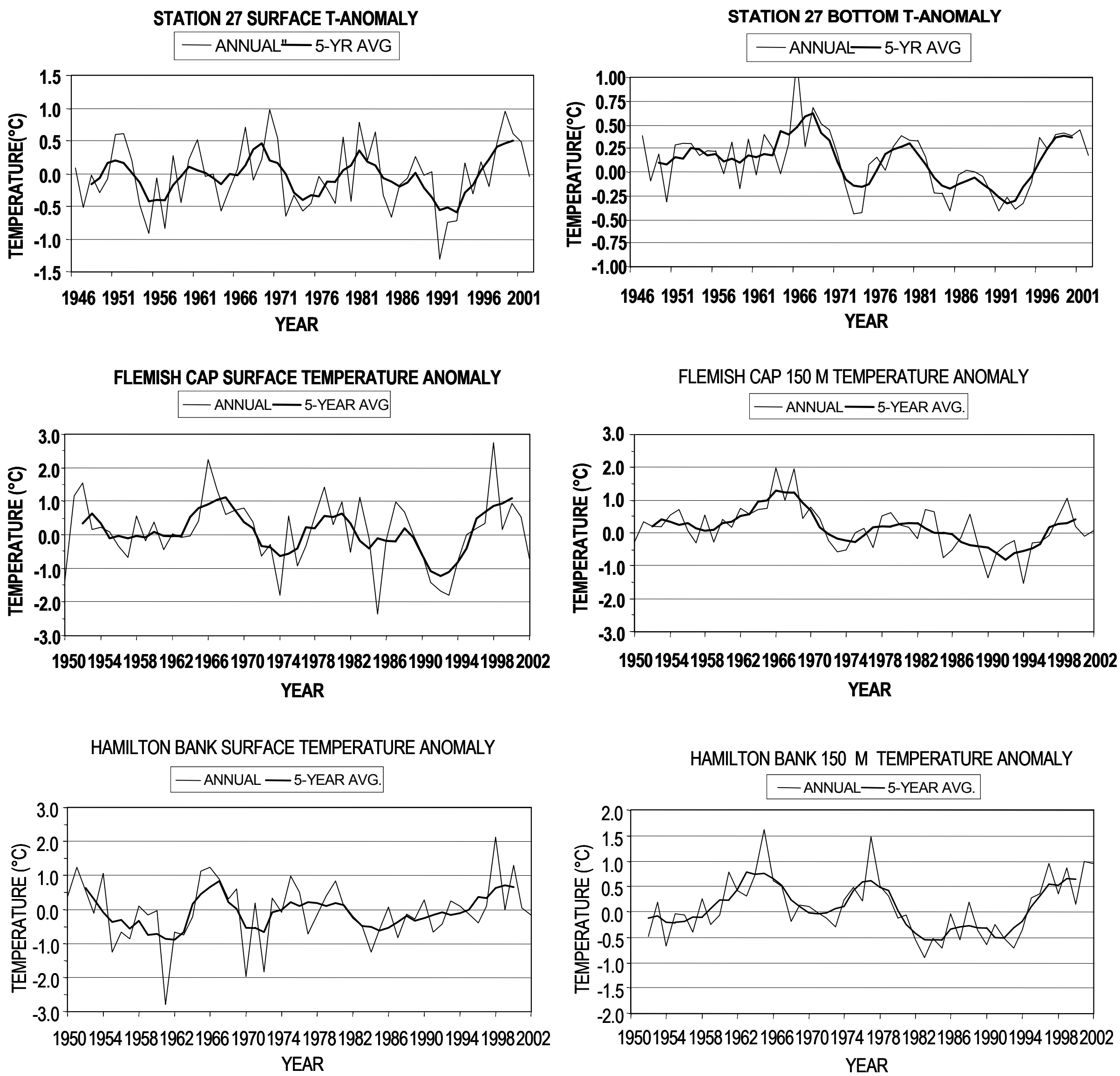

Figure 4. Surface and bottom annual temperature and salinity anomalies and their 5-years running means at selected sites on the Newfoundland and Labrador shelves.

The cross-sectional area of the Cold Intermediate Layer (CIL; <0°C water) on the Newfoundland and Labrador shelves during the summer of 2002 decreased over 2001 values along northern sections and along southern sections it remained very similar to 2001 (Fig. 5). The CIL areas were below normal along all sections from the Flemish Cap on the Grand Bank, to the Seal Island off southern Labrador. Off Bonavista, the CIL area was very similar to 2001, below normal for the eighth consecutive year (Fig. 5). These values are among the lowest observed since 1978 on the eastern Newfoundland Shelf. The total volume of <0°C water on the Newfoundland and southern Labrador Shelf during the fall increased very slightly compared to 2001, continuing the trend of below normal values observed since the mid-1990s.

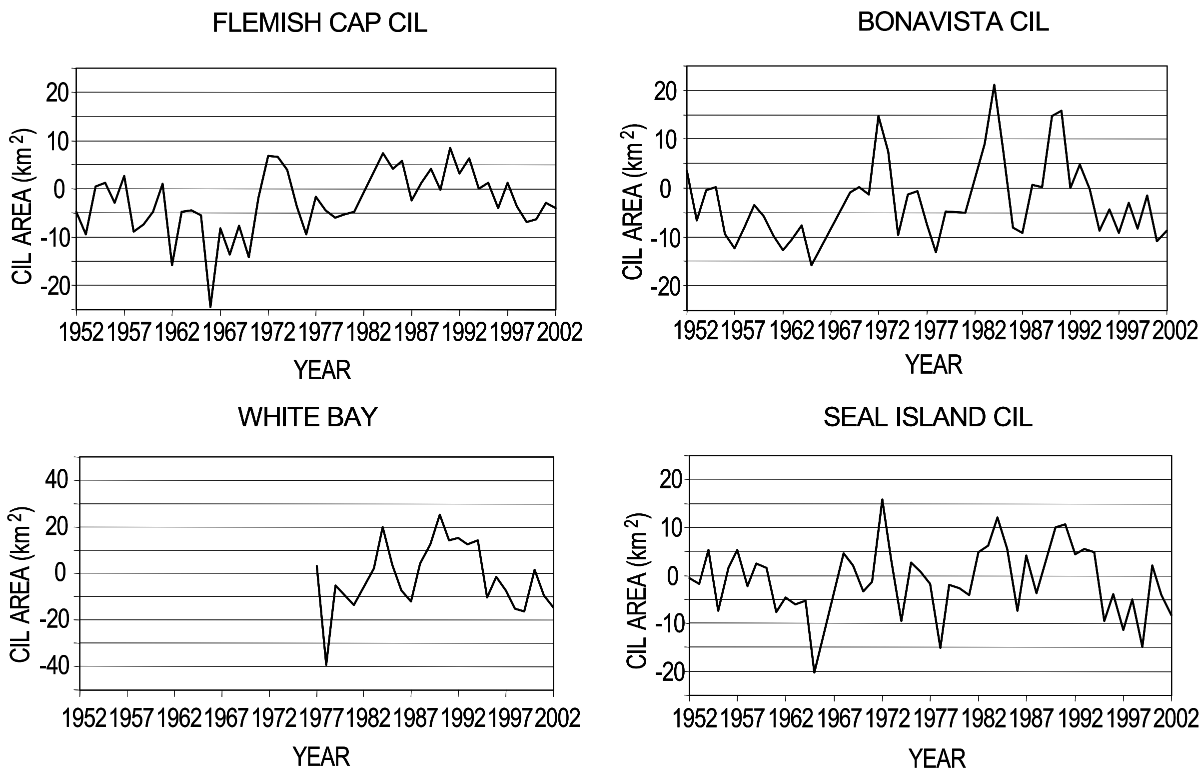

Figure 5. Time series of summer and fall Cold-Intermediate-Layer (CIL) areas with temperatures <0° C at selected sections of Newfoundland and Labrador shelves.

Bottom temperatures on the Grand Bank during the spring of 2002 ranged from near normal to above normal (by up to 0.5°C) over most areas. During the fall, bottom temperatures were generally above normal except for the shallow waters of the southeast Grand Bank, where they were up to 2°C below normal. Fall bottom temperatures in NAFO Divisions 2J and 3K were also above normal; up to 2°C on Hamilton Bank and up to 1°C on Funk Island Bank. The spatially averaged bottom temperature during 2002 in all NAFO Divisions remained very similar to 2001 values, except in 3K, where the mean bottom temperature increased slightly over 2001. 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 NAFO sub-Divisions 3Pn and 3Ps (southern Newfoundland), time series of temperature anomalies in the 3Ps (St. Pierre Bank) area show anomalous cold periods in the mid-1970s and from the mid-1980s to late 1990s. These conditions were similar to those observed on the continental shelf along the east coast of Newfoundland, except the latter cold period lasted longer on St. Pierre Bank than on the eastern Newfoundland Shelf. During the most recent cold period, which started around 1985, temperatures were up to 1°C below average over all depths and up to 2°C below the warmer temperatures of the late 1970s and early 1980s in the surface layers (Fig. 6). Temperatures in deeper water off the banks during all years show significant variations, but remained relatively warm with values in the 3 to 6°C range, compared to much colder values (often <0°C) on St. Pierre Bank. Beginning around 1996 temperatures on St. Pierre Bank started to moderate, then they decreased again during the spring of 1997 and returned to more normal values during 1998. During 1999 and 2000 temperatures continued to increase reaching the highest values since the late 1970s near the surface. During the spring of 2001 and 2002 however, temperatures cooled significantly over the previous two years to values observed during the mid-1990s (Fig. 6).

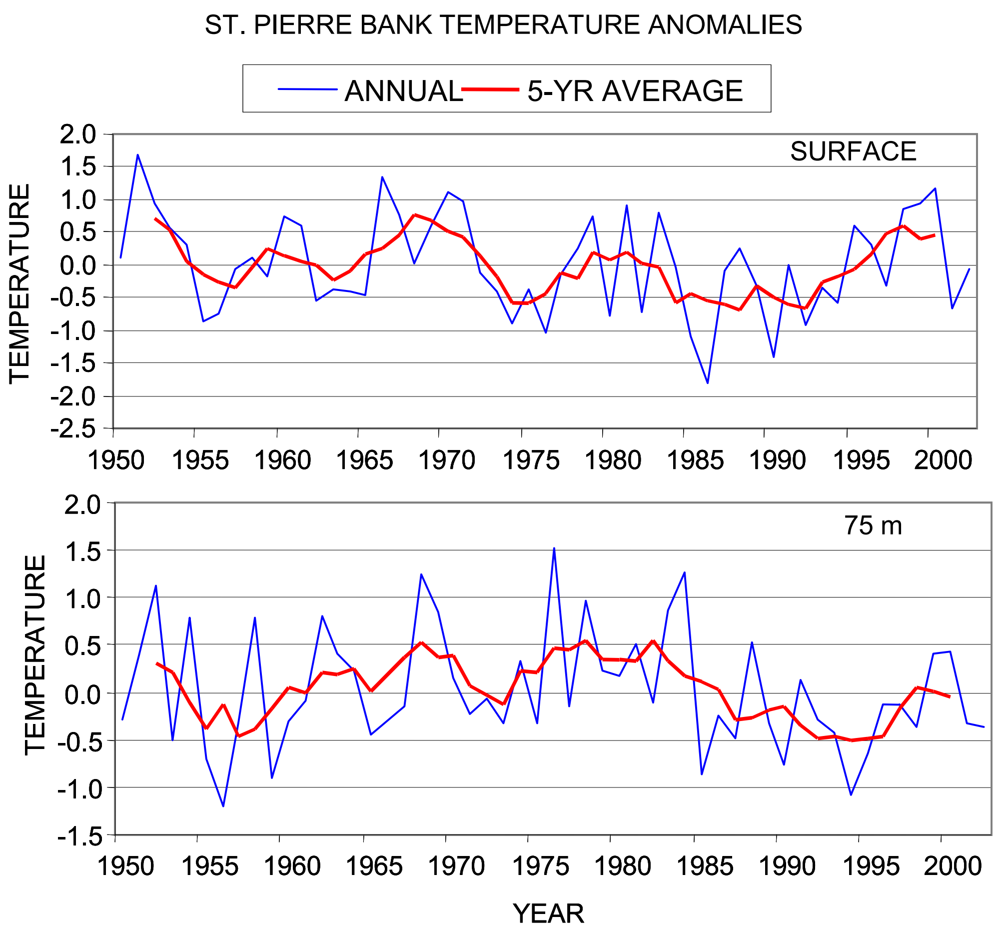

Figure 6. Annual near-surface and near-bottom temperature anomaly (° C) time series for the St. Pierre Bank constructed from all historical data. The heavy solid line represents the 5-year running mean.

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 (Fig. 7). During 2001, it increased again returning to values observed during the mid-1990s, but it decreased slightly again during 2002. Since 1995 the areal extent of bottom water with temperatures >1°C has been increasing, reaching pre-1985 values during 1999-2000. During 2001 this area decreased significantly compared to the previous 3-years but increased slightly during 2002. On St. Pierre Bank <0°C water completely disappeared during the warm years of 1999 and 2000. It has since increased to between 20-30% during 2001 and 2002. 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 low values during the past 2 years. In general, this analysis showed significant variations in the water mass characteristics particularly on St. Pierre Bank during the past several years. 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 too 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 as cold water returned to the region. Temperature conditions in this region during the spring of 2002 increased slightly over values observed in 2001, while salinity values were fresher than those observed in 2002.

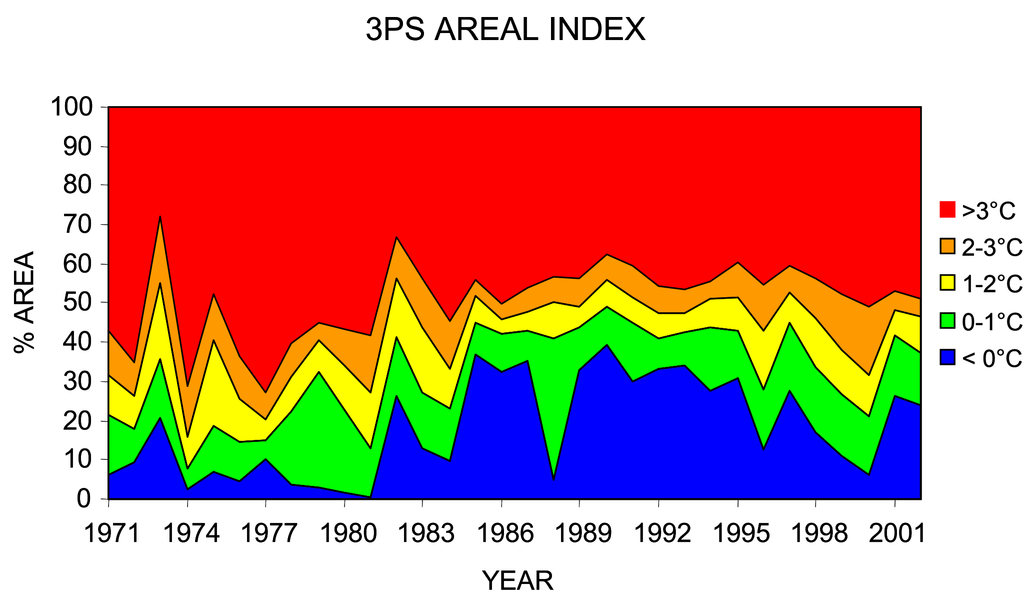

Figure 7. Spring time series of the percentage area of the bottom in NAFO Subdivisions 3Pn and 3Ps covered by water with temperatures ≤0° C, 0-1° C, 1-2° C 2-3° C and ≥3° C

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

A review of physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine and adjacent offshore areas during 2002 was presented. Warm and salty conditions tended to dominate the Scotian Shelf and Gulf of Maine areas in 2002. Mean annual sea-surface temperature at Boothbay Harbor was the 3rd warmest in the last 97 years and at St. Andrews the 9th warmest in the last 81 years (Fig. 8). At Prince 5, monthly mean temperatures and salinities throughout the water column were almost exclusively above normal throughout the year. At Halifax Station 2 (H2) the surface and near bottom layers were warmer-than-usual but at mid-depths they varied through the year between colder and warmer than average. Waters at all depths at H2 tended to exhibit above normal salinities.

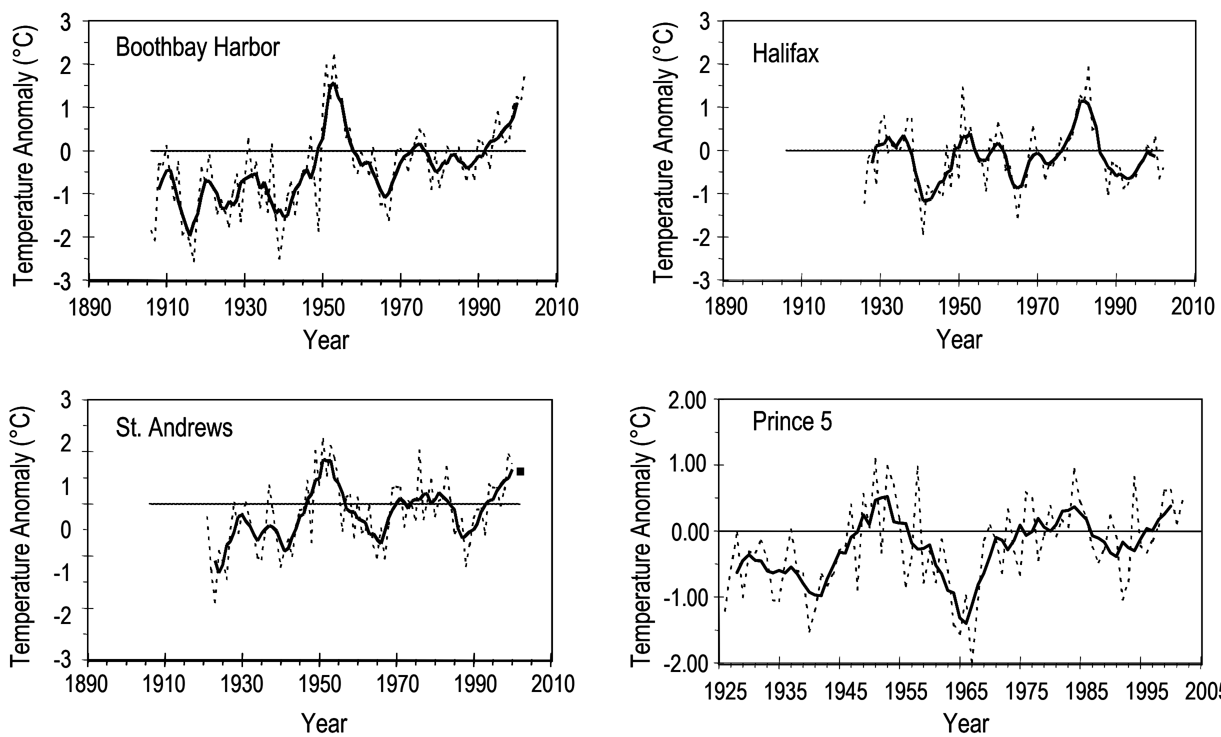

Figure 8. The annual sea-surface temperature anomalies and their 5-year running means for Boothbay Harbor, St. Andrews, Halifax Harbour and Prince 5 stations. Anomalies are relative to the 1971-2000 means.

Particularly warm waters were observed in the Gulf of Maine, at all depths in Georges Basin, on Georges Bank and on Lurcher Shoals. Similarly warm waters were found in the deepest reaches of Emerald Basin and in the upper 50 to 100m over Misaine Bank and on Sydney Bight. In these latter two areas, the lower layer waters tended to be colder than the normal. Cabot Strait deep-water (200-300 m) temperatures were on the high side of normal. Exceptions to the warm conditions included the sea surface temperatures at both Halifax and over most of the Scotian Shelf during the groundfish survey in July. During this survey, waters at 50 m and 100 m were spatially variable, varying about the long-term mean but with a slight preference for warmer-than-normal temperatures. Near-bottom temperatures in July were warm except in the northeast where the water temperature anomalies varied spatially (Fig. 9). However, there was a noticeable increase in bottom temperatures compared to 2001.

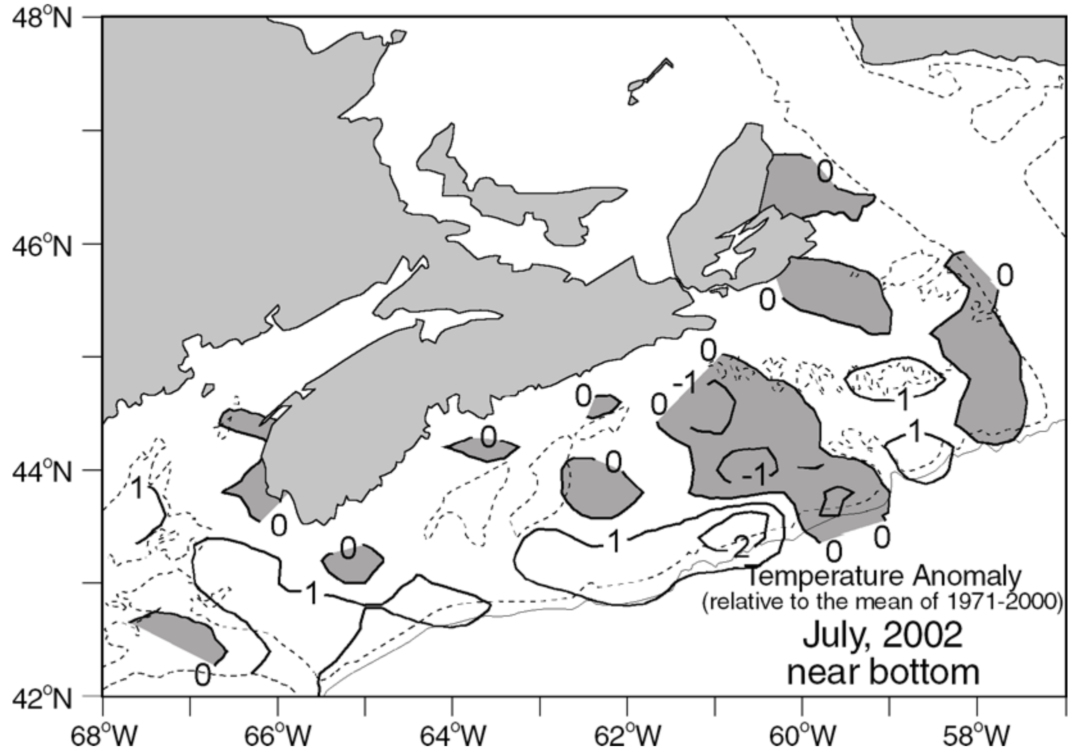

Figure 9. Contours of temperature anomalies near bottom during the 2002 July groundfish and ITQ surveys.

In May a very warm, salty water mass was observed at the offshore end of the Halifax Line (AZMP). This is believed to be a Gulf Stream eddy or meander. It appears that some of this water may have penetrated onto the Scotian Shelf and contributed to warmer and saltier conditions there in both May and June. During the AZMP cruise in October of 2002, warm conditions dominated on the Browns Bank and Halifax Lines with near normal temperatures on the Louisbourg section. In Cabot Strait, the near-bottom water temperatures were warmer-than-normal but the top 100 m tended to be colder. While the vertical stratification in the upper water column (between surface and 50 m) over the Scotian Shelf continued to weaken in 2002 relative to the last few years, it generally remained higher than normal. The Shelf/Slope front and the Gulf Stream were located, on average, at about the same locations as in 2001, which was shoreward of its normal position for the Gulf Stream but seaward for the Shelf/Slope front.

The monthly estimates of the ice area seaward of Cabot Strait since the 1960s show that only small amounts were transported onto the Scotian Shelf during 2002 compared to the long-term mean. The ice area, however, was slightly lower in magnitude than that observed in 2001. The integrated ice area was slightly lower than 2001 and remained well below the long-term average. This was the fifth consecutive year of very light ice conditions seaward of Cabot Strait.

3.2.3 Gulf of St. Lawrence (D. Gilbert and C. Lafleur)

According to Environment Canada, winter air temperatures in 2002 were warmer (by 0.5 to 2°C) than normal everywhere in the Gulf of St. Lawrence except in the Northeast Gulf where they were close to normal. In spring, air temperatures were below (0.5°C) normal in the northern Gulf but elsewhere and during the summer air temperatures were normal. In the fall, air temperatures were close to normal everywhere except in the Northeast Gulf where they were lower (0.5°C) than the normal.

Warm air temperatures in late 2001 slowed ice formation in the Gulf of St. Lawrence so that there was little ice at the beginning of 2002. Subtracting the long-term mean indicates that the time of first ice was later than normal over most of the Gulf by 1 to 2 weeks. The last presence of ice varied from late March to mid May with the result that it disappeared earlier than normal in the central (e.g., off western Newfoundland) and southern (e.g., Southern Magdalen Shallows) regions. Over the entire Gulf, ice duration was less than the long-term mean by between 10 and 30 days. Comparison of the monthly mean area of the Gulf covered by ice showed that in 2002 the peak areal coverage rose relative to 2001 and the previous several years (Fig. 10). Estimates of the duration of ice, however, indicate a value much lower than the long-term mean. Indeed, 2002 was a light ice year in the Gulf of St. Lawrence.

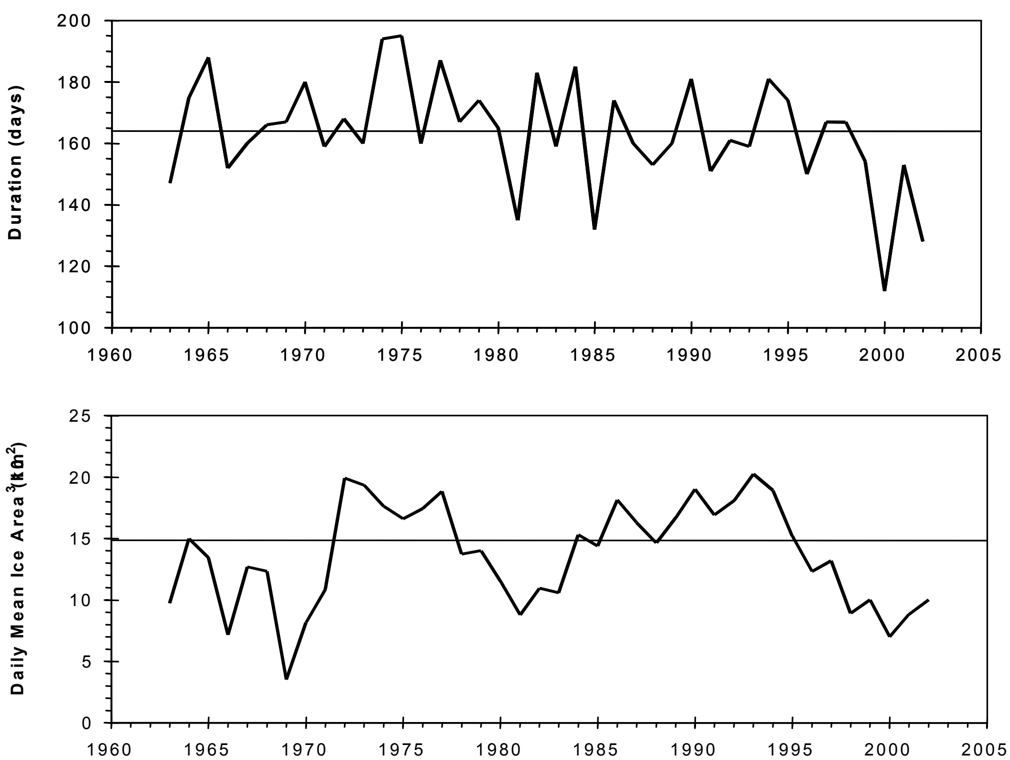

Figure 10. The time series of the duration of ice (top) and the annual integrated ice area (summation of the area times the number of days). The horizontal lines represent the long-term (1971-2000) means.

Precipitation over most of the drainage basin of the St. Lawrence River and Gulf of St. Lawrence was below normal in 2002. Consequently, relative to the long-term (1971 - 2000) reference period, the annual mean freshwater discharge at Quebec City was about 1500 $m^3 s^{-1}$ below normal for the fourth consecutive year (Fig. 11).

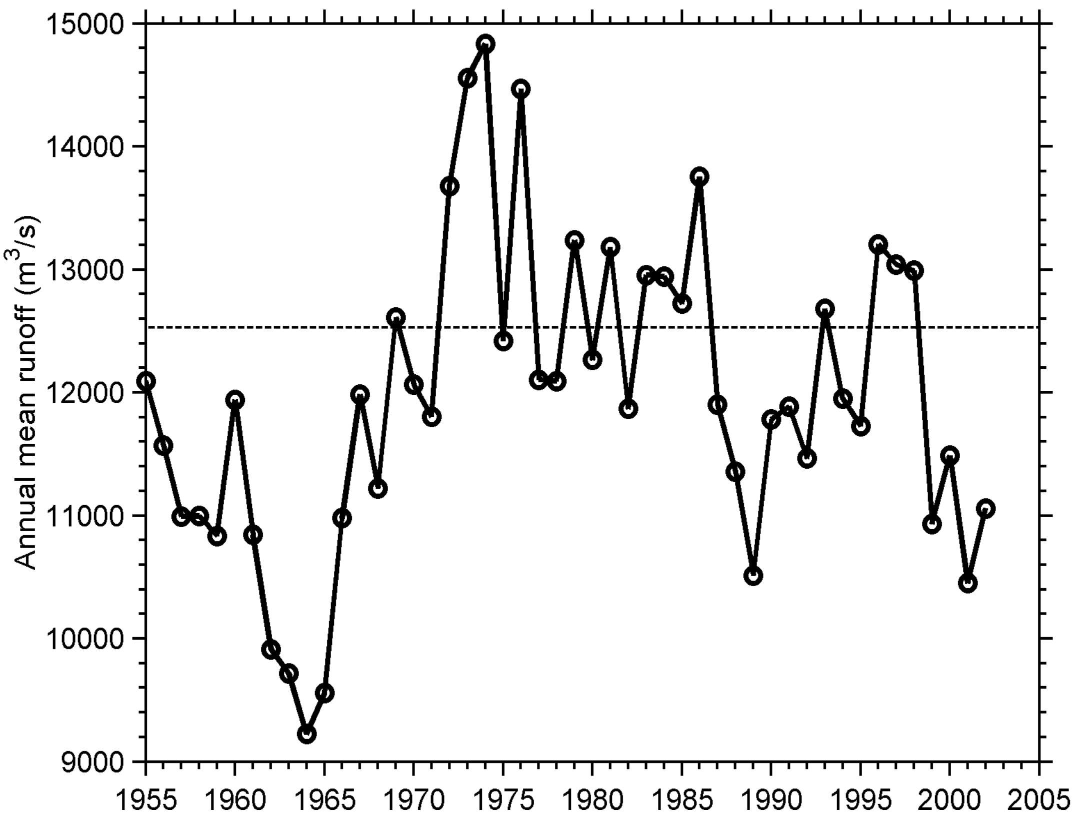

Figure 11. Yearly averaged freshwater discharge of the St. Lawrence River at Quebec City (line with circles) compared with the 1971-2000 climatological values (dashed line).

The minimum temperature within the Cold Intermediate Layer (CIL) slightly declined by 0.1°C in the deep parts of the Gulf and over the Magdalen Shallows (Fig. 12). However, the thickness of CIL waters with temperature below 0°C and 1°C decreased by 10 m and 14 m, respectively. This is unusual because a drop in CIL minimum temperature is normally accompanied by an increase in CIL thickness. In 2002, the CIL minimum temperature was close to the long-term median in the deep parts of the Gulf.

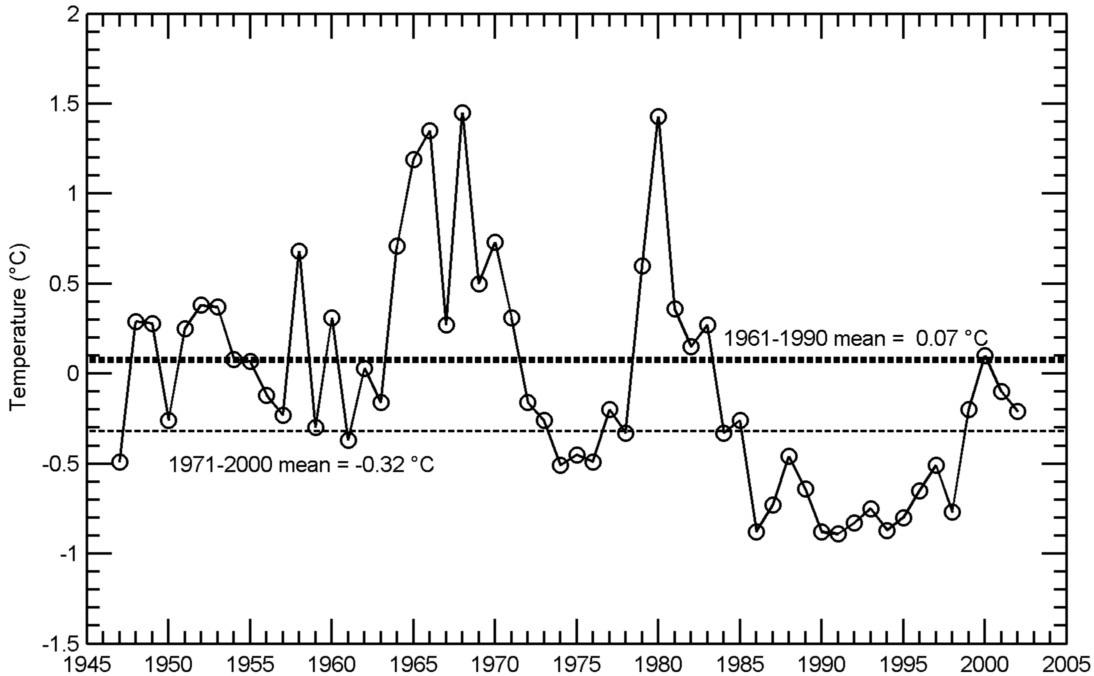

Figure 12. Composite index of CIL core temperature anomaly in the Gulf of St. Lawrence. The thick dashed line shows the 1961-1990 mean (0.07° C) whereas the thin dashed line shows the 1971-2000 mean (-0.32° C).

The temperature and salinity measurements (May to September) were analysed for different layers of the water column. The mid-summer (July 15) Gulf-wide average temperature between 30 and 100 m was warmer by ~0.3° C relative to 2001. In the 100-200 m layer, temperatures were also warmer (0.38° C) relative to 2001 and the 1971-2000 mean. Finally, in the 200-300 m layer, water temperature rose by 0.12° C in 2002 relative to 2001 and are now warmer by 0.27° C relative to the 1971-2000 normal.

3.2.4 Physical Environment Scorecard

As for the past years, all the various 2002 indices of the physical oceanographic conditions in the Atlantic Zone were summarized to facilitate comparisons among the Regions. The physical environment scorecard shows the 2002 anomalies (in standard deviations from the 1971-2000 reference period) in relation with anomalies since the year 1997 (Table 1).

Table 1 Environmental scorecard for 2002.

Index	Region	1997	1998	1999	2000	2001	2002	Stn. Devs.	
	NAO	-0.63	-0.34	1.18	1.10	-0.96	-0.37		
	Newfoundland/Labrador	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Stn. Devs.**	**Cold/Fresh Conditions**
Annual Air Temperature	Labrador (Cartwright)	0.125	1.10	1.841	1.007	1.22	0.18	>2	
	Newfoundland (St. John's)	-0.69	1.14	2.52	1.56	0.78	0.07	>1.5 to 2	
Sea Ice	Labrador & Newfoundland	-0.58	-0.99	-1.21	-0.88	-1.28	-1.04	>1 to 1.5	
Surface Temperature	Station 27	-0.40	0.85	1.81	1.15	0.93	-0.08	>0.5 to 1	
Integrated Temp	Station 27 (0-50)	0.05	0.18	1.25	0.96	1.73	-0.11	-0.5 to 0.5	
	Station 27 (0-176)	-0.03	-0.03	1.34	1.1	1.21	0.66		
Near-Bottom Temperature	Station 27	0.83	1.35	1.45	1.31	1.52	0.59		
	Newfoundland (Grand Bank)	-0.54	0.24	0.61	0.59	0.05	0.00		**Warm/Salty**
	St. Pierre Bank	-0.36	-0.18	0.61	0.65	-0.72	-0.19		**Conditions**
CIL	Eastern Newfoundland Shelf	-1.03	-0.35	-0.93	-0.17	-1.24	-0.98	>2	
	Grand Bank	0.26	-0.73	-1.38	-1.26	-0.55	-0.81	>1.5 to 2	
	Hamilton Bank	-1.46	-0.64	-1.91	0.25	-0.52	-1.07	>1 to 1.5	
Salinity	STATION 27 (SURFACE)	-0.26	-0.30	-0.39	-0.22	-0.57	1.09	>0.5 to 1	
	STATION 27 (BOTTOM)	-0.10	0.40	-0.20	-0.30	-0.10	-0.20	-0.5 to 0.5	
Stratification	STATION 27	0.40	0.90	1.30	0.50	1.00	-0.17		
	Gulf of St. Lawrence	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**		
Annual Air Temperature	Gulf of St. Lawrence (Magdalen Islands)	-0.26	1.917	2.777	1.468	1.95	0.62		
Sea Ice	Gulf of St. Lawrence	-0.45	-1.6	-1.3	-2.1	-1.62	-1.30		
Integrated Temp	Cabot Strait (200-300 m)	0.07	-0.81	0.629	0.137	0.57	0.86		
	Gulf of St. Lawrence (cont)	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**		

	Gulf of St. Lawrence (30-100 m)	-0.3	-0.81	0.356	0.927	-0.28	0.31
	Gulf of St. Lawrence (100-200 m)	-0.25	-0.3	0.533	0.533	-0.03	0.55
	Gulf of St. Lawrence (200-300 m)	0.30	-0.31	-0.13	0.027	0.30	0.54
Near-Bottom Temperature	Magdalen Sh. Area with T <0	0.17	0.85	-1.12	-0.47	-1.22	-1.17
	Magdalen Sh. Area with T <1	0.64	1.14	-0.58	-0.99	-0.05	-0.81
CIL	Gulf of St. Lawrence-Minimum temperature (1948-1999)	-0.38	-1.03	0.22	0.90	-0.38	0.21
	Scotian Shelf/Gulf of Maine	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Annual Air Temperature	Scotian Shelf (Sable Island)	-0.92	1.283	2.77	1.984	0.71	0.35
	Gulf of Maine (Boston)	-0.77	1.325	0.941	-1.01	0.93	1.19
Sea Ice	Scotian Shelf (Area)	-0.3	-1.37	-1.31	-1.20	-1.17	-1.49
Surface Temp	Halifax (SST)	-0.3		-0.03	0.44	-0.95	-0.65
	Bay of Fundy (St. Andrews SST)	-0.08	0.538	1.869	1.57		1.257
	Gulf of Maine (Boothbay SSTs)	0.34	0.538	1.993	2.38	2.28	3.44
Near-Bottom Temperature	NE Scotian Shelf (Misaine Bank-100 m)	-0.43	-0.02	0.797	1.406	-0.27	0.23
	Emerald Basin (250 m)	0.33	-1.69	-0.22	0.314	0.19	0.245
	Lurcher Shoals (50 m)	0.045	-1.39	1.156	1.779	-0.83	1.577
	Georges Basin (200 m)	0.34	-2.57	0.985	1.036	0.18	0.43
	Georges Bank (50 m)		-0.60	1.06	1.10	1.38	1.35
	Prince 5 (90 m), Bay of Fundy	-0.46	-0.85	1.893	1.596	-0.54	0.81
Salinity	Prince 5 (90 m)	-0.1	-1.07	0.799	0.483	-0.16	1.34

3.2.5 Questions and Discussion

The discussion on the physical environment conditions opened with an observation that the recent trends in temperature seem to depart from the highs that were recorded over the last few years.

Following the presentation on the physical conditions in Newfoundland and Labrador regions, there were questions on how the information could be (or is) used with biological information available from the ground fish surveys. Glen Harrison asked if we could continue to maintain the important ‘oceanographic’ efforts on the groundfish surveys and how important it really is and if such effort is sustainable? For example, what is the current use of the habitat index that is generated? It was remarked that in the Newfoundland region, for example, they have been successful in developing and using the indices because the equipment is trawl mounted. Similarly, the Gulf Region is successful getting the oceanographic data. These concerns were a return to questions raised at the last fall AZMP-FOC workshop on strengthening the link between the monitoring program and stock assessments, and also relevant to the question of how FOC could be more involved in the use of these indices. The presence of oceanographers at fish and invertebrate RAPs was mentioned and, for certain regions, the participation seems satisfactory.

Concerning the physical environmental conditions on the Scotian Shelf, the evolution of the stratification seems consistent between the years, but not the depth of the mixed layer. There was a discussion on the origin of the salinity anomaly. Similarities with what is observed at Station 27 were noted hence, part of the water might be coming from the Newfoundland Shelf. However, it was suggested that climatology of the mixed layer depth would be useful to our understanding.

A discussion was initiated about the fact that information on the physical oceanographic conditions of the Southern Gulf of St. Lawrence was not presented during the session on the physical environments. Ken Drinkwater assembled some information on the Southern Gulf to address the issue and a quick review for was presented:

- The bottom temperatures in September 2002 were warmer than the long-term means and had increased relative to 2001.
- The bottom temperature habitat index for snow crab has declined in 2002 compared to 2001, but temperature has been increasing in most snow crab areas over the last few years
- Temperature profiles show warmer conditions below 100 m.

Following the southern Gulf presentation, it was questioned whether the information should be incorporated in the Maritimes region SSR (as it is the case for the Chemical and Biological oceanographic conditions), be included in the Gulf of St. Lawrence physical oceanography SSR, or if it should remain a separate document. Comments were made that this has been an ongoing concern for FOC but at the end, it was decided to include the southern Gulf in the Gulf of St. Lawrence SSR.

The physical environment scorecard was also discussed. Glen Harrison commented on the summation of the indices. Ken Drinkwater explained that the weighting on the indices was equal. It was pointed out that a negative anomaly on the Cold Intermediate Layer anomaly was colour coded red to indicate warmer conditions. Positive stratification anomalies were shown as red. Ken Frank remarked that we are dealing with over 30 variables and suggested to aggregate indices to reduce, if possible, redundancies by making indices additive and using ordination techniques. It was suggested that mixing, atmospheric and advection features could be classed together. That lead to some discussion on the standardisation of information and how wide spread the changes were. This could be addressed by large/small scale ordination. The Committee agreed and recommend that further analysis of these indices could be done for next year meeting.

The consequence of the recent shift of reference period from 1961-1991 to the 1971-2000 was also briefly discussed. Denis Gilbert indicated that Environment Canada was using the 1951-1980 period but the statistics are being recomputed using a more recent reference period. Ken Drinkwater said the World Meteorological Organisation only updates the reference period every 30 years but it was desirable to update our reference period every 10 years to optimise the benefits of new technologies and recent changes in sampling. There must be consistency in the reference periods for all indices as the baselines shift with reference periods. In cases where this is not possible, we can rank annual means in terms of historic values or as excursions from a secular trend.

The possibility to introduce new indices was also discussed. Denis Gilbert expressed is satisfaction with a new dissolved Oxygen probe. The Seabird model 43 gave reliable and accurate measurements. Glen Harrison indicated similar results from his group. During recent field works, the DO_2 probe was automated, reducing Niskin bottle sampling and leaving more time for other work. The time saved was used to make more spot measurements. It was also remarked that a nitrate bottom map has limited use but Oxygen appears to be important in the Gulf of St. Lawrence Estuary, even more so than salinity.

Discussion then centred on spatial variability in the ecosystem. Knowledge of the temperature field was deemed to be of great value. Pierre Pepin talked of the role of modellers and spatial variability as well as forming linkages on broader scales. It was agreed that we are trying to understand the ecosystem, but that spatial variability can make this challenging. It was indicated that the FOC must be more efficient in relating aspects of ecosystem.

3.3 Biological Oceanographic Conditions

3.3.1 Newfoundland Shelf and Labrador (P. Pepin *et al.*)

The information 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 from the Atlantic Zone Monitoring Program (AZMP) activities were reviewed. Temporal and spatial series of the different biological, chemical, optical, and physical measures during 2002 were presented and contrasted to earlier periods when data are available.

The seasonality of chemical and biological variables at Station 27 and along the major AZMP sections was similar to previous years (i.e., 1999-2001). The timing of events on the Newfoundland Shelf (south of Seal Island) was also similar to conditions observed in the earlier years, but in contrast to 2001 when the onset of the spring phytoplankton bloom was delayed (Fig. 13). It is becoming clear that interannual variations in the seasonality of vertical mixing and water column structure plays an important role in the seasonal phytoplankton cycle along the Newfoundland Shelf. In 2001, the delay in the onset of the spring bloom was associated with persistent deep mixing of the water column. Although wind stress remained high in 2002, the overall impact on the water column may have been somewhat lessened by the relative timing and intensity of wind events such that the mixed layer depth shoaled more progressively in 2002, thus allowing an earlier spring bloom.

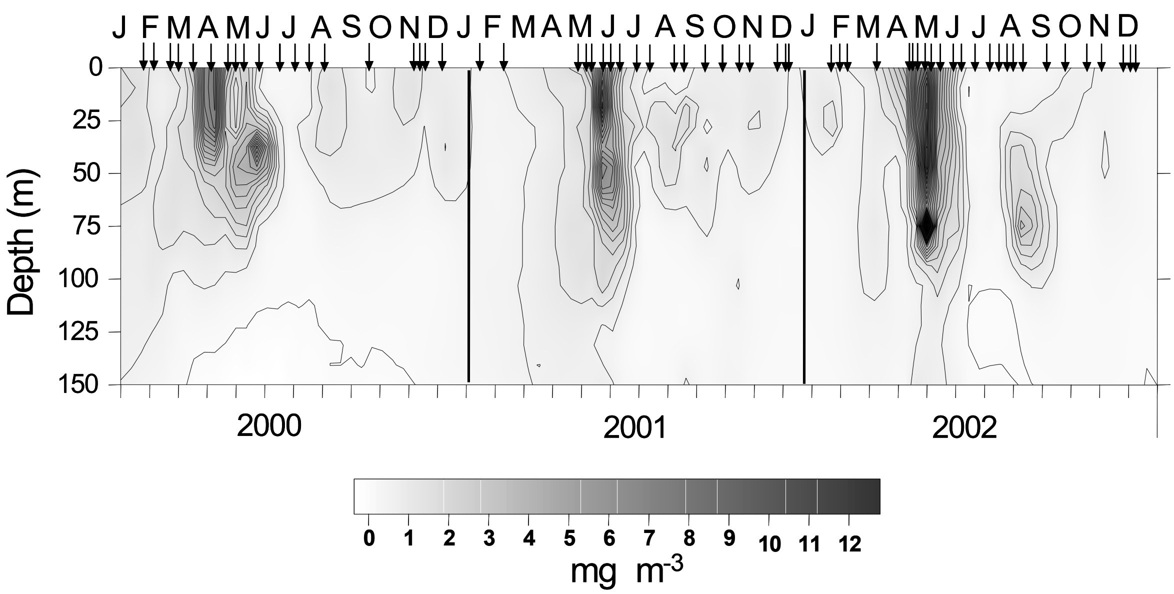

Figure 13. Seasonal variation in vertical structure of chlorophyll *a* concentration at Station 27 during the period from 2000 to 2002

Variations in the physical environment may also be contributing to a gradual increase in the magnitude of the spring phytoplankton bloom. Since 2000, there has been a gradual intensification in the overall productivity and standing stock of phytoplankton during the spring (Fig. 13). However, in addition to the factors that regulate the vertical structure of the water column, there is a preliminary indication that interannual variations in incident light may also have contributed to the increase in the overall intensity of the spring phytoplankton bloom. Preliminary indications reveal that incident radiation in 2001 and 2002 are at the upper extreme of light levels observed in the past three decades at St. John's Airport.

In 2001, the deep nutrient inventories (>50m) observed at Station 27 showed a 30-50% decrease over conditions in previous years but the change was not observed along any of the standard sections. The condition at Station 27 persisted in 2002 but there are some indications that the depletion of the deep nutrient pool may have expanded onto the inshore and mid-Shelf portions of the Bonavista Bay section. Here a notable decrease in deep nutrient levels was observed in 2002, but the magnitude was considerably less than was observed at Station 27 (seasonally averaged decrease of 10% versus 30% over the 2000-01 period).

The overall standing stock of phytoplankton on the north-eastern Newfoundland Shelf was generally less during the summer and fall surveys than in previous years. Although stratification was less intense, which suggests that nutrient replenishment may have occurred more readily, the integrated temperature was also lower, suggesting that decreases in temperature may play an important role in limiting production on the Shelf. Alternatively, higher grazing pressure from a slight increase in the density of large calanoid copepods may have maintained standing stocks at low levels.

The overall abundance of zooplankton at Station 27 was generally in keeping with previous observations, with the exception of the fall and winter of 2001-2002 when high concentrations of *Oithona* spp. and *Pseudocalanus* spp. were present (Fig. 14). The overall increase in overwintering numbers of these two species did not result in substantial increases in population densities during the subsequent spring and summer at this site, or along the sections further south. The most notable change in the zooplankton community structure at the fixed station has been in the increase in the abundance of cold-water species of copepods. Although other taxonomic groups have fluctuated in abundance, copepodites of *Metridia* sp., *C. glacialis*, *C. hyperboreus* and *Microcalanus* sp. have become more frequent members of the community, although the overall increase in their abundance has been modest. The warm water species, *T. longicomis*, whose abundance peaks during the fall, has shown a decrease in overall abundance but more importantly its relative frequency of occurrence at Station 27 appears to have decreased since 1999. The change in occurrence of cold and warm water species of copepods is relatively consistent with the changes in water mass characteristics, which have taken place since the late 90s.

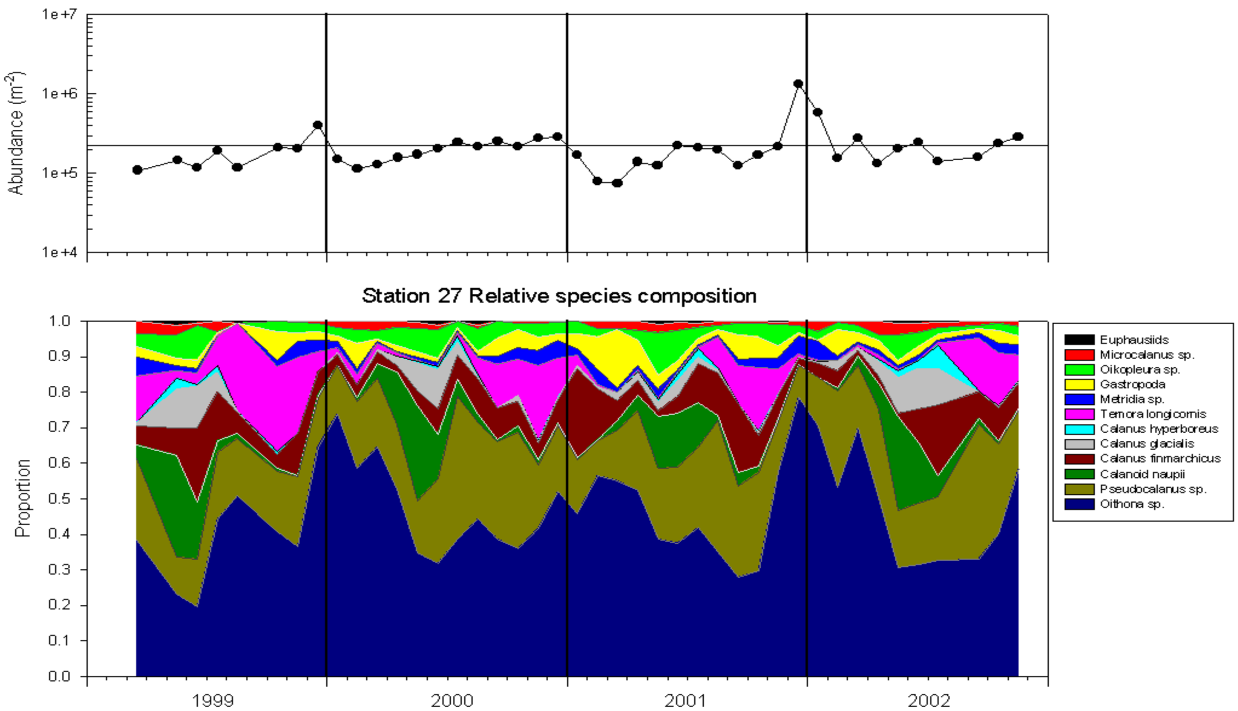

Figure 14. Time series of total zooplankton abundance (upper panel) and relative species composition (Lower panel) from vertical net collections performed at Station 27 since the inception of the AZMP.

The greater occurrence and abundance of large species of copepods such as *Calanus* and *Metridia* may have lead to an increase in the relative abundance of large calanoid nauplii on the mid- and outer shelf areas. Although small species of copepods, such as *Oithona* spp. and *Pseudocalanus* spp. still dominate the copepod community across much of the NE Newfoundland Shelf, the increase in the abundance of large species may have lead to an overall increase in the biomass of the zooplankton community, particularly within the core of the Labrador current.

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

Optical, chemical, and biological oceanographic conditions in the Maritimes and Gulf regions (Georges Bank, eastern Gulf of Maine, Bay of Fundy, Scotian Shelf and Southern Gulf of St. Lawrence) during 2002 were reviewed and related to conditions during the preceding year and over the longer-term means where applicable. In addition to descriptions of AZMP core data collections (fixed stations, seasonal sections, groundfish surveys, CPR, remote-sensing), some data from outside the Maritimes and Gulf Regions are discussed also to provide the larger, zonal perspective.

Sufficient data now exists from AZMP to begin to document recurring spatial and temporal patterns in optical, chemical and biological properties of the Maritimes and Gulf regions and to describe changes (trends) in oceanographic properties. Although many of the oceanographic features in the Maritimes and Gulf regions in 2002 were similar to observations from previous years a number of differences were noteworthy.

Optics and mixing: Notable differences in mixed-layer cycles were observed at all of the fixed stations in 2002. At the Shediac Valley station, summer time mixed-layer depths were shallower in 2002 than in 2001 whereas wintertime mixed-layer depths were shallower at Halifax-2. At Prince-5, summer time mixed-layers were considerably deeper than seen in previous years. These changes are likely driven by local meteorological events but this link has yet to be explored and established.

Nutrients: For the most part, the seasonal cycles of nutrients, vertical structure and regional variations were similar in 2002 to previous years. There were some differences however: (1) deep-water (>50 m) nitrate concentrations at all of the fixed stations were higher in 2002 than in 2001 but still below the climatological mean, at least for Halifax-2 where long-term data exist; (2) bottom water nitrate concentrations observed during the annual groundfish surveys were generally similar or slightly greater than concentrations observed in 2001 but lower than the climatological mean in the deep basins. Oxygen conditions (% saturation) were lower on the Scotian Shelf and in the Southern Gulf and low levels were more widespread in 2002 than in 2001. This could result from water mass changes or increased consumption from microbial activity. The former can be explored by analysis of hydrographical properties but data on the microbial community are not part of AZMP.

Phytoplankton: Despite the fact that phytoplankton variability (both temporal and spatial) is characteristically high in coastal waters, the development of a pronounced spring/summer (and less conspicuous fall) phytoplankton bloom is evident from observations at the Maritimes/Gulf fixed stations, seasonal sections, groundfish surveys, CPR and remote-sensing data. Recurring spatial patterns such as elevated chlorophyll *a* concentrations off southwest Nova Scotia, the eastern Gulf of Maine/Bay of Fundy and the western Southern Gulf of St. Lawrence are also seen yearly (Fig. 15). There were, however, some features of the phytoplankton growth cycle in the Maritimes and Gulf regions distinctive for 2002. Most prominent were the persistent and widespread high concentrations of chlorophyll *a* in the Southern Gulf seen in *in-situ* and satellite data; surface chlorophyll concentrations observed during the fall groundfish survey were highest on record. Field and satellite data also showed that the spring bloom on the Scotian Shelf (Halifax-2, Halifax line) was earlier and its duration shorter than in 2001 and that the late spring/summer phytoplankton bloom at Prince-5 was later in 2002 than in 2001. The high and persistent chlorophyll in the Southern Gulf could be linked to the shallow mixed-layers and higher nutrient levels in 2002. In a similar way, the increased summer mixed-layers at Prince-5 in 2002 could have been unfavourable for phytoplankton growth and could have contributed to the delay in onset of the spring/summer bloom there.

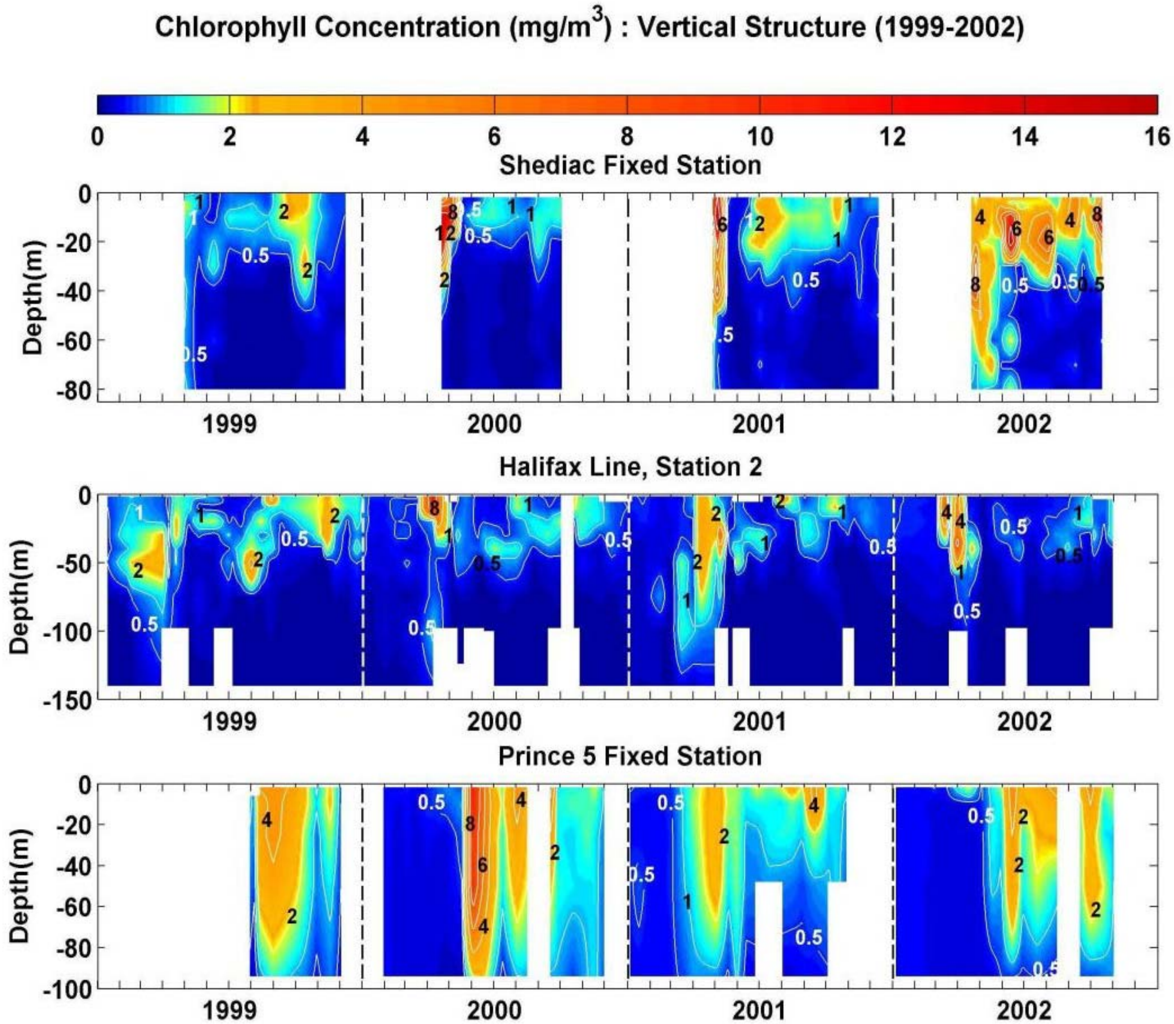

Figure 15. Time series of vertical chlorophyll structure at the Maritimes-Gulf fixed stations (AZMP) from 1999 to 2002.

The earlier spring bloom at Halifax-2 in 2002 could be linked to the reduced vertical mixing in the previous winter, setting the stage for favourable phytoplankton growth conditions earlier in the year. Satellite time series data are also establishing trends in phytoplankton abundance in the Maritimes and Gulf regions. For example, the magnitude of the spring bloom has been decreasing on the eastern Scotian Shelf and Cabot Strait since 1998 with lowest levels to date were recorded in 2002. A synoptic picture of phytoplankton conditions in the Northwest Atlantic in 2002 from satellite ocean colour indicated that overall levels decreased in some regions and increased in others but none of the changes were considered significant. Over the longer term, however, CPR data clearly show that contemporary phytoplankton abundance, region-wide, is much higher than it was decades ago and that the spring burst of growth is occurring earlier in the year now than in the 1960s and 1970s.

Zooplankton: Like phytoplankton, zooplankton in the Maritimes and Gulf regions is characterized by high spatial and temporal variability. Both biomass and numerical abundance of zooplankton are generally highest in spring and higher on the western Scotian Shelf - Eastern Gulf of Maine and Southern Gulf of St Lawrence than on the Eastern Scotian Shelf. Lower levels of zooplankton (and the important copepod, *C. finmarchicus*) have been observed at Prince-5 and the highest at Halifax-2. Community composition, for the most part, has remained relatively unchanged at the Maritimes and Gulf fixed stations since AZMP observations began in 1999. Some features of the zooplankton community were notable for 2002, however. There has been a trend over the past few years of decreasing zooplankton biomass and abundance. In fact, zooplankton biomass was down in 2002 at all fixed stations and copepod abundance and *C. finmarchicus* abundance at Halifax-2 had their lowest levels on record in 2002. At the Shediac Valley station, however, *C. finmarchicus* was up in 2002 from the previous year. It is tempting to relate the latter observation to the high and persistent chlorophyll levels in the Southern Gulf in 2002. Jellies and Appendicularians numbers were also elevated at Shediac Valley and Halifax-2 in 2002 compared with previous years. Zooplankton biomass observed during the 2002 annual groundfish surveys was similar to levels seen in 2001 while *C. finmarchicus* biomass and abundance observed on the fall section survey on the Scotian Shelf was higher on the eastern Shelf in 2002 than in 2001. Over the long-term, CPR data show that contemporary zooplankton abundance, region-wide, is considerably lower than in the 1960s and 1970s and continues to fall well below the climatological mean.

As for last year, observations from the Bedford Basin Plankton Monitoring Program were briefly presented. The nutrient regime appears to be undergoing a secular change with higher concentrations of phosphate, but lower concentrations of silicate. The ratios of nitrate:silicate and phosphate:silicate are currently at historically high annual average values. Contemporaneously, there is an increase in the size groups of nanoplankton and picoplankton; and in the cyanobacteria, prymnesiophytes and cryptophytes groups. The secular trends in phytoplankton composition may be an indication of the nutrient trends. Bacterioplankton abundance has remained essentially invariant at a level to be expected given the prevailing temperatures. The time series for mesozooplankton is too short to assess long-term change, but attenuated summer abundance was evident in many copepod species in 2000.

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

Information 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 (Rimouski, Anticosti Gyre and Gaspé Current) and six sections crossing the Estuary and Gulf of St. Lawrence was reviewed. The conditions prevailing in 2002 are also compared to observations from the 1992-2001 period.

In 2002, the initiation of the major phytoplankton bloom at Station Rimouski in the Lower St. Lawrence Estuary occurred in late June, which is near the historical mean date (Fig. 16). This contrasts with observations made from 1998 to 2001, when the spring phytoplankton bloom began 6 to 8 weeks earlier than normal (mid to early May). The average phytoplankton biomass during spring-summer 2002 at Station Rimouski was also somewhat higher compared to 1992-1994, 1998, and 2000-2001 periods, but much lower compared to 1995, 1997, and, more especially, to 1999 (Fig. 17).

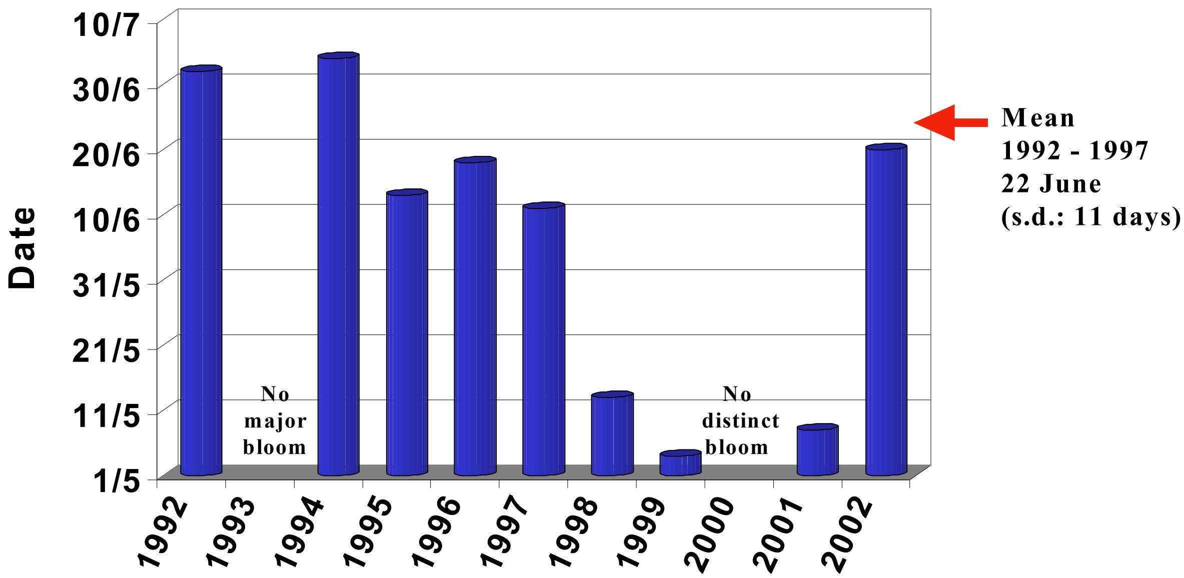

Figure 16. Date of onset of the primary bloom defined by the first incidence of chlorophyll concentrations greater than 100 mg of chlorophyll *a* per m^2 at Station Rimouski, 1992-2002

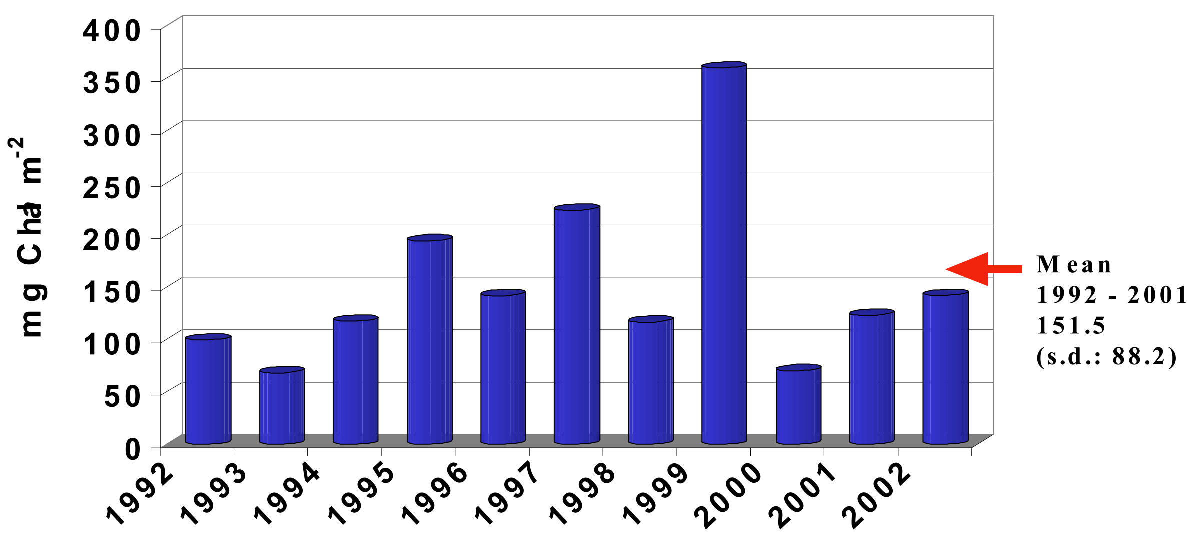

Figure 17. Mean integrated (surface to 50m depth) chlorophyll a levels at Station Rimouski from May to August, 1992-2002.

In the Anticosti Gyre and the Gaspé Current, the depletion of nutrients in the surface layer (0-50 m) during spring occurred later in 2002 compared to the 1996-2001 period, suggesting that phytoplankton growth was also initiated later in 2002 compared to recent years in the NW part of the Gulf. This was particularly true for the Gaspé Current. The reduction of nutrients in the surface layer during spring-summer was also somewhat more pronounced in 2002 compared to the 2000-2001 period, but much less compared to 1999. Thus based on the evolution of nutrients, phytoplankton production in the northwestern Gulf could have been higher in 2002 compared to the previous two years but much lower than for 1999 (Fig. 18). This is consistent with data from Station Rimouski in the Lower St. Lawrence Estuary.

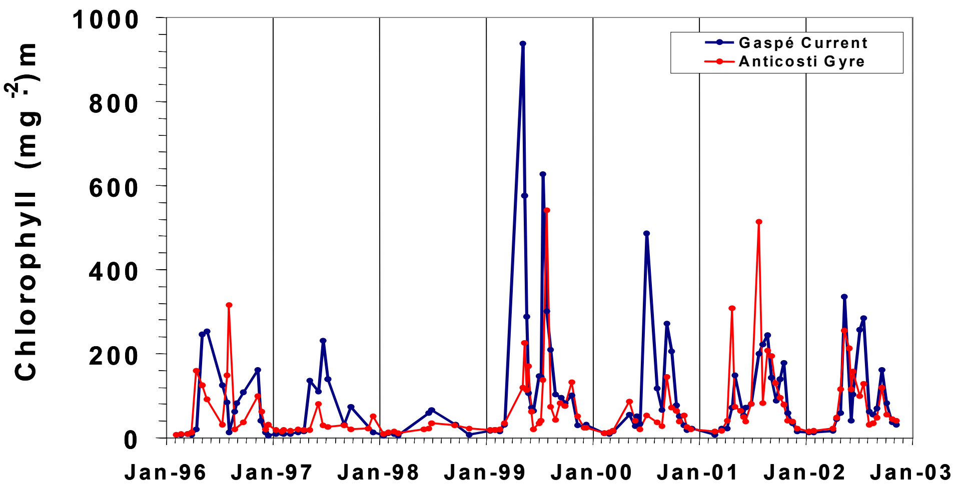

Figure 18. Chlorophyll a concentrations in the Gaspé Current and Anticosti Gyre, 1996-2002. Values are integrated over the upper 50 m of the water column.

For a second consecutive year, the analysis of community composition in 2002 revealed the massive presence of the diatom *Neodenticula seminae* in most areas of the Gulf of St. Lawrence, with concentrations up to 1 x 10^6 cells per litre. This phenomenon is unusual since this species is usually found in North Pacific waters. In the Atlantic Ocean, this species has only been recorded in middle to high latitude Quaternary sediments, dating from between 0.84 and 1.2 million years ago. It is proposed that this Pacific species was introduced naturally into the Gulf (across the Arctic, down the Labrador Current, and through Strait of Belle Isle) rather than via ballast waters. The return of *N. seminae* to the Atlantic coast is consistent with recent observations indicating a greater influx of Pacific waters into the Atlantic and the freshening of the North Atlantic waters.

Results on the temporal variability of the zooplankton biomass, abundance, and species composition at two fixed stations and six transects of the AZMP (Anticosti Gyre and Gaspé Current) in 2002 were also presented, along with an overview of the interannual variability of the macrozooplankton species composition, abundance, and biomass in the Lower St. Lawrence Estuary and the NW Gulf of St. Lawrence (GSL) as measured in September in each year between 1994 and 2002. The conditions during 2002 are compared with previous information from 1999, 2000 and 2001 for the AZMP results and from 1994 to 2002 for the macrozooplankton.

At AZMP fixed stations, the annual mean integrated zooplankton biomass in the Anticosti Gyre was similar to what was observed in previous years while in the Gaspé Current the mean integrated biomass was 1.5 times higher than in 2001 and 2000 (Fig. 19).

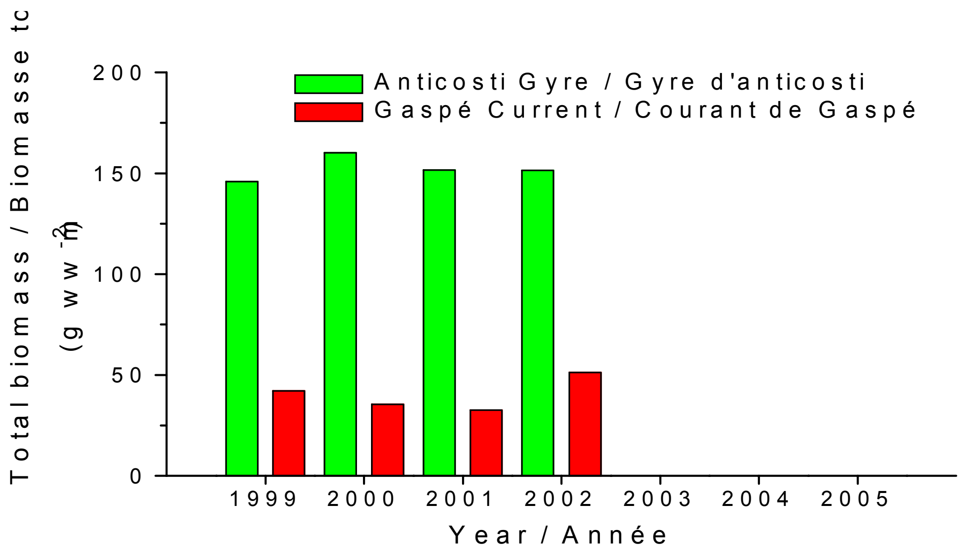

Figure 19. Mean integrated zooplankton biomass in the Anticosti Gyre and the Gaspé Current from 1999 to 2002.

Copepod eggs, juveniles, and adults were clearly dominant, accounting for more than 80% (numbers) of the zooplankton community for all sampling dates in the Anticosti Gyre and the Gaspé Current. The depth-integrated abundance of the stage composition of *C. finmarchicus* showed that in 2002 there were two periods of reproduction for this species in both stations. The first and the second period of reproduction occurred in summer (June-July) and fall (September-October) respectively and were synchronized in both stations. The same situation was observed in 2001 and 2000.

The zooplankton biomasses observed in 2002 along all transects for both seasons (AZMP) were in keeping with observations made in 2001 and 2000. However, contrary to the situation observed in 2001 where the overall abundance of zooplankton was generally lower than in 2000 in all regions for both seasons (except in the fall survey in the southern Gulf - Magdalen Island - transect), in 2002 the overall abundance of zooplankton increased to the levels observed in 2000 in all regions and seasons. The only exception was in the fall survey in the southern Gulf (Magdalen Island transect) where the abundance of zooplankton continued to decrease as compared to 2000 and 2001.

The meso- and macrozooplankton species composition, abundance, and biomass for the period from 1994 to 2002 in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence were also reviewed at the meeting. There was a slightly increase of the mesozooplankton biomass in 2002 compare to 2001 and no significant changes in the macrozooplankton biomass (Fig. 20). The year 2002 was characterized by a significant increase of the mean abundance the chaetognath *Sagitta elegans*, the gelatinous zooplankton *Aglantha digitale*, *Obelia* sp., and *Boreo* sp., and the pelagic amphipod *Themisto abyssorum* and a significant decrease of the mean abundance of the mysid *Boreomysis arctica* (Fig. 20).

In 2002, the mean abundance of *T. libellula* was similar to what was observed in 2001 and the significant relationship between the annual CIL core temperature index and the mean annual abundance of *T. libellula* observed in 2001 was still significant suggesting that the presence and the abundance of this predatory species in the Lower Estuary and the Gulf of St. Lawrence would be associated with the intrusion of the cold Labrador Current water into the Gulf via the Strait of Belle-Isle.

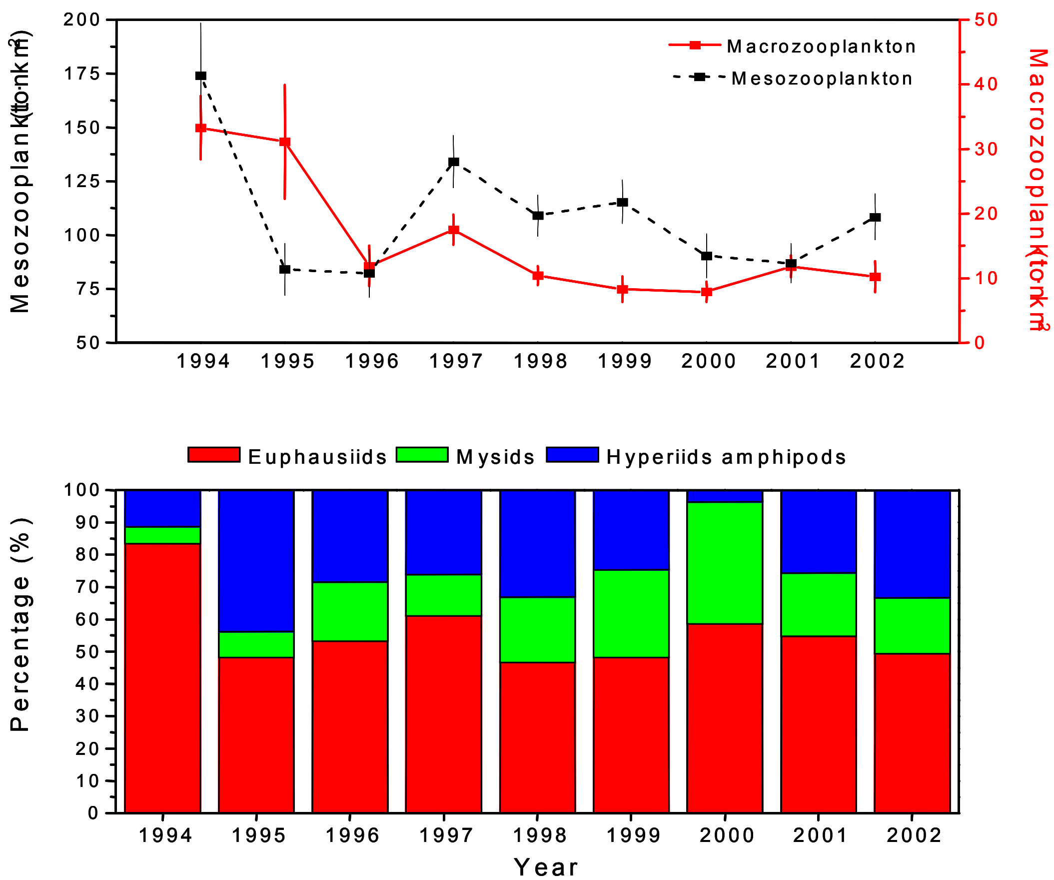

Figure 20. Mean biomass (± SE) of mesozooplankton and macrozooplankton in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2001 (upper panel) and relative abundance of the three most important macrozooplankton groups in term of biomass (lower panel).

3.3.5 Questions and Discussion

The discussion of Chemical and Biological oceanographic conditions opened with the presentation on the conditions on the Newfoundland and Labrador shelves. In response to comments from Glen Harrison on how primary production was calculated, Pierre Pepin said that they are effectively using the same algorithm as Platt and Sathyendranath[2] but with a relaxation of the assumptions concerning the vertical distribution of chlorophyll by using observed values as well as observed light levels. This results in a difference of approximately 20-30 percent between that calculated by Platt and Sathyendranath[1] and their estimates was not unexpected and overall the agreement between the estimates appeared to be reasonable although in some instances values were substantially different.

Concerning the Coccolithophore bloom of 29 July 2002, Glen Harrison noted that these were also seen in the Iminger Sea and asked if there could be any connection. Pierre Pepin replied that this was possible as the events were associated with stratification. There were also general comments about the spatial distribution of the bloom; that it appeared to be avoiding an area on the St Pierre Bank. Erica Head commented that there could have been changes in the relative abundance of large and small cells. This could influence satellite images. Glen Harrison noted that primary production was increasing and asked about chlorophyll concentrations. Pierre Pepin pointed out that the chlorophyll signal was increasing and was most intense in spring.

Discussion continued about explaining the increase in numbers of diatoms and the relative role of density stratification, the wind speed and direction. It was thought that an index of advection could be useful to explore the question further. This could be derived from TS properties to trace a water mass for example. Denis Gilbert suggested an upward sampling ADCP and Joel Chasse talked of using models to get advection and upwelling information. At the end, it was recognized that anomalous chlorophyll concentrations observed in 2001 could not be explained but a more detailed look at the hydrography may be useful. The desire to better integrate the biology and physics was expressed.

Discussion was initiated around the comparison of the Continuous Plankton Recorder (CPR) data with ocean colour (satellite data) and chlorophyll measurements. It was agreed that the AZMP should have the leading role in this process. One point raised was that there is not a straightforward correlation between net data and CPR and if there is a change in the community structure, the CPR should be checked; CPR would prove useful if large changes in *C. finmarchicus* were observed for example. It was suggested that if the CPR data were averaged appropriately we should get similar results with other methods. An effort should be made to do this before next September although this may not be possible. The pros and cons of the CPR data set were discussed, including the cost of 135k$/yr and the value of the data. It was agreed that CPR gives some indication of spatial variability and distribution of species, however its use as a model input and utility in providing a short-term index are questionable. Nevertheless, one remarked that there is a fair amount of relevant material from CPR data in the literature, such as the ICES publications. Other questions were posed on the similarity

[2] http://www.ioccg.org/software/Ocean_Production/

between the CPR results on the Newfoundland and Scotian shelves: Do they reveal similar regime shifts? Do they give the same spatial autocorrelation? It was suggested that the AZMP should look at the analytical side, considering amongst other things the bias introduced by varying ship speeds, etc. and keep inform the Committee of the findings.

There was a general desire to have a more comprehensive analysis than simply computing annual means. Nonetheless, progress had been made in presenting interannual variability in terms of standard deviation units. One suggestion was to pay more attention to the timing of bloom events and seasonal effects, especially to look at the winter nitrate concentrations as it may be affecting the spring bloom. There will be soon 5 years of data from AZMP to look at those issues.

3.4 Recruitment trends

3.4.1 Newfoundland Shelf and Labrador (E. Dalley)

Recruitment indices were compiled on selected stocks in the Newfoundland region. Recruitment data available were used from recent assessment documents that have gone through, or are in the process of going through the peer review process. Mean recruitment values and standardized anomalies were calculated for each year class of each stock/species. The anomaly for the most recent year class was expressed (1) relative to the value of the previous year class, (2) relative to the previous 5-year classes, and (3) to the baseline. Most fish populations in the Newfoundland region included in this analysis changed very little for the most recent year-classes. The largest change occurred for American plaice in NAFO Division 3LNO, for which the 1998 year-class increased relative to the baseline, the previous 5 years, and the previous year. American plaice in Division 3PS, on the other hand, was slightly higher compared to the baseline, similar to the previous 5-year classes, and lower than the previous year. The most recent yellowtail (3LNO) year class was stronger than the baseline but similar to recent years from fall survey results. Spring surveys indicated recruitment was lower than the previous year and the previous 5 years. The most recent turbot year class increased modestly relative to recent years and relative to the long term. Cod populations generally indicated negative recruitment relative to the baseline but with less change relative to the previous year or the previous 5 years. Capelin declined at a relatively high rate for the 1999 year-class. Herring all indicated declines for the 1997 and 1998 year-classes. Similar to the cod populations those of salmon generally decreased at a lesser rate in recent years relative to the overall baseline. Recruitment of crab populations in the most recent year has generally decreased slightly relative to the previous year, but more so in comparisons with the longer term. Recruitment of 3L shrimp has increased relative to the baseline and relative to the previous 5 years, but changed little compared to the previous year. The most recent estimate of 2J3K shrimp recruitment has increased slightly in relation to the baseline and the previous 5 years but is lower than in the previous year.

3.4.2 Scotian Shelf (K. Frank)

A different approach was used for the Scotian Shelf report on recruitment trends. First, it was pointed out that information on recruitment can be taken from SPA and/or research vessel surveys, however the ration R/SSB will account for the effect of the spawning stock biomass. On the other hand, the residual of (Riker's) stock-recruitment (S-R) relationships could indicate environmental influences. An analysis of data available revealed that many stocks showed a significant Allee effect; i.e., a positive ×-axis intercept (zero recruitment at SSB > than zero). Although the phenomenon is not easily interpreted, it should be of interest as possibly indicative of why some stocks do not recover.

3.4.3 Southern Gulf of St. Lawrence (H. Benoît and D. Swain)

Recruitment indices were compiled for selected species of marine fish in the southern Gulf of St. Lawrence (NAFO div. 4T), namely, cod, American plaice, spring-spawning herring, thorny skate, winter skate and smooth skate. Recruitment indices for fall-spawning herring were not available, as a sequential population analysis (SPA) could not be conducted in 2002. Recruitment indices for snow crab were also not available at the time this paper was drafted. For each species, a time series of spawning stock biomass (SSB) from SPA or an index of SSB from the annual bottom trawl survey was presented, as well as series for recruitment (absolute numbers or relative index) and recruitment rate (recruitment/SSB).

Cod recruitment was slightly higher in 2000 relative to the minimum low of 1999 but, overall, declining from a recent peak seen in the mid-1990s. American Plaice recruitment was stable between 1996-97 (the most recent estimates since recruitment is estimated at age 5). On the other hand, skates, especially thorny skate, show strong recruitment from the late 1980s to the mid 1990s despite low SSB.

3.4.4 Northern Gulf of St. Lawrence

No information was available for the meeting.

3.4.5 Recruitment scorecard

Summary of recent recruitment trends for selected stocks were presented for Newfoundland and the Gulf regions; however, there is no standard scorecard available at the moment. A general database is currently in preparation and it was proposed to wait for that product to prepare a standardize report of recruitment for each region.

3.4.6 Questions and Discussion

Although a standardized scorecard is not yet available, suggestions were still made on the summary tables that were presented. In particular, that recruitment and recruitment rate (R/SSB) mean and standard deviation, which form the basis for the information presented for each stock, were based on arithmetic means. Given that recruitment data are generally skewed, it was questioned whether the current scorecard provided an adequate representation of the anomalies in recruitment. Pierre Pepin argued that the estimates should probably be based on the mean and standard deviation of the transformed data, which would give a relative (proportional) indicator of the changes taking place. If the data are not transformed in the calculation of the index, there will be a greater tendency for the scorecard to indicate that recruitment indices are below the long-term mean.

There was also a question about the appropriateness of considering information on size at age in the stocks as part of the recruitment trend. At the moment however, although the data are collected for some of the stocks, the estimates of reproductive potential (SSB) were not corrected for changes in the physiological state of the stock.

For the southern Gulf, it was remarked that the information for snow crab and lobster is important to the fishery but was not presented. The data for snow crab was not available for the meeting and there are currently no data on the recruitment for lobster because the fishery is regulated through catch rates. It was pointed out also that recruitment to the skate (southern GSL) and flatfish (NL) stocks were generally in a positive trend. However, the interpretation of these apparent shifts in "dominance" is not readily obvious. Other ecosystems have shown differences in species composition when the dominant groundfish stocks were at low levels, but the dynamics of the systems under consideration is complex and largely unknown.

Ken Frank's presentation on recruitment patterns of finfish and invertebrates from the Northwest Atlantic generated a long discussion. There were questions about the underlying reliability of the S/R relationship and the possibility that the use of non-SSB corrected information might provide different insights into the relative coherence of the data. When there is a poor fit to the standard Ricker model, there would be relatively no underlying effect of the trends in overall population abundance. The underlying application of the Allee effect concept to most fishery data remains difficult to deal with, and the coarseness of the data may prevent us from detecting the threshold of the populations. Fitting a curve without information of low stock sizes may yield a strong Allee effect simply because of the fitting procedure. Moreover, it was pointed out, that the database was generally lacking the most recent information, when many of the stocks had collapsed. As a complement of information, it was mentioned that in the initial fitting exercise, 20 of the 61 stocks showed an Allee effect but only 10 of the 20 had confidence intervals that did not include a true zero intercept (0 recruitment at zero stock). Moreover, studies of depensatory recruitment patterns might provide an alternative model to the Allee effect. However, most fisheries reference points still do not take those elements into consideration. There is still no definition of a minimum spawning stock size. The stocks that show coherence in recruitment patterns should point to the underlying environmental factors that are at play. The use of environmental information may require a closer look at the coherence of the changes in the ecosystems under consideration rather than attempting to find the simplest correlate or descriptor of the long-term fluctuations in population abundance. This requires a reasonable level of knowledge of structure of the ecosystem rather than simply considering the simplest common descriptor of state of the environment.

Lastly, it was pointed out that the worldwide database on recruitment data assembled few years ago need to be upgraded. Ken Frank proposed that a general database be developed to provide a general overview of the recruitment patterns in the Atlantic Zone. Martin Castonguay suggested that the information from such a database would be useful and that from that database could provide information on a regional report. However, he also indicated that many of the stocks do not have age-based information and indices from some groups (e.g. invertebrates) are also lacking because most of the analyses presented were based on age-based. It was indicated that any time series with reliable SSB and/or recruitment information (index) could be included in the analysis. Lastly, the creation of a central database might place some limitations, but an additional advantage would be that it would maintain general continuity because of changes in personnel or individual commitments that might limit the presentation of information on an annual basis.

Therefore, FOC recommends that the working group on the recruitment scorecard (K. Frank, M. Castonguay, E. Dalley, D. Swain) should work in collaboration to provide a common and continuous source of information to feed into the database from which the annual report would be produced.

Invertebrates should also be included in the fundamental structure of the database. When information on spawning stock abundance is not available, the scorecard would be based on recruitment indices alone. Additional information on the spawning season for each stock would assist in looking for general patterns among the stocks and regions. In addition, there needs to be a standardization of colour schemes for the presentation among the regions. In the physical scorecard, the group had decided to display the information for the last five years instead of the current recruitment scorecard that showed the current (relative to the long term mean), relative to the past year, and relative to the last five years. The Committee decided that next year, the format of the scorecard should follow that used by the physical overview.

4. General Environment Session

Each year the FOC issue a call for papers on general interest, covering the fields of fisheries oceanography, species interactions, climate, and ecosystem or fisheries issues. At this year meeting, five papers were presented ranging in topics from instrumentation to change marine ecosystems. The session was greatly appreciated as judged by the discussion that followed the presentations. A summary of each presentation and of the discussion that followed are reproduce for the report.

A new buoy network to monitor environmental conditions and validate satellites data in the St. Lawrence ecosystem (P. Larouche *et al*., DFO – Québec Region, IML)

The St. Lawrence marine ecosystem, located in eastern Canada is a complex environment that possesses both estuarine and oceanic characteristics. Freshwater runoff, large-scale meteorological events, winds and tides acting at different time and spatial scales and coupled to a complex bathymetry contribute to generate a strong spatial and temporal variability of the physical and biological properties within the ecosystem.

To monitor such a complex ecosystem, the department of Fisheries and Oceans developed a St. Lawrence monitoring program to better understand and eventually quantify environmental changes. As part of this program, remote sensing techniques are mainly used to provide the regular large-scale view of the ecosystem. The two main parameters extracted from the images are the sea surface temperature and the phytoplankton biomass. The regular sampling of a monitoring stations network to measure basic physical and biological parameters complements the remote sensing information. The sampling frequency at these stations is however not appropriate to validate the remote sensing images. It was thus necessary to improve the *in situ* sampling efforts by installing a network of oceanographic buoys to provide the higher frequency data sampling necessary to complement the remote sensing program. As part of the buoy network development, it was thus decided to install a series of buoys at key locations. It was also decided that the data should be transmitted in real-time to the Maurice Lamontagne Institute for processing and assimilation into remote sensing data analysis and eventually into operational ocean models of the St. Lawrence ecosystem.

The first task of the program was to develop a low cost buoy capable of hosting a series of sensors measuring key physical and biological oceanic parameters. A standard navigation buoy was selected as the platform to support the necessary oceanic and atmospheric instrumentation. The buoy was also equipped with sensors to measure its heading, tilt and roll together with battery voltage, energy generated by the solar panels and energy consumption by the system. We then had to build a controller powerful and flexible enough to take care of the large number of sensors installed on the buoy and the high sampling frequency necessary to sample the changing environment. This controller is based on an Intel 80C188EB 16 bits processor. It can accept inputs from 16 sensors using analog outputs, 10 sensors using RS-232 outputs and can control 4 instruments through on/off gates. It has also 16 I/O analog interrupt channels. It has also a solid-state memory allowing storage of the entire season's results in case of a failure of the data transmission module. Because of this capacity, the buoy can easily grow to incorporate other sensors such as a Doppler profiler, a nutrient sensor or a Seahorse.

Optical, oceanic and atmospheric parameters are acquired at a 15 minutes interval. Bromine is used as a protection against biological fouling for the temperature, salinity, fluorometer and CDOM sensors. A copper bioshutter is also used to protect the optical sensors. The sensors sample at 6 Hz during a one-minute period and the controller calculates the mean and the standard deviation of each parameter for transmission to the Maurice Lamontagne Institute. Data transmission is done using a UHF modem allowing high data throughput and low operational costs or a satellite link for offshore stations. Upon arrival at the Institute, the raw data is processed using a custom built software, displayed on a dedicated computer and transferred to the St. Lawrence Observatory web site.

The first operational mooring was done in the St. Lawrence estuary in 2002. The mooring location was 30 km from the Institute. Comparison between the buoy data and the weekly measurements made using a small craft indicate that both methods can follow the seasonal trends of temperature and salinity variation. However, the fluorometer values can be quite different. Some transient events were also completely missed by the traditional monitoring approach showing the higher temporal variability of the St. Lawrence estuary. The improved sampling frequency of the buoy is thus required for satellite validation. Results from this first operational mooring indicate very well the complementarities of both sampling approach. The buoy can be used as a platform allowing a very good temporal sampling at the surface while the ship measurements allow for a more complete set of measurements to be made along vertical profiles.

Discussion: There was considerable enthusiasm about the presentation and of the potential usage of the system for future applications within AZMP. Buoy and seahorse data could be used to make the point about the advantages of adding moored systems to supplement periodic information, within the context of the AZMP program. The addition of sounders (e.g. ADCP) could be used to monitor particle abundance throughout the deployment. Pierre Pepin indicated that a large number of instruments could be mounted in the future and he will keep the Committee posted about the progress being made on the development of further applications.

Model-based summer oceanic conditions in the southern Gulf of St. Lawrence in 2002. (J. Chassé, MPO – Gulf Region, GFC)

We present the results of a three-dimensional bio-physical modeling system used to hindcast summer oceanic conditions as well as the drift, growth and survival the early life stages of lobster, snow crab and cod in the Southern Gulf of St. Lawrence. Individual-Based Models (IBM) of the early life stages are incorporated into a full 3-D hydrodynamic model of the ocean. The main biological input to the model is the parameterization of the distribution and abundance of the early stages of the life cycle as well as growth and mortality rates. The model is driven with the NCEP atmospheric forcing, by the tides and river runoffs. All of the data required to force the model from 1950 to 2003 have been collected. For summer 2002, the model hindcasts a weaker Gaspé current (0 – 20 m) in June and July with a tendency to develop small scales gyres relatively to the mean. A weaker coastal current is also obtained along the western coast of Cape-Breton. In August, the Gaspé current and coastal Cape-Breton currents are stronger than the normal. More heat was entering the ocean in the Gaspé current in June compared to the mean while the heat flux was closer to average conditions over the Magdalen Shallows during July and slightly higher than usual in August. A significant flow of heat into the water is obtained in the Northumberland Strait during August. There was less heat entering the water over the Magdalen Shallows during the summer of 2002 compared to the summer of 2001. The Gaspé current was cooler than normal in June, but did warm up during July to reach slightly above normal values in August. Elsewhere, the temperatures were close to the averages. For the three summer months, the average temperature in the surface layer over the Magdalen Shallows was lower than the normal. There was a decrease in the average temperature in 2002 compared to 2001. Most of the cod larvae settlement occurred in the area northward of Price Edward Island in 2002. For most NAFO areas, the cod larvae survival shows decrease compare to 2001. Total survival reached its lowest value since 1998. For lobster larvae, the time series of total survival shows an increase over 2001. The model predicts that there was an eastward shift in the settlement pattern of snow crab larvae in 2002 compared to 2001. The total snow crab larvae survival in

2002 is the lowest of the time series (1991-2002). This is the first attempt to provide model-based information of the environment and survival of the early life stages of cod, lobster and snow crab in the Southern Gulf of St. Lawrence. Although the modeling system is not perfect, it could provide useful information on the processes occurring in the Gulf. This information could be presented annually at the FOC meeting.

Discussion: G. Harrison suggested that the indices produced from the model would be useful for FOC. There were questions that FOC needs to understand the underlying accuracy and error of the various model elements to assist in the interpretation of any mode-based index because many elements of the environmental variability that may affect the circulation are not included in the model's formulation. The forecasts of model-based survival index have shown some correspondence with observed indices of recruitment but this is not the case for all species. The question is not necessarily simple to address because of the nature of the data. There needs to be a clear comparison of various circulation models to determine the accuracy and underlying error of model in forecasting circulation and subsequent drift. We have to identify the types of information that we want from such models, what types of indices and understand the underlying assumptions of such models and how they will influence the forecasted indices. The advantage of having the information presented at the meeting, is that the usage of biophysical models can be made operational and provides some feedback about some of the underlying understanding of the predictions from the model. It provides a first step in integrating modeling activities into the discussions of the Committee.

It is therefore recommended that the Committee should identify underlying questions about the use of biophysical circulation models and prepare the development of a special session in 2005.

Changes in the apparent distribution of cod in the southern Gulf of St. Lawrence in September: earlier migration or a true shift in distribution? (H. P. Benoît, D. P. Swain, G. Chouinard and A.Rondeau MPO – Gulf Region, GFC)

NAFO div. 4TVn cod are broadly dispersed throughout the southern Gulf of St. Lawrence during the summer and early fall, overwintering in the Sydney Bight area north-east of Cape Breton Island. Migration out of the Gulf typically occurred in late November prior to the 1980s, but fishery catch data suggest it has been occurring progressively earlier since then. At the same time, catches of cod from the annual September research survey of NAFO 4T have increasingly been concentrated in the southern and eastern portions of the survey area. This pattern may reflect the inferred earlier migration (i.e. movement of cod within the southern Gulf as they begin migrating out) or may represent a true shift in distribution accompanying the dramatic decrease in abundance that has taken place during the past two decades. Cod catch data from two non-synoptic research surveys (snow crab bottom-trawl and Sentinel surveys) suggest that the distribution of cod during the summer is consistent with that observed in September, supporting the latter hypothesis. These surveys do, however, suggest some within-Gulf movements of cod beginning in August. We also used spatial patterns in the characteristics of individuals to examine the earlier migration hypothesis. Vertebral counts, which distinguish southern Gulf cod from resident 4Vn cod, suggest that less than 3% of the southern Gulf stock had migrated into the Sydney Bight area in September 1995. Similarly, depth-dependent patterns in growth and condition of cod in September do not suggest large movements of fish.

In summary, all of the evidence examined to date suggests that the distribution of cod in the southern Gulf during the summer and early fall has gradually contracted southward and eastward over the past twenty years. Although there is some evidence of pre-migratory movements within the southern Gulf prior to September, there do not appear to be any large migrations out prior to or during that month. Even if individual cod are not beginning their migration earlier than before, the majority of the population may be leaving the southern Gulf sooner, given the increasing proximity between where most individuals spend the summer and their overwintering area.

Discussion: The question was posed about the typical pattern of departure of southern Gulf cod from their summer feeding ground compared to what was presented. It seems that fish now leave in mid-October compared to November in the past. However this is not necessarily the case if fish now settle further to the east on their summer feeding grounds.

Temperature variability in coastal Newfoundland waters. (J. D. G. Craig and E. B. Colbourne, MPO – Newfoudland Region, NWAFC)

The time series of thermograph, meteorological and sea surface temperatures were used to explore variability in the inshore temperature regime. The timing and frequency of temperature excursions were compared with the meteorological wind data as a means of characterization and identification the causes of the variability. Wind appears to account for much of the variability in the thermograph time series. For sites in the northeast coast, the variability during three months preceding the seasonal temperature maximum was significantly greater than for those following the peak. Such a difference was not apparent at sites on the southern part of Newfoundland.

Discussion: It was suggested that the coherence between winds and temperature from thermographs should be examined with spectral analyses techniques. However, this was tried but it seems the data were not amenable to this type of analysis.

State of the Eastern Scotian Shelf Ecosystem (K. Frank, MPO – Maritimes Region, BIO)

Historical information available from groundfish surveys was used in an investigation of fish community changes within an area based on species abundance ratios. There was a progressive change in the fish community since 1970 to the present (2000). There was changed in dominant species for each epoch and a notable shift toward smaller species in the Scotian Shelf ecosystem. A multispecies or community condition index was also developed from a compilation of weight vs. length relationships 'anomalies' standardized for 'target' species. There was an abrupt change in the community condition in 1984 and most groundfish species seem to be in poor condition since then. That may be an indication of lower ecosystem productivity and/or a reduction of carbon fluxes to benthos.

Discussion: A first comment was about the absence of the invertebrates in the analysis. While condition of many groundfish stocks diminished, many populations of benthic invertebrates were increasing during the period. The quality of the work was praised and also that it was a good exercise that will help to identify important and missing aspect of our monitoring activities (i.e., like benthos monitoring). In addition, a condition index for the pelagic species was not presented, although in that case it could be included in the future. Particularly, it seems herring are more closely associated with the bottom in the 1990s and there has been a major colonization of offshore areas. In fact, evidence supports a large increase in herring abundance. Capelin also increased significantly on the Eastern Scotian Shelf and in the Gulf of St. Lawrence.

5. Theme Session

5.1 Introduction

The study of extreme events has in the past led 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. Zooplankton biomass in the southern Gulf of St. Lawrence was also the highest in a 20-year series. The year 1999 also appears to have been the highest year for mackerel recruitment in the southern Gulf since 1982 but one of the lowest on record for southern Gulf cod. Haddock on the Scotian Shelf had phenomenal recruitment, as did scallops. Some exceptional events in fisheries were also noted on the Grand Banks. The goal of the Theme Session was to document the various changes that occurred in 1999 and attempt to establish links between the environmental changes and the possible responses of the various fish stocks in eastern Canada. Six papers were presented at the session. In addition, Ian Perry (DFO-Pacific region) who was at IML at the time of the meeting was invited to present a seminar on the recent change in oceanographic conditions in the north-east Pacific. The summary of each presentation is reproduce below.

Meteorological, sea-ice and ocean conditions in Maritime Canada during 1999: an unusual year? (K. Drinkwater, B. Petrie and G. Harrison – Maritimes Region, BIO)

Conditions in the marine areas of Atlantic Canada during 1999 were examined from meteorological, sea-ice and oceanographic data. During the year, south to west winds tended to dominate from southern Labrador to the Gulf of Maine, resulting in warmer-than-usual air masses over the region. This contributed to record high air temperatures, the highest in over 100 years at most sites, and in one case as long as 126 years. Hours of bright sunshine in 1999 indicated an average of almost 1-hour per day more sunshine than normal. The warm air temperatures and extensive sunlight during the winter lead to low amounts of ice in the Gulf of St. Lawrence and on the Scotian Shelf. Annual sea-surface temperatures were generally 1º-2ºC warmer than usual from the northeast Newfoundland Shelf to the Scotian Shelf, including most of the Gulf of St. Lawrence, setting records in several areas. In the summer, this rose to 3º-4ºC above normal. Subsurface temperatures in many of the regions also tended to be above normal but at levels less than those at the surface. Stratification on the Scotian Shelf was well above normal but not as high as it had been in 1998. Satellite imagery indicated that chlorophyll-a levels were higher over most of Atlantic Canadian marine areas in 1999 compared to the 1998-2002 mean. These data also suggested an earlier and longer phytoplankton bloom than usual. In summary, 1999 was in several ways an unusual year, being very warm and sunny with little ice and high primary production.

Environmental conditions in Newfoundland Waters during the late 1990s -was there an influence on Cod Recruitment? (E. Colbourne, G. Lilly, E. Dalley, E. Murphy, J. Anderson, J. Brattey, D. Stansbury, P. Shelton – Newfoundland Region, NWAFC)

A review of recent changes in the ocean climate in waters adjacent to Newfoundland and Labrador were presented together with trends in the abundance of pre-recruit Atlantic cod. During the decade of the 1990s the northwest Atlantic experienced some of the most extreme climatic variations on record. Air temperatures increased from below normal values during the early 1990s to a 126-year record high in 1999 on the Labrador Coast. Sea ice extent on the Newfoundland Shelf also decreased rapidly from the heavy ice years of 1990-1994 to some of the lightest ice-years on record by the late-1990s. Ocean temperatures ranged from record low values during 1991 to record highs during 1999 in many areas, particularly on the Grand Bank of Newfoundland. Temperature anomalies on the Grand Bank, for example, ranged from 1°C above average in northern areas and up to 4° C above normal on the southern portion of the bank. The cold intermediate layer waters of the Newfoundland Shelf also decreased from the third highest ever-recorded in 1991 to the third lowest in 1999, a 22-year record. This shift in the thermal habitat from the Arctic-like conditions of the early-1990s to the more temperate conditions of the late-1990s likely contributed to the observed changes in the pelagic ecosystem on the Newfoundland Shelf. During 1998 and 1999 there was a sharp increase in the nekton biomass with an order of magnitude increase in o-group Atlantic cod found in pelagic surveys on the Grand Bank. Data from the annual fall multi-species bottom trawl surveys of northern cod (1995-2002) also showed a similar increase in the numbers of 0-group cod. It is emphasized however that the limited increase in production during 1998-1999 was not significant compared to historical levels and in fact did not continued during the most recent years. Nevertheless, there appeared to be a limited response to the warm conditions of the late-1990s but temperature is clearly not the sole factor determining production of cod in Newfoundland waters. It is also noteworthy that salinities on the Newfoundland Shelf remained low, which resulted in high stratification levels throughout most of the 1990s and up to 2001. Finally, the catch rates of Atlantic cod up to age three were significantly correlated with the three-year averaged salinity for the years 1983 to 2002. Additional investigation of these relationships will incorporate potential influences of spawners stock biomass.

Upper trophic level surprises off B.C. during the 1990s and their physical and biological drivers: Global warming in action? (Ian Perry and the West Coast Canada GLOBEC Team)

During the 1990s, atypical species distributions, changes in community composition, and changes in survival were observed for many high trophic level fishes and seabirds off the west coast of British Columbia. These include changes in the growth and survival of seabird chicks, increased abundances of warm water pelagic fishes such as Pacific hake, sardine and chub mackerel, and decreases in the populations of cold-water pelagic fishes such as several species of salmon. Much of the 1990s were unusually warm off BC, which ended rather abruptly in 1999 with a return to cool conditions typical of the 1960s and early 1970s. We provide a synthesis of Canadian GLOBEC studies off the west coast of Canada during the 1990s and examine in detail the physical and biological oceanographic changes and their consequences for higher trophic levels. We conclude that the changes in physics are fairly small, those in phytoplankton were a little larger, whereas those in zooplankton were more distinct and in fish and birds they were very sharp. However, the responses were species specific. For example, euphausiids were enhanced because of lower upwelling but zooplankton biomass overall was reduced. The 1990's did not bring a simple shift of ecosystems to the north. While plankton conditions off the BC coast did resemble those off California, off BC sea temperatures were higher but upwelling was reduced. The hardest hit species are those with land ties: the seabirds and the salmon as they cannot simply move northwards to compensate.

Model-based information of the drift, growth and survival of the early life stages of cod, snow crab and lobster in the southern Gulf of St. Lawrence in 1999. (J. Chassé, BIO-GFC)

A three-dimensional biophysical modeling system is used to hindcast summer oceanic conditions during the summer of 1999 in the Southern Gulf of St. Lawrence. The modeling system also hindcasts the drift, growth and survival the early life stages of lobster, snow crab and cod. Individual-Based Models (IBM) of the early life stages are incorporated into a full 3-D hydrodynamic model of the ocean. The hydrodynamic model is driven with the NCEP atmospheric forcing, by the tides and river runoffs. There was a strong wind anomaly from the southwest in June 1999. More wind than the normal was blowing eastward during July while the wind anomaly diminished close to none for the month of August. The strong wind anomaly in June intensified the eastward circulation in the southern Gulf and displaced the Gaspé current towards Anticosti Island. The usual eastward circulation along the north coast of PEI and in the Northumberland Strait was weakened due to a water level setup along the coast of western Cape-Breton. In July and August, the circulation pattern was closer to normal. There was a strong heat flux anomaly into the ocean during June 1999. The flux was particularly strong in the Gaspé current, at the mouth of Baie des Chaleurs and along the eastern coast of New-Brunswick. In July, heat flux into the ocean was still higher than usual in the Gaspé current, but close to normal over the Magdalen Shallows. In August, heat flux was very close to normal everywhere in the Southern Gulf. The average heat flux into the ocean was slightly higher than normal. Temperature in the 0 to 20 m layer was noticeably higher than usual during the months of June and July, but closer to normal in August. The average temperature for the three summer months was the third highest value since 1987. Due to the strong eastward wind anomaly in June, the snow crab larvae would have been pushed towards the east, into cooler water, resulting in around-average total survival despite the good temperature conditions in the Southern Gulf. The total survival of cod and lobster larvae picked up in 1999 after three years of low recruitment, but it wasn't the best year of the time series.

Interannual Variations in Hydrography, Plankton and Haddock Year Class Strength on the Scotian Shelf; 1998-2001 (E. Head – Maritimes Region, BIO)

Year-class strength in many commercial species of fish varies greatly and seems to be determined early in life. Survival is thought to depend on the timely presence of food and favourable hydrographic/hydrodynamic conditions. Each spring AZMP surveys on the Scotian Shelf allow assessment of biological and hydrographic conditions and each July groundfish surveys provide information on the survival of spring-spawned juvenile fish. Between 1998 and 2001 springtime temperatures over Western Bank, an important spawning area for haddock, were cool (1998, 2001) or warm (1999, 2000). During the warm years a high proportion of young-of-the-year haddock had settled before July, when they were caught as year-0 fish. During the cool years the proportion settling by July was lower. These differences were likely partly due to temperature-related changes in growth rate. Subsequent observations of abundance of 1 or 2 year old fish showed that year class strength was good in 1998 and 2000, exceptional in 1999 and poor in 2001. In 1999, peak-spawning activity of *C. finmarchicus*, an important food for larval and juvenile haddock, was co-incident with an intense spring bloom, and both occurred relatively early in late February. *C. finmarchicus* reproduction occurred at more-or-less the same time in the other 3 years (mid-March), while the spring bloom was of intermediate intensity and in late February in 1998, weak and in mid-March in 2000 and intense and in late March in 2001. Historically, haddock spawning used to peak in March on Western Bank and in every year except 1999, early haddock larvae hatching from eggs laid in March would have co-occurred with *C. finmarchicus* eggs and nauplii. On the other hand, however, the sizes of the year-0 haddock caught in July suggest that they derived from larvae that hatched in February, implying that currently some haddock spawn as early as January/February. In 1999 and 2000 these early-spawned year-0s constituted a large proportion of the total year class and uniquely in 1999 (the year of the exceptionally strong year class) these early hatchlings would have co-occurred with high levels of their preferred food (*C. finmarchicus* eggs and nauplii). These observations suggest that hatching early confers some advantage for survival and that the timely presence of abundant food is also important. As well, the relatively warm temperatures in 1999 probably promoted high growth rates further aiding survival, and in addition the circulation must have been such that the juvenile haddock were transported to areas where the bottom type was favourable for settlement. A unique set of conditions may have lead to the exceptionally strong year class of 1999, but good year classes occurred in years (1998, 2000) that did not share the same conditions in either temperature or spring bloom dynamics. Overall, it seems that a number of factors may contribute to differences in year class strength, but these do not act independently, but rather in combination.

*The anatomy of a strong year-class: the case of the Atlantic mackerel (*Scomber scombrus *L.) in 1999* (F. Grégoire and M. Castonguay – Quebec Region, IML)

Pelagic species of marine fish such as herring (*Clupea harengus harengus* L.) and the Atlantic mackerel (*Scomber scombrus* L.) are characterized by periodic strong pulses of recruitment. In Atlantic mackerel, these pulses have been observed on several occasions in the past and were responsible for the presence of the 1967, 1969, 1974, 1982, 1988, 1996 and more recently, 1999 strong year-classes. These year-classes are of a great importance for stocks of pelagic fish because they can support a fishery for several years. Strong year-classes are recognized by the examination of the commercial catch at age and length frequencies. In mackerel, an inverse relationship has also been observed between the strength of a year-class and its growth defined by the mean length or weight at age and the measurement of the otolith height at 1 year old. There are also good indications that the coming of a strong year-class is linked with plankton abundance and water temperature. The 1999 year-class owns all these characteristics and up to 2002, its importance in the landings at 1, 2 and 3 years old has never been equaled in previous records. The 1999 year-class was so important in 2002 that no difference was observed in the length frequencies of fish caught by the dominant gear types used by mackerel fishermen in all Eastern Canada. Hypotheses have been formulated to explain the appearance and strength of that particular year-class. Suggestions include the idea that a greater proportion of spawning activity occurred on the Scotian Shelf compared to the southern Gulf of St. Lawrence, or that the spawning season was earlier in the Gulf. Both suggestions are based on the observation of the mean daily gonadosomatic index values. A reduction of the larvae density caused by an expansion of the spawning area and favourable conditions of food and temperature could explain why that year-class had a better rate of growth during its first year than any of the other strong year-classes observed since the mid-seventies.

*Covariation in shrimp (*Pandalus borealis*) and Greenland halibut (*Reinhardtius hippoglossoides*) recruitment in the Estuary and the Gulf of St. Lawrence since 1990: Looking for environmental and/or trophic interactions* (L. Savard, B. Morin, P. Ouellet, M. Starr and M. Harvey – Quebec Region, IML

Since 1992, the annual shrimp and G. halibut (turbot) recruitment has shown similar fluctuations in the Lower St. Lawrence Estuary (LSLE) and northwest Gulf of St. Lawrence (NWGLS), and both series peaked in 1999. Shrimp recruitment was defined as abundance of 3-y old shrimp caught during the summer (August) groundfish survey from 1990 to 2002 (i.e., 1987 to 1999 year-classes), and from the abundance of 1- to 3-y old shrimp (i.e., 2000 and 2001 year-classes) from a special June survey carried out since 2000. Turbot recruitment was defined as the abundance of 1-y old fishes during the summer groundfish survey. Both recruitment series were significantly correlated ($r = 0.906$, $P < 0.001$). However, when standardized by an index of spawning stock abundance (i.e., recruitment rate, R/SS), the highest recruitment rate in shrimp was observed in 1994 (1999 was second best) and the correlation between shrimp and turbot R/SS series was non-significant due to low spawner biomass in the early 1990s and very poor year-classes between 1992 and 1994. In fact, shrimp and turbot recruitment rates were correlated ($r = 0.88$, $P = 0.008$) for the 1995 to (?) 2001 (year-classes). Little is known of turbot reproductive biology in the LSLE and NWGLS but spawning is believed to occur in winter and early spring, so that the larvae are probably present in the water column in the spring. Indeed, the significant correlation found between turbot recruitment rate and the integrated (0-50 m) chlorophyll *a* biomass in the LSLE suggest that spring biological production influences turbot larvae survival. However, no correlation was found between shrimp recruitment rate and chlorophyll *a* in the LSLE.

Shrimp are much more abundant in the Gulf of St. Lawrence than in the LSLE. Berried females aggregate in the NWGLS in early spring for emergence of the larvae from end of April to the end of May. The first three larval stages are present in the upper water column and they prey on small zooplankton. Therefore, spring conditions for high biological production should be favorable to shrimp recruitment. As a first attempt to validate the hypothesis, correlations were estimated between shrimp recruitment rate in the NWGLS and various physical and biological indices: (1) the date of 75% larval emergence, (2) the upper-layer mean water temperature in May, (3) the stratification (sigma-t: 5 – 30m) index in May, (4) late winter nitrate pool in the upper layer, and (5) nitrate depletion in the spring. Notably, late winter nitrate and nitrate depletion where both higher in 1999, and the only significant correlation ($r = 0.93$, $P = 0.023$) was observed between the nitrate depletion index.

In summary, the 1999 year-class was the highest of the last 10 years for turbot and the second best for shrimp. Integrated chlorophyll *a* biomass in LSLE and a nitrate depletion index in the NWGLS were also maximal in 1999. Between 1992 and 2002, shrimp and turbot recruitment and these indices of biological productions were correlated suggesting a significant influence of trophic interactions (bottom-up) control on recruitment. These preliminary results are supportive of continued monitoring, especially winter and early spring monitoring and for process oriented studies to quantify linkages.

5.2 Discussion

The papers presented at the Theme Session incited a fair amount of interest and discussion. Clearly, 1999 presented unique environmental conditions for the recent (5) years period. Thermal conditions in 2000 were also anomalously high and the timing of the bloom was also relatively early in the Lower St Lawrence Estuary (the bloom was at the normal time on the Scotian Shelf/Western Bank) but not as much as in 1999. However, the increase in abundance of young cod observed in 1998-99 on Newfoundland Shelf (possibly linked to increased biological productivity) does not seem to have persisted to the present. A comment was made that environmental effects on catchability might explain the results, as environmentally driven distribution shift for yellowtail flounder is suspected, but it appear that it is not the case for cod.

Concerns were expressed about the summer temperature fields generated by the model in the southern Gulf of St. Lawrence; in comparison to the observed temperatures the model output did not appear to capture the magnitude of warming seen in the observations for 1999. This is an important issue since growth and survival of the larvae of many stocks would be sensitive to earlier (spring) environmental conditions. Joel Chassé indicated that further work is planned to address the differences in model output in relation to observations and to concentrate more on initial conditions in running the model, i.e. on early spring. There was also some discussion about the model's representation of larval mortality and the appropriateness, at this stage, of the "index of survival" term. However, the Committee agreed that the effort to develop those indices should be continued.

Erica Head concluded her presentation with a plea for more information on circulation on the Scotian Shelf in 1999 (and in general as well). In fact, drift dynamics may be as (or more) important as the characteristics of the biological cycles in explaining the 1999 observations in plankton and fish recruitment. That presentation was also followed by a more general discussion about the "Match-Mismatch Hypothesis" and if, in fact, plankton cycles and observed haddock spawning cycles were consistent with the hypothesis. For example, haddock larval development may take up to a month or more after spawning which could put the first-feeders out of sync with the food supply. Also, there is evidence in the literature that some species will eat anything available in the water at the time of larval development and survival may not necessarily depend on the optimum availability of plankton species or taxonomic group. Erica Head suggested that less favorable (cooler) temperature conditions have in the past supported strong year-classes of haddock but contends that exceptional years of recruitment are associated with warm years.

About the exceptional mackerel 1999 year-class, Erica Head commented that there may be a link between the abundance of *C. finmarchicus* and the CIL in the Southern Gulf, i.e. *C. finmarchicus* prefers colder waters and uses deep/old waters as refugia. There was considerable discussion on the interpretation of the changes in spawning stock biomass (the 1999 year class seems to have originated from a relatively low SSB) with speculations that lower SSBs in the Southern Gulf may mean earlier spawning outside the region. The suggestion was made to look for evidence of early mackerel spawning on the Scotian Shelf in the 2002 survey data to help answer this question. The observation was made that both mackerel (warm water species) and capelin (cold water species) are increasing in the Southern Gulf. However, it was noted that capelin have been increasing steadily over the past several years whereas the mackerel increase has been rapid/recent phenomenon.

The question was posed if the relationship observed between winter nutrient concentrations and shrimp recruitment rate were similar to the observation made a number of years ago in the Gulf of shrimp abundance (CPUE) and winter nutrient inventories (lagged by a number of years). But, in fact there is no relation between the two investigations. In the work presented at this meeting recruitment (year-class strength) and not adult yield was considered and that would not require a lag between the environmental and recruitment series. A general question was about why these strong correlations are seen for some species but not for (closely related) others species. Perhaps that subtle but sufficient nonetheless differences with regard to life cycles result in different responses to environmental/food conditions.

One last question posed was if the 1999 events persisted? The answer to that question was a qualified "yes" in some cases and "no" in others. The full answer to that question will have to wait further analysis. Nevertheless, the feasibility of pulling the theme session information together for a primary publication was debated. Some felt it was a logical thing to do while others had some reluctance since important gaps in our understanding of the breath and nature of the 1999 "event" still exist. In general, however, there was support for this idea. No leader was identified but Patrick Ouellet and Ken Drinkwater agreed to pull summaries together from all contributors to the theme session and draft an outline for such a paper for further discussion. It was also agreed that a short article for the AZMP Bulletin on the 1999 "event" would be produced in the fall 2003.

The special seminar presented by Ian Perry generated a good discussion. One first question was if changes in zooplankton size-spectra for the period were also looked at. It would have been interesting, as well as for total biomass, but that was not the case. An interesting point was the opposite patterns in the fish community from the Atlantic and Pacific coast (e.g., groundfish declined in the Atlantic and increased in the Pacific). Atmospheric systems are all interconnected; therefore it may not be surprising to see correspondence in patterns across coasts but that the surprise was that patterns are opposite and there is no good explanation for that. The increase of El Nino frequency was also pointed out. It would seem that events in the tropics affect those in the north Pacific, affecting the Aleutian low for example. However, BC does not experience all El Nino but only the larger ones. In fact, the system in BC is more affected by Aleutian low and the Pacific high. It seems also that not everyone is convinced that the pattern observed was a true shift. However the marine systems is looking much more like a cold water system. The warm conditions of the 1990s are no longer seen in the area.

Ian was asked to comment on the needs for monitoring programs to integrate communities, given that responses are species specific. Commercially important species feed on non-commercial species that are typically not monitored. This is a problem since there is an important link that is not being quantified. However, there is no easy way to do it. There is also an advantage in using upper trophic level species since we monitor them regularly and they integrate a lot of the high frequency variability.

Other questions were about the migration pattern of fish species and what caused the changes observed. The stronger currents were progressively moving species up to the north and favourable condition up north "attracted" species. That lead to questions concerning the problem that this may represent for the implementation of marine protected areas, which tend to be small and could be of little use if there are environmentally driven shifts in distribution. Those concerns will need to be taken into consideration in determining future MPAs so that they will reach their objectives. Similarly, regarding species at risk, it will be necessary to consider shifts in distribution (determine which species a resident in Canada and which come in to Canadian waters only in certain time periods).

6. General discussion and FOC Business meeting

The chairman opened the discussion by reviewing the recommendations from the November workshop on strengthening the link between monitoring and stocks assessment as in the regard to the role that could be played by FOC on this matter. Concerning interactions between oceanography and fisheries, AZMP and FOC were contacted to participate at the recent Zonal review on cod (Halifax, February 2003) and FOC (Patrick Ouellet) gave a presentation on recent plankton trends in the Atlantic Zone. Denis Gilbert commented that oceanography presentations are now carried out at IML in November, two months before the RAP meeting, to allow time for biologists to incorporate environmental information if deemed warranted. He also remarked that his relationship with assessment biologists present at the FOC/AZMP meeting has increased since the workshop.

It was agreed that FOC has been active but we need to be fed more information from stock assessment people. However, although environmental indices have been developed for their needs, sometimes fisheries scientists may not know how information provided by oceanographers can be used. A proposition was that FOC should reflect more on what ecosystem management should mean and maybe look, for example, at the US ecosystem-based management plan which essentially involves concern for target species, concern for bycatch, and concern for the habitat. Also, in Europe, they are working on 5-year projections on stocks and include environmental information in these projections. From the FOC perspective, it seems desirable to go further than to report on what is colder or warmer each year, and highlight the usefulness of our environmental overviews. Maybe more specific issues can be addressed at the business meeting and special session of the annual meeting. Another comment made concerned the possibly for FOC to interact with the FRCC. For example, to summarize the report for the Environment and Ecology Subcommittee concerned with these issues. However, the Committee did not support that suggestion.

In order to stimulate further discussion on this subject, the Chairman asked Eugene Colbourne and Ian Perry to make short unscheduled presentations to illustrate some successes that are currently being realized in getting oceanographers and stock assessment scientists talking to one another and working together.

An example of how fruitful interactions with stock assessment scientists have developed in the Newfoundland region. The work with snow crab and shrimp scientists was presented and details of what environmental data are discussed (and how it is used) at the stock assessment meetings was presented by Eugene Colbourne. Time-series of abundance data (CPUE) are lag-correlated (7-8 yrs) with environmental data to generate forecasts. In the case of both snow cab and shrimp, auto-regressive models forecast abundance (temperature - independent variable) 7-8 years ahead and can account for 20-70% of the observed variance. Cold temperatures correlate with large year classes and environmental (temperature) trends at present predict declining abundance. However, some members were concerned about the wisdom of promoting such correlative forecasts (in the absence of a clearer understanding of underlying cause-effects) to DFO managers (and fishers) that may adopt a “take while we can” strategy and fish harder, assuming the stocks will be gone soon due to natural causes. It was also questioned whether management and fishers understood the concept of uncertainty in such correlative methods. It was also suggested that there is evidence that the adult of these species may be able to tolerate higher temperatures than implied by these empirical relationships and that the young stages are the more temperature-sensitive. The Chairman concluded the discussion with the comment that the environment-SA working group in FOC should probably continue next year with a mandate of developing case-studies as recommended in the Montreal workshop; the Newfoundland experience might be a candidate.

Next Ian Perry provided a brief overview of the Pacific’s counter-part to the FOC, the Fisheries Oceanography Working Group (FOWG). Their approach is distinctly different from the FOC. For example, series of formal papers, i.e. Res Docs, SSRs are not produced by the

FOWG; however, notes from the meeting discussions on conditions for the year form the basis for an annually produced State of the Ocean Report (normally completed within a month or so of the meeting). The report is linked to various data sources also. Representatives from different species groups are on the WG and report their information to the oceanographers. The State of the Ocean Report includes predictions and speculation on where the fisheries are going. It is not formally reviewed and copies go to regional senior management. Because of it speculative content, lack of a formal review, and because it is a public document, it tends to make some senior managers uncomfortable. Ian mentioned that efforts are underway to synthesize the information and make it more quantitative, something along the lines of the integrative methods Ken Frank outlined earlier in the week.

Next on the agenda was to review the activities of the FOC ad-hoc working groups. The Working Group on incorporating environmental information into the assessment process was established a couple of years ago to address the question of linkages between fisheries and the environment. The WG was active in the preparation of the Theme Session for the 2002 Annual Meeting and also in the organization of the FOC-AZMP Workshop in November 2002. There was a discussion about the continuation of the WG in the light of all the other commitments of it members. However, the Chairman pointed out that recommendations were made to the FOC at the Montreal workshop about the implication of the Committee in establishing case studies to aid in the exploration of environment-fish relationships and their possible use in assessment work. It was decided that the WG will be maintained and the Chairman is to examine possible activities that can be initiated in relation to its mandate.

The Working Group on Recruitment Indices (WGRI) will continue to develop the recruitment reports and the recruitment scorecard for the FOC annual meeting. The WG is to work in collaboration to contribute information for a common database on recruitment and to develop standardized statistical analyses to compare recruitment indices between stocks and regions. Members include John Anderson (Edgar Dalley), Martin Castonguay, Ken Frank and Doug Swain.

The Working Group on Monitoring of Pelagic Ecosystems (WGMPE) formed in 2001 was discontinued for the moment. Many of the issues that formed the term of reference for the WG were raised at the FOC-AZMP Workshop and recommendations about how to enhance monitoring of nekton and the pelagic community were made to the AZMP. The FOC decided that it should wait for the results of the AZMP program review and proposition on that question before to discuss future actions.

The Committee then discussed possible theme sessions for its 2004 Annual Meeting. Although no final agreement was reached the possibility of having a Theme Session on the current status of pelagic fish stocks seemed to have the support of many Committee members.

Lastly, it confirmed that the 2004 Annual Meeting will be held at the Northwest Atlantic Fisheries Center (NWAFC) in St. John’s, Newfoundland, in late March 2004.

Fisheries Oceanography Committee

Annual Meeting, March 11-14, 2003
OSD Boardroom
Maurice Lamontagne Institute, Mont-Joli, Qc.

AGENDA

Thuesday, March 11

8:30 Introduction and administrative details
Chairman

Review of 2002 environmental conditions in the Northwest Atlantic.

Physical Environment

8:45 An overview of meteorological, sea ice and sea-surface temperature conditions off Eastern Canada during 2002.
K. Drinkwater, B. Petrie, R. Pettipas, L. Petrie and V. Soukhovtsev

Physical Conditions in the Labrador Sea in 2002
R. Hendry (*presented by K. Drinkwater*).

9:40 Physical oceanographic conditions on the Newfoundland and Labrador Shelves during 2002.
E. Colbourne

Oceanographic conditions in NAFO Subdivisions 3Pn and 3Ps during 2002 with comparisons to the previous year and the long-term (1971-2000) average.
E. Colbourne.

10:30 BREAK

10:45 Physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine during 2002.
K. Drinkwater, B. Petrie, R. Pettipas, L. Petrie and V. Soukhovtsev

11:30 Physical oceanographic conditions in the Gulf of St. Lawrence in 2002.
D. Gilbert and C. Lafleur

12:15 LUNCH

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

Biological and Chemical Environment

13:45 Biological and Chemical oceanographic conditions on the Newfoundland Shelf during 2002 with comparisons with earlier observations.
P. Pepin, G. L. Maillet, S. Fraser and D. Lane

14:30 Optical, chemical and biological oceanographic conditions on the Scotian Shelf, in the Gulf of Maine and the Southern Gulf of St. Lawrence in 2002.
G. Harrison, D. Sameoto, J. Spry, K. Pauley, H. Maass and V. Soukhovtsev.

Bedford Basin Plankton Monitoring Program: 1992-2002 (Li, WKW, PM Dickie, JA Spry, T Perry and EJH Head) [no presentation].

15:15 BREAK

15:30 State of phytoplankton in the Estuary and the Gulf of St. Lawrence during 2002.
M. Starr, L. St-Amant, L. Devine and L. Bérard-Therriault

16:15 State of the Ocean: Biological oceanographic conditions in the Estuary and the Gulf of St. Lawrence in 2002.
M. Harvey, J.-F. St-Pierre and M.-F. Beaulieu

16:45 Discussion of biological overviews.

Wednesday, March 12

Recruitment trends

8:40 Recruitment of selected fishes and invertebrates in the Southern Gulf of St. Lawrence.
D. Swain and H. P. Benoît.

9:00 Recruitment of selected fishes and invertebrates from the Northern Gulf of St. Lawrence.
M. Castonguay.

9:20 Recruitment of selected fishes and invertebrates on the Scotian Shelf
K. Frank.

9:40 Recruitment of selected fishes and invertebrates from Newfoundland and Labrador.
E. Dalley

10:00 BREAK

10:30 Recruitment Scorecard and Discussion

Misceallaneous papers

11:15 A new buoy network to monitor environmental conditions and validate satellites products in the St. Lawrence ecosystem.
P. Larouche, et al.

11:45 Model-based summer oceanic conditions in the southern Gulf of St. Lawrence in 2002.
J. Chassé

12:15 LUNCH

13:00 Changes in the apparent distribution of cod in the southern Gulf of St. Lawrence in September: earlier migration or a true shift in distribution.
H. P. Benoît, D. P. Swain and G. A. Chouinard

13:30 Temperature variability in coastal Newfoundland waters.
J. D. Craig and C, E. Colbourne

14:00 State of the Eastern Scotian Shelf Ecosystem.
K. Frank

14:45 [Paper removed]

15:15 BREAK

15:30 FOC - AZMP and SA Workshop: Discussion and action on the recommendations?
Chairman & core members

Thursday, March 13

Theme Session: 1999: an exceptional year in the environment and fisheries?

8:45 Introductory remarks
Chairman

9:00 Meteorology, sea-ice and ocean conditions in Maritime Canada during 1999: An unusual year?
K. Drinkwater and B. Petrie

9:30 Environmental conditions in Newfoundland waters during 1998-2000: possible influences on cod recruitment.
E. Colbourne, G. Lilly, E. Murphy, E. Dalley and J. Anderson

10:00 BREAK

10:30 **Special presentation:** Upper trophic level surprises off British Columbia during the 1990s and their physical and biological oceanographic drivers: global changes in action?
Ian Perry (PBS)

12:00 LUNCH

13:00 Model-based information of the drift, growth and survival of the early life stages of cod, snow crab and lobster in the southern Gulf of St. Lawrence in 1999.
J. Chassé.

13:30 Interannual variations in hydrography, plankton and haddock year class strength on the Scotian Shelf (1998-2000).
E. Head

14:00 Anatomy of a strong year-class: The analysis of the 1999 Atlantic mackerel year-class.

F. Gregoire and M. Castonguay

14:30 Covariation in shrimp (*Pandalus borealis*) and Greenland halibut (*Reinhardtius hippoglossoides*) recruitment in the Estuary and Gulf of St Lawrence since 1990: Looking for environmental and/or trophic influences?
L. Savard, B. Morin, P. Ouellet, M. Starr and M. Harvey

15:00 BREAK

15:15 General discussion & Discussion and approval of environmental overview SSRs

Friday, March 14

FOC Business Meeting

1. Stock Status Reports
   - Discussion and approval of environmental overview SSRs (cont'd)
   - Do we need a distinct format for the environmental SSR?
   - FOC and the Ocean Science "State of the Ocean" or "State of the Ecosystem" report
2. Reports on FOC Working Groups:
   - WG: *Incorporation of environmental data into stock assessments*
   - WG: *Monitoring of pelagic ecosystems*
   - Others WGs?

3 Next year meeting: Location/Date & Theme session

4 Other business?

List of participants

Anderson, Martha	DFO-(Ottawa)
Benoît, Hughes	DFO-Gulf Region (GFC)
Bourdage, Hugo	DFO-Québec Region (IML)
Castonguay, Martin	DFO-Québec Region (IML)
Chassé, Joel	DFO-Maritimes Region (BIO)
Chifflet, Marina	DFO-Québec Region (IML)
Colbourne, Eugene	DFO-Newfoundland Region (NWAFC)
Craig, Joe	DFO-Newfoundland Region (NWAFC)
Dalley, Edgar	DFO-Newfoundland Region (NWAFC)
Devine, Laure	DFO-Québec Region (IML)
Drinkwater, Ken	DFO-Maritimes Region (BIO)
Frank, Ken	DFO-Maritimes Region (IML)
Gilbert, Denis	DFO-Québec Region (IML)
Grégroire, François	DFO-Québec Region (IML)
Harrison, Glen	DFO-Maritimes Region (BIO)
Head, Erica	DFO-Maritimes Region (BIO)
Lafleur, Caroline	DFO-Québec Region (IML)
Larouche, Pierre	DFO-Québec Region (IML)
Lefaivre, Denis	DFO-Québec Region (IML)
McQuinn, Ian	DFO-Québec Region (IML)
Morin, Bernard	DFO-Québec Region (IML)
Pepin, Pierre	DFO-Newfoundland Region (NWAFC)
Perry, Ian	DFO-Pacific Region
Savard, Louise	DFO-Québec Region (IML)
St-Amand, Liliane	DFO-Québec Region (IML)
Spry, Jeff	DFO-Maritimes Region (IML)
Therriault, Jean-Claude	DFO-Québec Region (IML)