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Atlantic Zone

Final Report of the 1997 Annual Meeting of the **Fisheries Oceanography Committee**

February 25-27, 1997
Gulf Fisheries Centre
Moncton, New Brunswick

K. Drinkwater
Chairperson

April 1998

Canada

Atlantic Zone

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Fisheries Oceanography Committee

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At the Gulf Fisheries Centre
Moncton, New Brunswick

K.F. Drinkwater, Chairman

June, 1997

Executive Summary of the 1997 FOC Annual Meeting

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans (DFO) met in Moncton, New Brunswick, at the Gulf Fisheries Centre on 25-27 February, 1997.

1. The FOC began by examining environmental conditions in the Northwest Atlantic during 1996. Five papers were reviewed on the meteorological and physical oceanographic conditions and three on plankton and nekton. It was noted that DFO's failure to pay our bill on time for the continuous plankton recorder meant that these data were not available for the meeting. Significant changes were observed in the large-scale atmospheric circulation patterns as reflected in the largest annual decline in the North Atlantic Oscillation (NAO) index in over 100 years. Associated with this change were weaker northwest winds in winter over the Labrador Sea, warmer air temperatures and less sea ice than in the early 1990s. Water temperatures over the Newfoundland and Labrador shelves were at their warmest level in over a decade. Cold conditions persisted in the waters within the cold intermediate layer (CIL) in the Gulf of St. Lawrence and in the subsurface waters on the northeastern Scotian Shelf and off southwest Nova Scotia. There was also a continuation of above normal temperatures in the deep basins on the Scotian Shelf and Gulf of Maine.

2. Four papers were reviewed and 2 additional presentations were made in a general environmental session. One paper reported on temperature data collected during redfish surveys, 3 discussed plankton (one on development of plankton indices, one describing plankton and nekton collected during summer surveys on the Newfoundland and Labrador shelves in 1994 and 1995 and another discussing the ecology of Calanus) and 2 were on fish stocks (one on seasonal temperature associations of cod and plaice and another on cod distribution, both in the southern Gulf of St. Lawrence).

3. A special presentation was made by J.-C. Therriault on the proposed Zonal Monitoring Program. After providing a brief description of the objectives and an outline of the proposed program, a lively discussion and question period was held. The FOC generally supported the Proposal for an East Coast Zonal Monitoring Program feeling that its adoption would provide a more ecosystem based approach to monitoring than is presently carried out. Several reservations were expressed, however, and the FOC particularly noted that the spatial representativeness of the biological data, whether from the CPR line or the proposed fixed stations or transects, needs to be resolved.

4. The 1997 theme session for the FOC meeting addressed environmental effects on invertebrate populations. A total of 15 papers were reviewed and another 3 presentations were made. These covered six species including all of the major commercial species (snow crab, lobster, scallop and shrimp). One or more papers or presentations were given of environmental effects on each of the following topics: growth, distribution, abundance, recruitment and catchability.

5. A discussion was held on the role of the FOC in addressing important environmental issues and especially the linkages between the environment and fisheries. It was generally felt that the committee should become more proactive. In addition to providing a forum for discussion of selected topics, i.e. the special theme sessions during our annual meetings, the FOC decided to form specially tasked working groups. Two such groups were formed and asked to report back to the Committee at next year's annual meeting. A Cod Growth Working Group (CGWG) will investigate the effects of temperature and density dependence on the growth of cod for all major Canadian east coast stocks. An Environmental Indices Working Group (EIWG) will detail how each of the main environmental indices are calculated and work towards standard methods of calculation and analysis. The latter working group is to be chaired by F. Page and the former by K. Drinkwater.

6. Next year's annual meeting is to be held at the Bedford Institute of Oceanography during the last week of February. The theme session will be on growth and reproduction, with special emphasis upon possible environmental influences.

Sommaire de la réunion annuelle du COP de 1997

Les membres du Comité Océanographique des Pêches (COP) du Ministère des Pêches et des Océans (MPO) se sont réunis au Centre des Pêches du Golfe, à Moncton (Nouveau-Brunswick), du 25 au 27 février 1997.

1. Le COP a tout d'abord examiné les conditions environnementales dans le nord-ouest de l'Atlantique en 1996. Les membres ont examiné cinq documents sur les conditions météorologiques et océanographiques physiques ainsi que trois documents sur le plancton et le necton. Comme le MPO n'avait pas payé à temps la facture du Comité relative à l'enregistrement du plancton en continu, les membres n'avaient aucune donnée à ce sujet à la réunion. Les configurations à grande échelle de la circulation atmosphérique ont connu des transformations en profondeur. En effet, l'indice d'Oscillation Nord-Atlantique (ONA) a connu la plus forte baisse annuelle depuis plus de 100 ans. Ce changement a été accompagné d'un norois plus faible pendant l'hiver au-dessus de la mer du Labrador, de températures atmosphériques plus chaudes et de moins de glaces de mer qu'au début des années 1990. Les températures de l'eau sur les plateaux continentaux de Terre-Neuve et du Labrador ont été les plus chaudes depuis plus d'une décennie. Les eaux sont restées froides à l'intérieur de la couche froide intermédiaire (CFI) du golfe du Saint-Laurent et sous la surface au nord-est de la plate-forme néo-écossaise et au large du sud-ouest de la Nouvelle-Écosse. Les températures sont restées au-dessus de la normale dans les bassins profonds de la plate-forme néo-écossaise et du golfe du Maine.

2. Pendant la séance générale sur l'environnement, on a examiné quatre documents de même que deux autres exposés. Un des documents faisait état des données sur la température recueillies pendant les relevés du sébaste. Il était question de plancton dans trois documents (un sur l'élaboration des indices planctoniques, un autre décrivait le plancton et le necton recueillis en 1994 et en 1995 dans le cadre de relevés effectués pendant l'été sur les plateaux continentaux de Terre-Neuve et du Labrador et un troisième sur l'écologie du *Calamus*) tandis que deux autres documents portaient sur les stocks de poisson (un sur les associations de températures saisonnières touchant la morue et le poisson plat et un autre sur la répartition de la morue, et ce, dans le sud du golfe du Saint-Laurent).

3. J.-C. Therriault a présenté un exposé spécial sur le programme de contrôle des zones proposé. Il a d'abord fait une brève description des objectifs et des grandes lignes du programme proposé. Puis, s'ensuivit une discussion animée et une période de questions. De façon générale, le COP appuie la proposition de mettre sur pied un programme de contrôle des zones de la côte est, car il considère qu'ainsi, le contrôle serait davantage axé sur les écosystèmes. Toutefois, on a exprimé plusieurs réserves. Le COP a mentionné tout particulièrement qu'il faudrait régler la question de la représentativité spatiale des données biologiques, peu importe qu'elles proviennent de l'axe CPR ou des stations fixes ou des transects proposés.

4. La séance thématique de la réunion du COP de 1997 portait sur les répercussions de l'environnement sur les invertébrés. On a examiné 15 documents de même que trois autres

présentations. Il y était question de six espèces, dont toutes les espèces principales pêchées commercialement (crabe des neiges, homard, pétoncle et crevette). Un ou plusieurs documents ou exposés ont porté sur les répercussions de l'environnement sur chacune des questions suivantes : croissance, répartition, abondance, recrutement et potentiel de capture.

5. Une discussion a été tenue au sujet du rôle que devrait jouer le COP en matière de questions environnementales importantes et tout particulièrement des liens entre l'environnement et les pêches. On a considéré de façon générale que le Comité devrait être davantage proactif. Le COP a décidé qu'en plus d'agir à titre d'organe de discussion de questions particulières, notamment les séances thématiques spéciales tenues pendant les réunions annuelles du Comité, il devrait former des groupes de travail chargés de fonctions spéciales. On a constitué deux groupes de ce genre et on les a chargé de faire état de leurs activités à la prochaine réunion annuelle du Comité. Un Groupe de travail sur la croissance du saumon (GTCS) étudiera les répercussions de la température et de la densité de l'eau sur la croissance de la morue de tous les principaux stocks de la côte est canadienne. Un Groupe de travail sur les indices environnementaux (GTIE) expliquera en détail le calcul de chacun des principaux indices environnementaux et tentera de mettre en place des méthodes de calcul et d'analyse normalisées. Ce dernier sera présidé par F. Page tandis que le premier sera présidé par K. Drinkwater.

6. La réunion annuelle de l'an prochain aura lieu à l'Institut Océanographique de Bedford pendant la dernière semaine de février. La séance thématique portera sur la croissance et la reproduction de façon générale et tout particulièrement sur les influences environnementales éventuelles.

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1. Introduction

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans (DFO) met in Moncton, New Brunswick, at the Gulf Fisheries Centre on 25-27 Febraury, 1997, to (1) review the environmental conditions in the Northwest Atlantic during 1996, (2) examine linkages between environmental factors and invertebrate fisheries, (3) review other relevant papers on the environment or fisheries-environment linkages and (4) discuss the zonal monitoring proposal. This report provides a summary of the working papers and discussions during the meeting plus the Committee's core-membership. The approved agenda, list of working papers and meeting participants appear in Appendices 1, 2 and 3, respectively.

2. FOC Core-Membership

While participation in the activities of the FOC are open to all, the Committee formally consists of a number of core-members whose responsibilities are to disseminate information in their respective laboratories and to provide a leadership role within the committee. Since our last meeting, we have had one change in committee membership. Patrick Ouellet from the Laurentian Region has replaced Jeff Runge who stepped down due to other commitments. At the time of 1997 annual meeting, the FOC core-members were:

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

3. 1996 Environmental Overviews

As part of the FOC mandate, the Committee provides an annual review of environmental conditions in the Northwest Atlantic. A total of 9 papers were reviewed. Two papers were

covered in the presentation by F. Page on the temperature and salinity conditions during the annual groundfish surveys of the Scotian Shelf and Bay of Fundy. Zooplankton conditions in the St. Lawrence Estuary during 1996 were presented by P. Ouellet on behalf of J. Runge. This year, each paper was assigned two reviewers to help improve the quality of the manuscripts by providing detailed comments, ensuring editorial correctness and possible suggestions for next year's overview papers. Reviewers delivered their comments to the senior authors before the end of the meeting or shortly thereafter.

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

Annual air temperatures over most of eastern Canada in 1996 rose above their long-term means, warming for the second year in succession and were well above the very cold conditions of the first half of the 1990s (Fig. 1). Winter temperature anomalies were above normal for the first time in over a decade. The warm winter air temperatures over the Labrador Sea were related to a

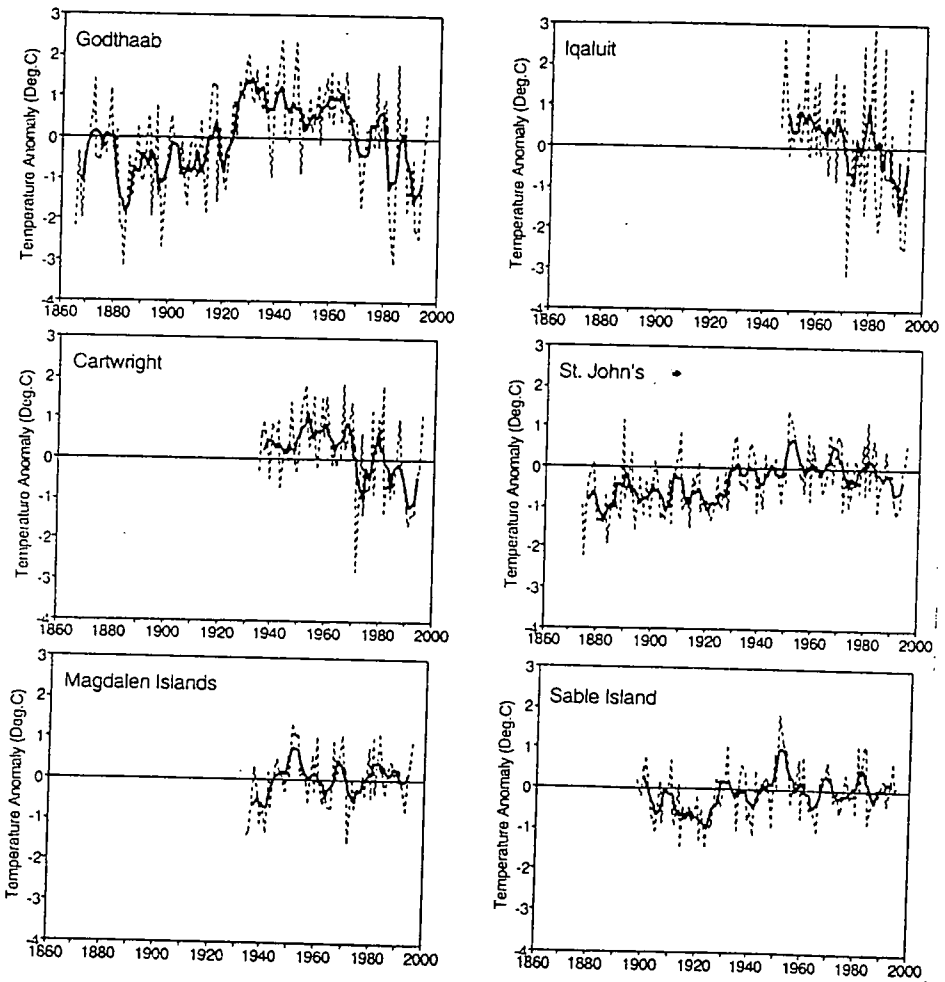

Fig. 1. Annual (dashed) and 5-yr running means (solid) of air temperature anomalies relative to 1961-1990 means at selected sites.

reduction in the strength of the northwest winds caused by an weakening of the large-scale atmospheric circulation. This resulted in a weakened Icelandic Low and a reduction in the North Atlantic Oscillation (NAO) index (Fig. 2). The decrease in the NAO index was the largest annual decline in the over 100 yr record. The relatively warm air temperatures and weak northwest winds in winter led to ice forming late, a smaller areal extent than normal and a shorter duration of sea ice off Newfoundland (Fig. 3). In addition, the numbers of icebergs reaching the Grand Banks fell by more than a factor of 2 from the high values recorded in 1995 and 1994. The areal extent of sea ice in the Gulf of St. Lawrence was near normal but on the Scotian Shelf it was well below normal and the lowest areal coverage in over a decade.

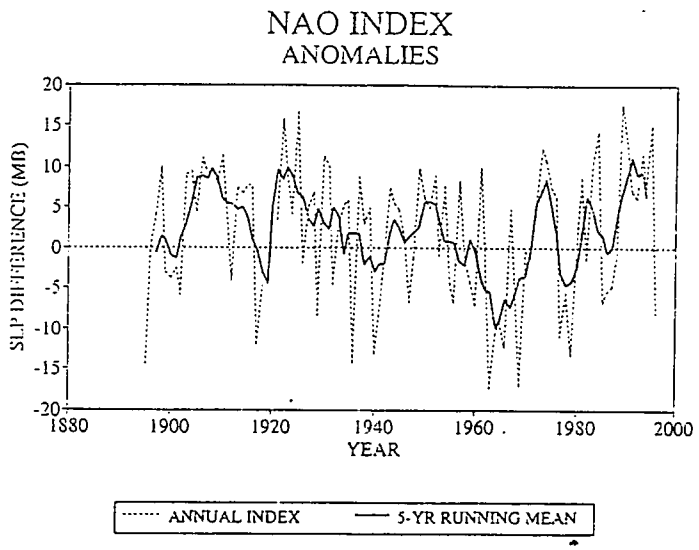

Fig. 2. Annual (dashed) and 5-y running means (solid) of anomalies of the North Atlantic Oscillation (NAO) index.

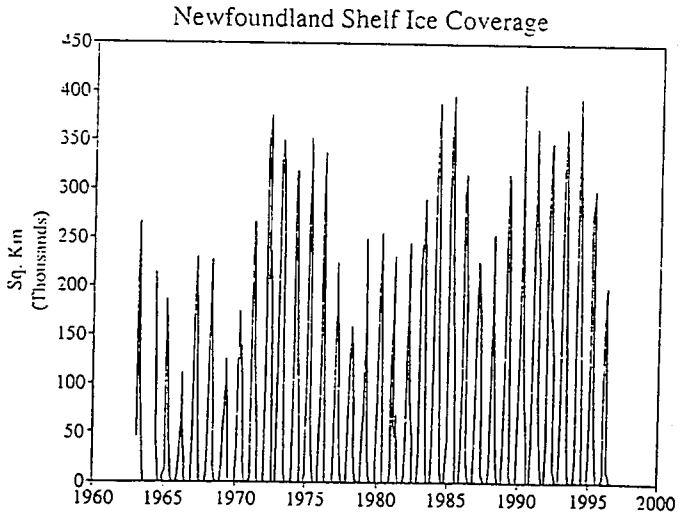

Fig. 3. The time series of the monthly mean area of sea ice off southern Labrador and northern Newfoundland between 45°N and 55°N.

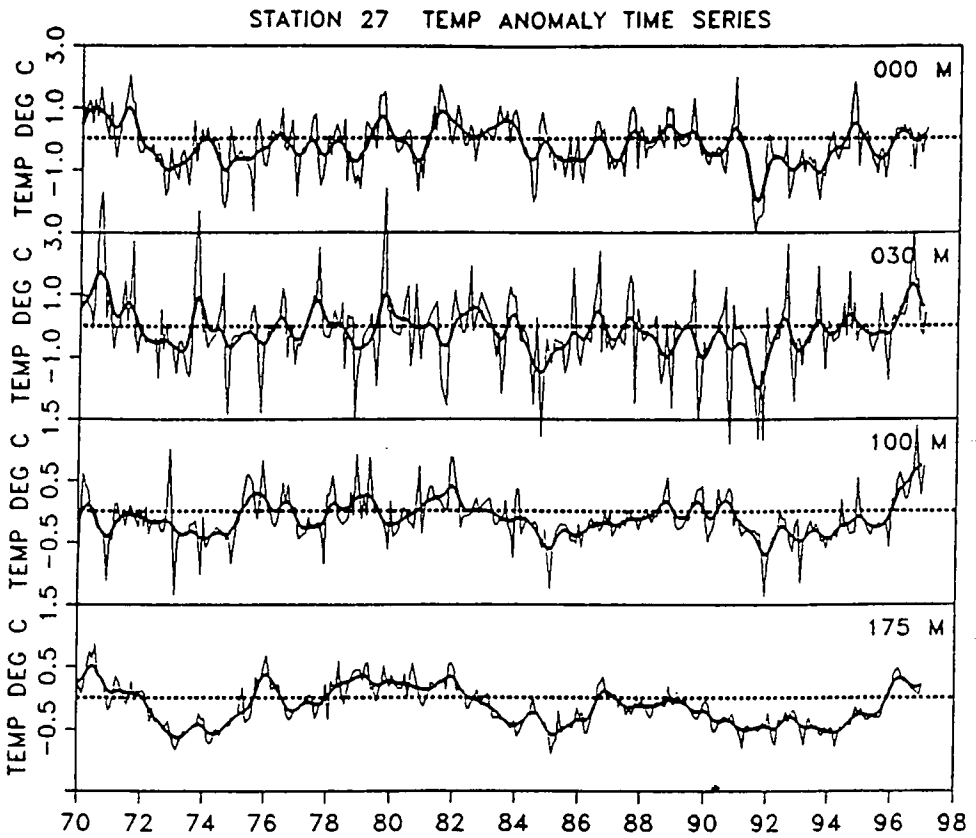

Fig. 4. Low-passed filtered temperature anomalies at Stn. 27 at standard depths.

3.2 Physical Oceanographic Conditions

3.2.1 Newfoundland/Southern Labrador (E. Colbourne)

Water temperatures off Newfoundland and southern Labrador warmed significantly during 1996, especially relative to the cold conditions of the early 1990s. For example, temperatures at Station 27 off St. John's were near or above normal at all depths throughout most of the year (Fig. 4). Subsurface temperatures were typically the warmest observed since the early 1980s. Salinities freshened and were below normal. Moderating temperature conditions were also evident from the smaller amount of cold intermediate layer (CIL) water (Fig. 5) over the shelves and the rise in bottom temperatures recorded during the groundfish surveys. The latter were near normal or slightly above normal. While temperatures at depths below 50 m off southern Newfoundland in the vicinity of St. Pierre Bank remained cold, they too showed evidence of moderation rising slightly during 1996.

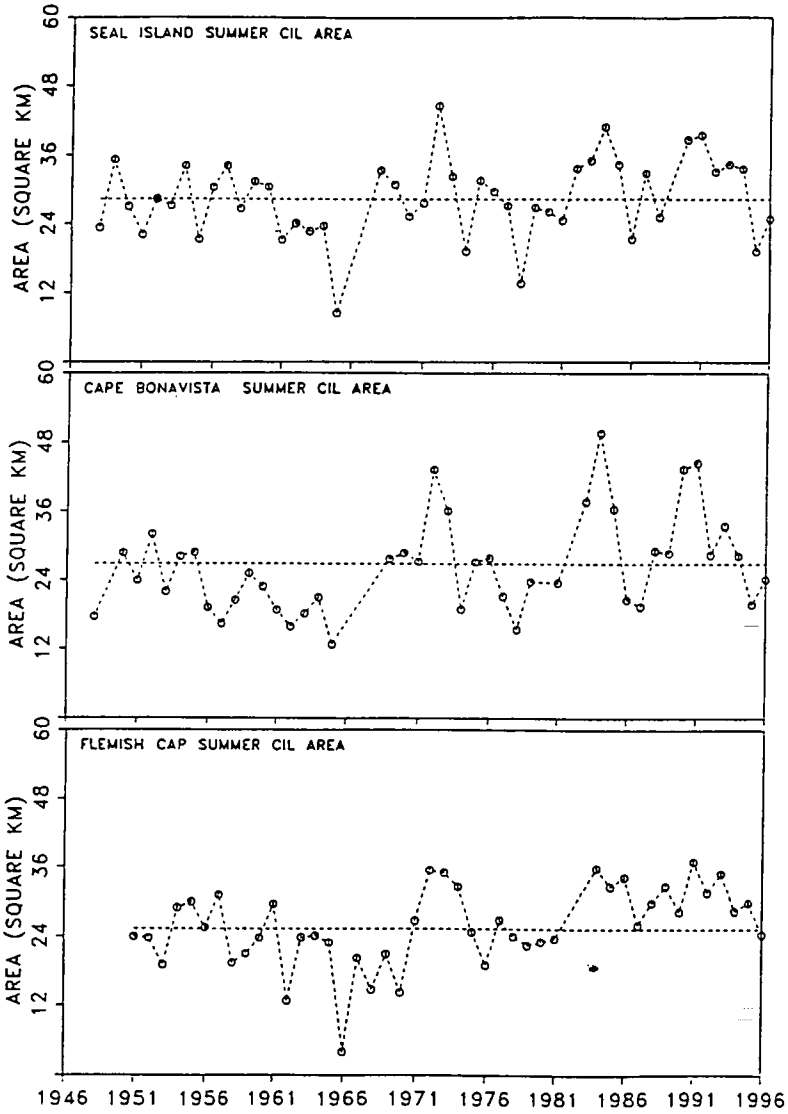

Fig. 5. The CIL area along selected transects. The horizontal dash line represents the 1961-1990 mean.

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

During 1996, colder-than-normal temperatures were observed for the 13th consecutive year in the CIL waters in the Gulf of St. Lawrence. However, similar to last year the minimum CIL temperature during mid-summer rose slightly relative to the very cold conditions of the earlier 1990s (Fig. 6). The thickness of the CIL throughout the Gulf, as defined by waters <0°C, decreased by approximately 10 to 20 m compared to 1995 but no decrease was observed for waters <3 °C. Large areas of the Magdalen Shallows continue to be covered by cold bottom waters during the September annual groundfish surveys although the area covered by temperatures of <0°C and <1°C did decline slightly (Fig. 7). Deep water temperatures (200-300 m) remained near normal, both at Cabot Strait (Fig. 8) and throughout the Gulf.

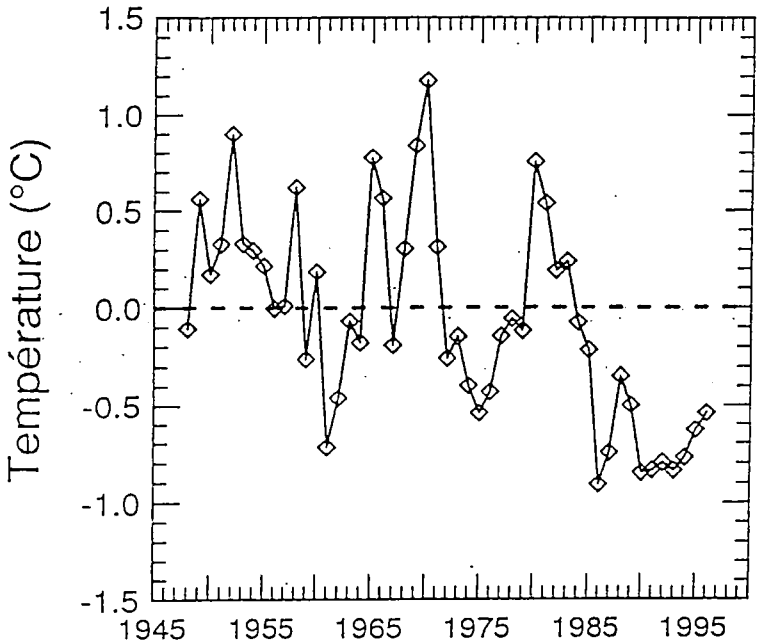

Fig. 6. Mid-summer composite index of CIL core temperature in the Gulf of St. Lawrence.

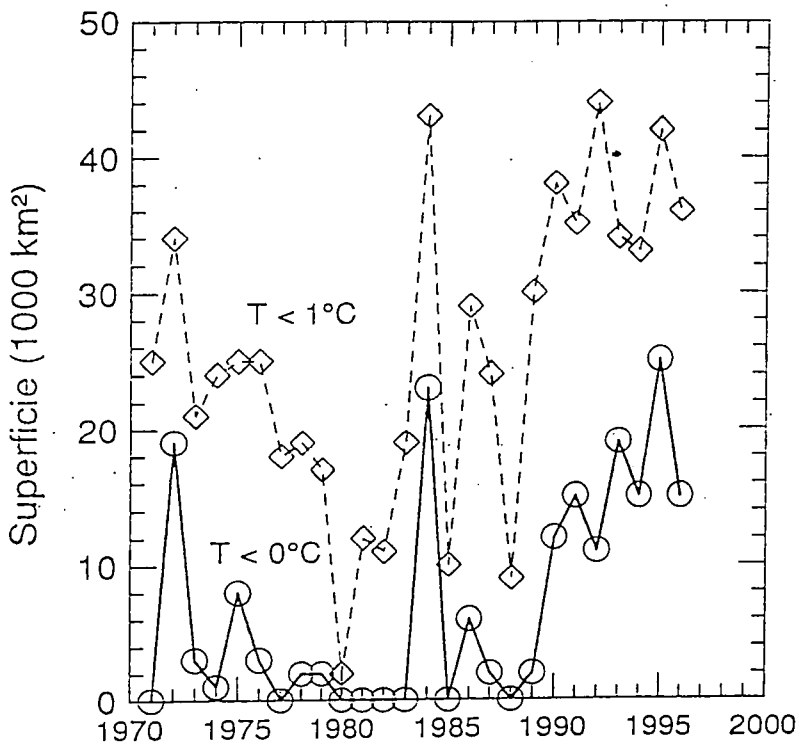

Fig. 7. Area of the Magdalen Shallows with bottom temperatures below 0° and 1°C in September.

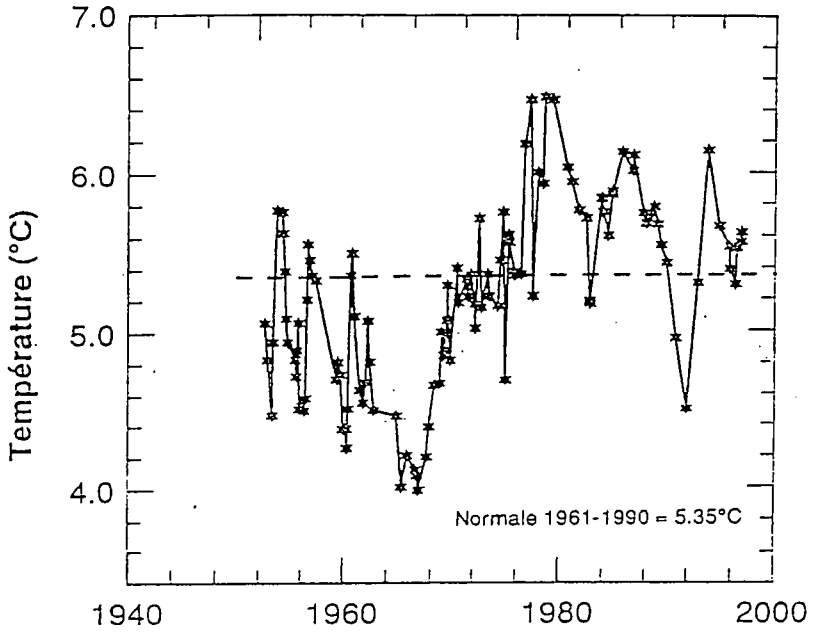

Fig. 8. Average temperature of 200-300 depth layer in Cabot Strait.

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

Subsurface waters (below 50 m) on the northeastern Scotian Shelf remained cold, continuing a trend that has persisted since the mid-1980s (Fig. 9). Colder-than-normal water was also observed over much of the remainder of the Scotian Shelf as observed during the July groundfish survey (Fig. 10). The only notable exception lay in the vicinity of Emerald Basin where warm slope water continued to keep near-bottom temperatures higher than average (Fig. 10, 11). The waters in the central Gulf of Maine also appeared to be warmer-than-average during the survey. For the second consecutive year, sea surface temperatures at Boothbay Harbor and St. Andrews were generally above normal whereas at Halifax they tended to be below normal.

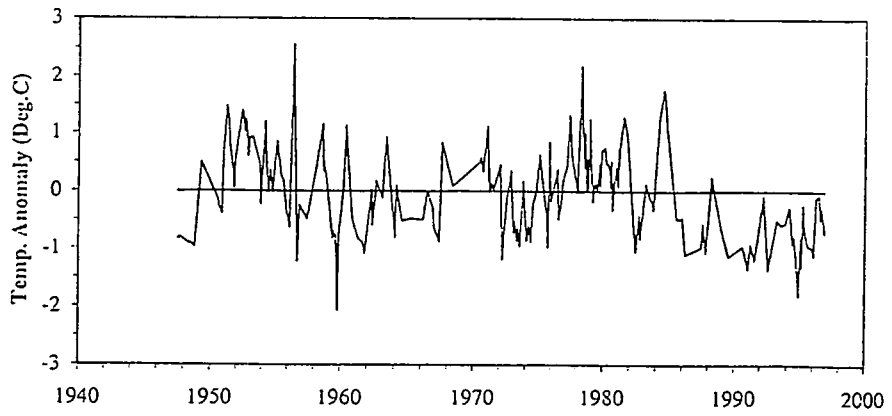

Fig. 9. Temperature anomalies (relative to 1961-90 mean) at 100 m on Misaine Bank.

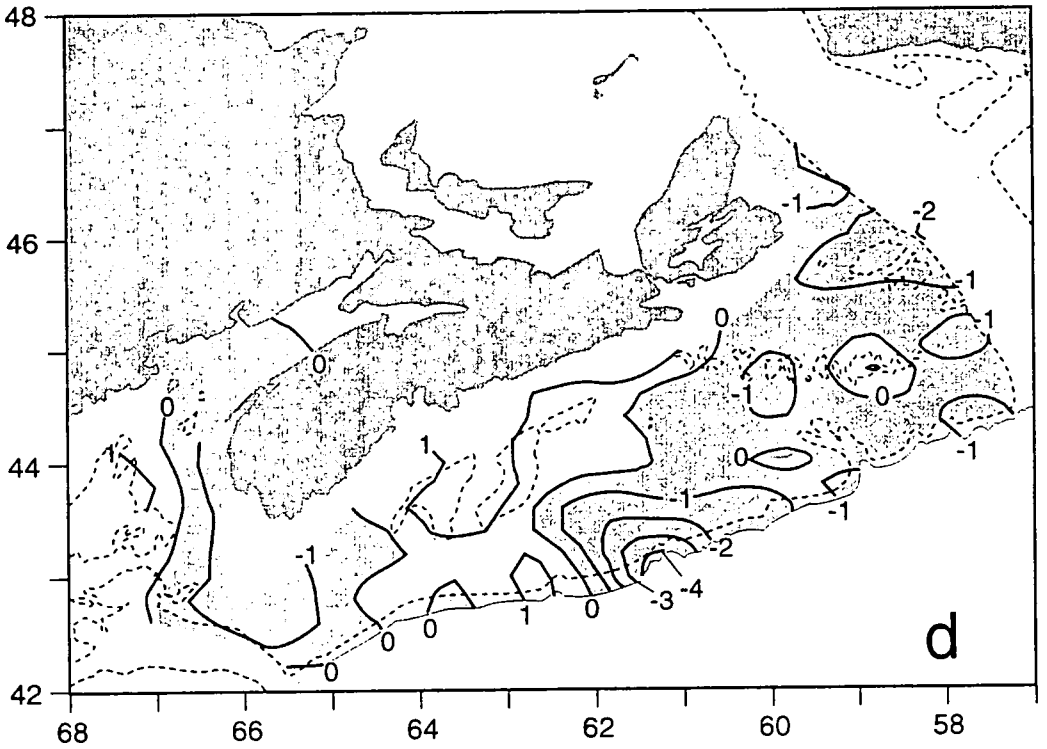

Fig. 9. Near bottom temperature anomalies (relative to 1961-90 mean) during the July groundfish survey. Negative anomalies are shaded.

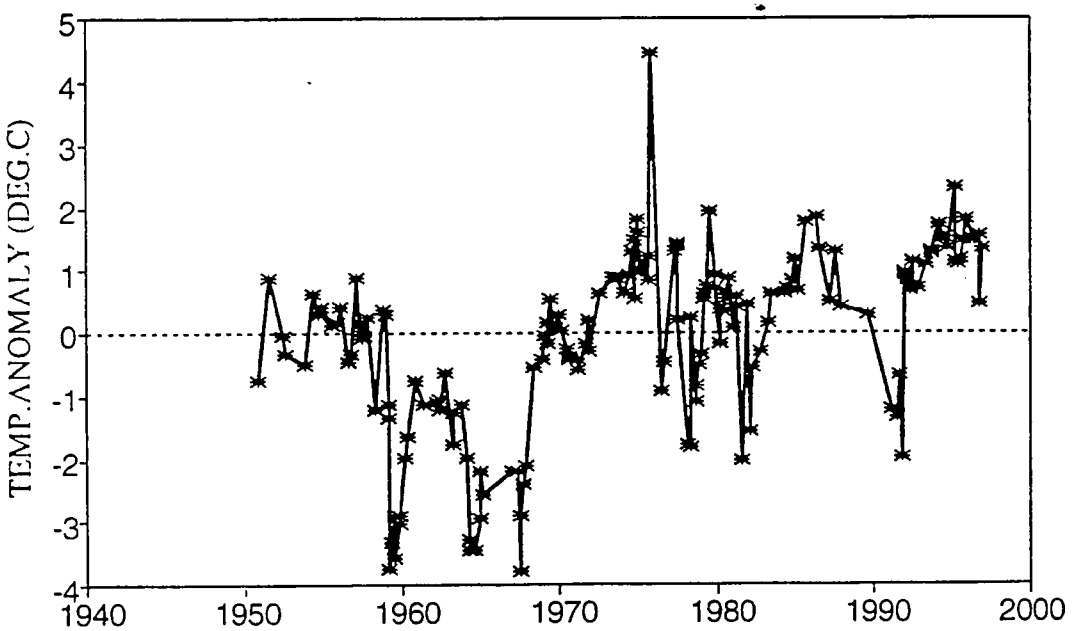

Fig. 10. Temperature anomalies (relative to 1961-90 mean) at 250 m in Emerald Basin.

3.3 Biological Oceanographic Conditions

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

Plankton and nekton distribution and abundance were described based upon a 1996 late summer pelagic fish survey covering an area from southern Labrador to the Tail of the Banks. Results were compared to 1994 and 1995 surveys. Surface and 50 m temperatures increased southward as is typical for this time of the year. Surface temperatures were higher than those encountered during the 1995 survey but were lower than in 1994. At 50 m temperatures in 1995 and 1996 were higher than 1994. The mean total plankton biomass catch in the bongo nets was significantly higher in 1996 and 1995 than in 1994. The lowest mean wet nekton biomass, including or excluding jellyfish, occurred in 1996. Mean catches of pelagic 0-group Arctic cod (which made up 72% of the total abundance) and +1 capelin (8% of the total) remained low during 1996 relative to 1994 levels. Larval and juvenile Atlantic cod abundance decreased significantly in 1996 for the second year in a row. Squid catches were also down (3% of total abundance). Sculpins, seasnails and white hake were caught in significantly greater numbers in 1996 then in the previous 2 years but these account for less than 5% of the total abundance.

3.3.2 Gulf of St. Lawrence (J. Runge, presented by P. Ouellet)

Since 1994, an annual zooplankton survey has been conducted in September in order to estimate biomass for an exploratory fishery for *Calanus* species and euphausiids in the Lower St. Lawrence Estuary. The biomass of Calanus and total plankton generally increase with depth. Krill biomass is lower than *Calanus* and not dependent upon depth. Zooplankton biomass in 1995 and 1996 was significantly lower than in 1994. Krill biomass was lower by a factor of 10 in 1996 compared to 1994, total plankton biomass was down by a factor of 2, and *Calanus* biomass down by a factor of 3. At present no explanation for these fluctuations is available. Another survey is planned for 1997 but none thereafter.

3.3.3. Scotian Shelf (D. Sameoto et al.)

Plankton data collected on the Scotian Shelf with the Continuous Plankton Recorder (CPR; 1961-75, 1991-94) as well as vertical net tows and high-frequency acoustics along the Halifax and Louisbourg transects (1984-96) were discussed. On the western half of the Scotian Shelf, the CPR phytoplankton (colour) index was relatively high from summer to autumn with no spring peak during cold years (1961-68), in contrast to a strong spring peak during warm years (1969-74). On the eastern Scotian Shelf, spring blooms dominated even in cold years. Since 1991, both regions have had the traditional strong spring peak and a weaker autumn bloom. The abundance of stage 5 and 6 *Calanus finmarchicus* appeared higher in the warm period in both regions. CPR data together with net tows and acoustics all indicate that the lowest levels of meso- and macro-zooplankton typically occur on the eastern Scotian Shelf. In Emerald Basin where the longest time series of net tows and acoustics are available, *C. finmarchicus* levels have been relatively stable since the high levels in 1985 and 1986. Abundance levels in 1996 were, however, the lowest on record. On the other hand, euphausiid and fish larvae abundance showed a sharp increase in 1996

from the low levels in 1995 to the high population levels prior to 1995. Cause of these population fluctuations are unknown.

3.4 General Discussion

Doug Sameoto noted during his presentation that the CPR data for 1995 were not made available to DFO because the bill was not paid. He did say that Ottawa had acted to rectify the situation and he hoped to have the data in hand shortly. These data are collected by the Hardy Foundation in England and become available approximate 1 year later. The delay is required for processing and quality control. *The FOC strongly recommends that payment for the CPR lines be on time so that the data are available for analysis and presentation at the FOC annual meeting.*

Ken Drinkwater remarked on the lack of measured or geostrophic wind estimates in the meteorological overview paper for which he has been responsible. He informed the committee that he will attempt to assemble wind information for next year's review. *The FOC therefore recommended that additional wind indices be incorporated into the meteorological overview papers beginning next year.*

A general discussion was held on the overviews. It was generally felt that many of the oral presentations were too long and resulted in little time for discussion. It was also felt that because of the relatively large number of overview papers, it was sometimes difficult to obtain an overall impression of environmental conditions in the previous year. It was suggested that perhaps a "scorecard" containing the most important variables be used next year and filled in after each presentation to help the audience. Having the Stock Status Reports (SSRs) on the State of the Ocean for each region as well as the overall summary for the NW Atlantic available for review by the FOC would help to summarize conditions. While the SSRs had been requested for this year's meeting, only that for the Laurentian Region (D. Gilbert) was available. *The FOC recommended that at the annual meeting (1) the overview presentations be shortened, concentrating only upon the highlights, in order to provide additional time for discussion on their implications to fisheries issues and (2) the environmental SSRs be available for review.*

In a related issue, Fred Page felt that his overview of the temperature during the Scotian Shelf and Georges Bank groundfish surveys should be incorporated within the broader based environmental review and not presented as a separate paper. The FOC agreed but the Chairman will contact the Marine Fish Division in the Maritimes Region to ensure that they are in agreement.

For the past two years the Maritimes and Newfoundland Regions have been providing annual overviews of plankton from CPR data and plankton surveys. The FOC was pleased that this year, Laurentian Region provided an overview on plankton from surveys in the Lower St. Lawrence Estuary. The Chairman hoped that all 3 regions will continue to provide such annual reviews to the FOC and the assessment process.

[As in past years, a brief environmental summary was written following the meeting and sent together with the working papers to the Regional Assessment Process co-ordinators for each of the regions. A copy of that summary is provided in Appendix 4. A second summary was assembled and presented in early June to the North Atlantic Fisheries Organization (NAFO) Standing Committee on Fisheries and the Environment (STACFIN) as a research document (*Overview of environmental conditions in the Northwest Atlantic in 1996,* co-authored by Drinkwater, Colbourne and Gilbert, NAFO Res. Doc. 97/63).]

4. General Environmental Session

Each year the FOC receives several papers on topics unrelated to the major theme session. This year the committee reviewed 4 papers in this category and had two additional presentations.

F. Page (no working paper) informed the committee of temperature data collected during redfish surveys in 1995 and in 1996. The data were collected with minilogs attached to the trawls and are available in the Ocean Sciences Division database. Frequency plots of the temperature and depths during the survey were presented.

G. Harrison reported on progress made in developing plankton indices. At the 1996 FOC meeting he had proposed a suite of indices that may be useful in fisheries assessment During this last year he and his colleagues have been analyzing CPR data by region (southwestern Grand Banks covering St. Pierre Bank; northeastern Scotian Shelf; southwestern Scotian Shelf; and Gulf of Maine/Georges Bank). They compared patterns during the cold period on the Scotian Shelf (1961-68) with those observed in the warm period (1969-74) and recent times (1991-94). Seasonal variations in CPR colour during the cold and warm periods were similar to, or slightly lower than, the long-term mean while in the 1990s there were consistently higher than the mean. Noteworthy were the absence of a spring bloom on the southwestern Scotian Shelf during the cold period and the presence of a winter peak on Georges Bank in the 1990s. During the warm 1970s autumn diatom abundance was lower than normal in all regions. The spring/early summer dominance of diatoms and late summer/fall dominance of dinoflagellates is evident in all regions except on Georges Bank in the 1990s when diatoms dominated in all seasons. Qualitatively, the cold period and the 1990s appear similar. They differ from the warm period in the degree and persistence of autumn dominance by dinoflagellates. The latter was greater during the warm period. Further studies involving statistical analyses are planned.

E. Dalley described the dominant plankton and nekton in late summer 1994 and 1995 during pre-recruit surveys covering an area from southern Labrador to the Tail of the Banks. The highest biomass of plankton and nekton was consistently over the Northeast Newfoundland Shelf and contrasted with the low pelagic biomass over the Grand Banks. The dominant zooplankton species was *Calanus finmarchicus* while the fish biomass caught in both bongo nets and the IGYPT trawl were primarily capelin and Arctic cod, and to a lesser extent squid. Capelin larvae were most

abundant inshore which is consistent with their inshore spawning. Arctic cod were most abundant over the NE Newfoundland Shelf and inshore in 1994 and off southern Labrador in 1995. They were absent on the Grand Bank in both years, perhaps due to temperatures being too high. Juvenile squid (believed to be an Arctic species) were abundant over the NE Newfoundland Shelf in 1995. In 1994, Atlantic cod distribution suggested three spawning areas (offshore of Hamilton Bank, inshore Newfoundland and on the southern Grand Bank) but abundance was low. In 1995, spawning only occurred in the inshore regions and abundance remained very low. Few fish larvae and juveniles were observed on the southern Grand Banks. This was unexpected as it has traditionally been a spawning area for several groundfish species. The 1994 and 1995 surveys suggest the inshore areas were the primary spawning grounds in the late summer.

E. Head (no working paper) discussed the ecology of *Calanus* spp. from measurements on the Scotian Shelf (April 1995; May-June 1996) and the Labrador Sea (summer 1995; spring and autumn 1996). The life histories of the three main *Calanus* species (*C. finmarchicus, C. glacialis and C. hyperboreus*) in the Labrador Sea were described. *C. finmarchicus* overwinter in deep water in the Labrador Sea and their geographic distribution in springtime reflects the overwintering location. Survival of the earliest stages of *Calanus* appears to require low numbers of predators and sufficient quantities of food. These requirements are best satisfied on the shelves in spring and in the deep water later in the year. On the Scotian Shelf in spring, the coldest water species, *C. hyperboreus*, and to a lesser extent *C. glacialis* are more abundant on the Louisbourg Line than along the Halifax Line. They only occur inshore of Emerald Basin on the Halifax Line, consistent with a Gulf of St. Lawrence origin and advection along the Scotian Shelf by the Nova Scotia Current. At this time of the year, *C. finmarchicus* are primarily found at the shelf break. This questions the hypothesis that the source of the copepods on Emerald Bank is from Emerald Basin. Further studies on the ecology of *Calanus* in the Labrador Sea and on the Scotian Shelf are underway.

D. Swain compared temperature distributions of cod and plaice between their summer feeding and overwintering periods. Data were obtained during 1993-95 from groundfish surveys in September on the Magdalen Shallows and in January in the Cabot Strait region. Temperature distributions differed markedly between September and January for both cod and plaice, with both species occupying warmer water in winter. Young cod occupied relatively warmer waters in summer and cooler water in winter than older cod. The difference in summer may reflect a trade off between greater food supply in warmer water versus lower metabolic cost in cooler waters. The tendency for older cod to occupy warmer water in winter is consistent with promotion of gonad maturation. Female plaice tend to occupy warmer water than males in September but not in January. This is consistent with higher growth rates in females.

D. Swain also discussed changes in the distribution of cod in the southern Gulf of St. Lawrence in an attempt to determine if they were a result of environmental change or due to density dependent shifts in environmental preference. An index of distribution was developed based upon the proportion of cod occupying the central Magdalen Shallows during the September groundfish

surveys (1971 to present). Similarly, a temperature index was obtained from the mean bottom temperature during the cruises. Cod abundance was obtained from recent stock assessments. Results were age dependent. Both temperature and density dependence appeared to contribute to the distributional changes of age 3 cod. The distribution of cod ages 4-6 were mainly responding to density dependent effects whereas ages 7 and 8+ did not appear to respond to either factor. This presentation emphasized the importance of analyzing alternate explanatory factors simultaneously and of using models that accommodate autocorrelation in the dependent factors. For example, simple correlations between the indices of cod distribution and temperature supported the hypothesis that changes in the distribution of cod aged 4-6 yr reflected a response to environmental change. However, this "environmental change" hypothesis was not supported for these ages of cod when models also included indices of cod abundance or accomodated autocorrelation in the cod distribution.

5. Special Presentation on the Zonal Monitoring Proposal

5.1 The proposal

Jean-Claude Therriault, Chairman of the Ocean Monitoring Working Group (OMWG), presented an overview of the Proposal for an East Coast Zonal Monitoring Program to the FOC. The working group was requested to put together a zonal monitoring program by Ottawa and the proposal will be considered for possible funding in the near future. The proposal adopts an ecosystem approach using different sampling strategies in an attempt to resolve spatial and temporal variability of physical, chemical and biological variables at seasonal, interannual, decadal and climatic time scales. The sampling strategy includes (1) representative sections across the shelves and in the Gulf of St. Lawrence that would be occupied once a year quasi-simultaneously during the autumn and in other seasons on an opportunistic basis, (2) a number of fixed stations at logistically accessible locations throughout the region that would be occupied at least once a month in winter and twice a month at other times, (3) monthly CPR sampling along the present existing route (crossing the Grand Bank, St. Pierre Bank, the Scotian Shelf and Georges Bank) and possibly a new one in the Gulf of St. Lawrence, (4) remote sensing of temperature (immediately) and phytoplankton (in the future through ocean colour), and (5) supplementary data from existing programs such as the LTTM (long-term temperature monitoring), the toxic algae program, and fisheries surveys, which provide temperature, salinity and other types of data. The OMWG assumes that these later sampling efforts will continue to be funded regionally. At the sections and standard fixed stations, a suite of physical, chemical and biological (phytoplankton, zooplankton) measurements would be undertaken. The proposal also included a data management system that would provide access to the data, the integration and the development of databases (in particular a new biological database), the formation of a data analysis group that would produce and develop data products to respond to client's needs, and the formation of a zonal management group that would ensure coordination of all monitoring related activities within the Atlantic zone.

5.2 Questions and Comments (not in order of importance)

Although no break down of the financial costs were provided, concern was expressed by the FOC that the costs of the present proposal would be high. Jean Claude Therriault (JCT) answered that he did not include the costing of the proposal because he wanted to restrict the discussion to the scientific basis behind the proposal. He noted that the OMWG had cut their initial proposal costs by approximately one-half and expressed the opinion that the present program was not expensive given that it was spread over three regions. It presently sits at about $155 K/yr per region, including cost of maintaining the two present CPR lines ($100 K/yr).

The FOC felt that in future, groups other than DFO will likely be involved in monitoring, either in collecting data directly or providing platforms from which data could be collected. It was suggested that fishermen and the fishing industry, the FRCC, the Coast Guard, offshore oil, gas and mineral industries, and universities should have input to the present proposal. Also long-term stations could be developed at sites such as Hibernia, Sable and the PEI Link and consideration should be given to data collection from ferries and commercial ships-of-opportunity. More attention should be given on how to bring data from different sources together.

A question arose on whether the OMWG considered there was still a need to collect temperature, salinity data during the fisheries survey. It was noted that much of the data during the past decade or so have been from the fisheries surveys. JCT noted that the OMWG believes that the continued collection of these data, and perhaps other types of data, during the fisheries surveys will be an important part of monitoring. However, the OMWG felt that they should remain a regional responsibility.

The FOC noted that a clear delineation of what was part of the zonal program and what would remain at the discretion of the regions was not provided. It was suggested that a brief section be included in the proposal stating present programs that would be maintained, followed by a list of new activities and what gap in our knowledge they will fill. JCT stated that such a break-down was available through examining the cost estimates but unfortunately these were not provided to the FOC.

Several FOC members noted that while they generally supported the aims and objectives of the monitoring proposal, especially in strengthening the chemical and biological components over what is presently being done, they had concerns that the present written version of the proposal was being oversold on fisheries issues. They noted that the present proposal, if implemented, will unlikely result in significant input to the assessment process over the next few years. It was felt that the proposal should acknowledge this. The FOC recognizes and hopes that the expanded monitoring program will lead to the establishment of new linkages between fisheries and the environment that can be used in future assessments. Also, some FOC members noted that at the beginning of the recent cod crisis in Newfoundland, one of the questions asked was whether

there were any significant changes in plankton that could help explain the decline in the cod stock. At that time, the scientific community were unable to answer the question because the data were not being collected. The present proposal would go a long way to being able to answer such questions in the future.

A good deal of discussion occurred on the priority of sections versus fixed stations. JCT mentioned that the OMWG could not decide on the priority to give to sections versus the fixed stations, since both were felt to be of equal importance but for different reasons. Also, in response to a question of ranking the importance of the individual transects, the FOC was informed that the OMWG felt all transects were essential. JCT noted that removing a couple of sections would not produce significant savings with perhaps an important loss of information. Many of the biologists within the FOC expressed the opinion that they would prefer to see higher priority placed on the stations and were not convinced of the usefulness of the large scale transects. It was pointed out both by other members of the FOC and JCT that the transects are particularly useful for the physicists, in that they would allow estimates of geostrophic transports and the data could be used as input to numerical circulation models. Previous studies have shown that interannual variability in transport can be detected from annual occupation of certain standard sections. The transects were also felt to be extremely useful for the collection of broad-scale chemical data.

Extensive debate ensued about the usefulness of one series of transects per year for resolving fisheries issues. The FOC noted that primary and secondary production are probably most important to fish larvae and associated recruitment questions. If so, autumn surveys would not be as useful as a spring survey which would coincide more closely with most spawning. JCT pointed out that the timing of the transects was the subject of much debate within the OMWG meetings. Autumn was chosen as it was considered to be the most stable period of time (allowing more accurate comparison between years) and also for logistic reasons related to the ship planning. On the other hand, it was felt the timing of important spring events may vary by almost one month within a region and by as much as two months between regions. Some OMWG members had felt that information on the state of the zooplankton in the autumn would provide an index of what would be available in the spring, although this remains to be proven. This was debated within the FOC with views expressed both for and against such a hypothesis. OMWG members acknowledged that temporal variability is not resolved by the autumn transects but felt that sufficient knowledge of the low frequency (seasonal/interannual) variability would be obtained from the fixed station data.

The FOC noted that the location of all of the fixed stations were near shore but that many of our clients needs are for offshore data. Also, seasonal and interannual variability will be addressed but not higher frequency fluctuations. JCT noted that the OMWG discussed monitoring at higher frequencies than seasonal. A thorough analysis of the physical oceanographic data showed that the sampling needed to properly resolve higher frequency fluctuations was prohibitive from a financial and personnel perspective. Thus, their attention was directed towards seasonal and

lower frequency sampling. It was suggested that if higher frequency sampling was indeed needed for a specific fisheries purpose then this would have to be undertaken by fisheries scientists themselves or in collaboration with ocean sciences personnel in the context of a specific research project. As to location of the fixed stations near shore, existing stations such as Station 27 off St. John's, Newfoundland and Prince 5 off St. Andrew's, show high coherence over large areas of the Shelf indicating that these near shore sites are representative of events over the wider shelf regions, at least from the physical perspective.

This led to the question of the representativeness of the biological data collections to be obtained at the fixed stations. It was generally felt by the FOC and the OMWG that we do not know how spatially or temporally representative the biological data from the fixed stations or the transects will be. The spatial representativeness of the CPR data is also unknown. Both the FOC and the OMWG support further analyses to determine how representative these data sets may be. For example, previous biological collections such as from the SSIP program and along the Halifax and Louisbourg Lines need to be explored further together with the CPR data to determine the spatial scale of biological events. The FOC noted that the usefulness of the biological data collected under the monitoring program will increase with the length of the datasets, as has clearly been shown for the northeastern Atlantic. It is very important to recognize that the spatial representativeness of stations will depend upon the period, i.e. longer (decadal) variability tends to show coherence over larger areas than shorter term (year-to-year) variability.

Questions arose as to why 5 fixed stations were chosen in the Gulf but only 3 outside to cover a much larger region. JCT noted DFO scientists will monitor on a regular basis only 2 of the 5 stations in the Gulf and all 3 stations outside. The remaining 3 stations in the Gulf will be monitored by trained fisherman under contract. These sites were considered to be representative of important regions (northeastern and southern Gulf) where there is insufficient information and to which access by DFO is difficult. Not as much data would be collected at these sites as at the DFO monitored sites. Other stations visited by fishermen could be added but the cost of the proposal would increase.

Given the potential problem with funding and the removal of precious PY resources away from the regions to carry out the monitoring program, is it required that we identify zooplankton to the species level? JCT responded that the proposed level of identification of the zooplankton and phytoplankton samples would not put a significant drain on the resources while providing potentially important information on the changes in community structure. Some members mentioned the possibility of using the newest video technology to identify species rapidly. It was noted, however, that this technology is not proven and groups presently owning such systems have not been able to obtain satisfactory results.

It was suggested that offshore sampling using existing buoy technology, including conventional current meter moorings, yo-yo sensors, and telemetering data onshore be considered. JCT

mentioned that these options had been carefully examined by the OMWG and rejected because of the prohibitive costs and the general lack of biological data collected by such technology.

It was noted that the statistics on the source of client requests that are presented in the present proposal are biased towards the offshore because of the particular scientists upon which the statistics were based. It was noted that at St. Andrew's the vast majority of requests are associated with the inshore. If such statistics are to be provided in the proposal, they should better reflect a wider cross section of the oceanographic community.
The FOC felt that rapid processing and editing of the monitoring data, including production of standard products, was essential. JCT agreed and felt that this was achievable with the proposed data analysis group.

The OMWG members stated they would be willing to adjust their proposal to incorporate environmental data that could be shown to be of importance to fisheries interests but were not presently being collected, provided this can be addressed reasonably on a zonal basis.

There was also discussion on the data management aspects of the proposal. It was felt that better access to data was needed. JCT answered that the monitoring proposal will develop a biological database that would not only include data collected as part of the monitoring program but also contain data collected in the past. Regarding the latter, the proposal includes retrieval of historical biological data. This was felt to be especially important as many scientists are retiring or leaving DFO and we need to ensure that their data are archived. As part of the proposal, new money is being requested to support development of a biological database. Adequate databases already exist for physical and chemical data.

Questions arose as to what particular problem was being addressed by the monitoring program or what hypothesis was being tested. JCT noted that the objective of the monitoring program was to be able to detect and describe changes in the environment. Monitoring programs such as Station 27 have been used to test numerous hypothesis not envisaged by the originators of that program.

Some FOC members hoped that the present monitoring program will be able to go beyond looking at temperature as a cause of changes in the fisheries and look at ecosystem changes. JCT stated that with the proposed program DFO should be in a good position to do just that.

It was suggested by FOC members that the monitoring program may provide an early warning system for problems in the fisheries. This is one way in which the monitoring program could be sold.

The importance of the nearshore zone is recognized by the FOC and is of special interest to certain segments of the fishing industry. Any monitoring program should include coverage of this zone at some basic level. JCT mentioned that the OMWG recognized the importance of the

nearshore and present monitoring programs in this zone such as the Long-Term Temperature Monitoring (LTTM) and toxic algae. The OMWG considers continuation of these programs to be a regional responsibility. Wider and easier access to these data would be ensured through the proposed data management system.

5.3 Summary

Following the above discussions, the FOC listed those items that they felt the Proposal offers that are not presently available. They included:

1. a minimal and long-term commitment to monitoring by DFO that would not be under constant financial pressure;

2. development of a monitoring program of primary and secondary biomass and trophic structure that would include data collection at standard fixed stations, at least one quasi-synoptic view over the entire Atlantic region each autumn, and maintenance of the CPR lines (with potential expansion to the Gulf of St. Lawrence);

3. development of a monitoring program for chemistry that would include nutrients and O_2 at fixed stations and along transects in the autumn;

4. expansion of the monitoring of physical oceanography through better temporal coverage over a wider area from the fixed stations while the transects will provide estimates of geostrophic transports and data for assimilation into shelf models (in the future);

5. an Atlantic zone data management system including better access to monitoring data, development of a biological database and integration of physical, chemical and biological databases; and

6. better zonal coordination of monitoring activities on the Atlantic coast.

The FOC felt that adoption of the proposal would lead to the development of a more ecosystem based approach to monitoring which the Committee encourages. On the basis of the above items, the FOC generally supported the Proposal for an East Coast Zonal Monitoring Program although certain reservations were expressed. The FOC particularly noted that the spatial representativeness of the biological data, whether from the CPR line or the proposed fixed stations or transects, needs to be resolved.

6. 1997 Theme Session: Environmental Effects on Invertebrate Populations

6.1 Introduction

Given the importance of invertebrate stocks in eastern Canada, especially in terms of their economic value (in 1995 invertebrates accounted for over 85% of the total landed value in Atlantic Canada), the 1997 theme session focused upon Environmental Effects on Invertebrate Populations. The FOC also hoped that this might encourage more invertebrate biologists to examine environmental issues related to their stocks and to become involved in the committee. Papers were requested on the following.

* Influence of the physical environment, as well as the primary, secondary and benthic production levels on the large-scale distribution and structure of invertebrate populations.
* Growth, reproduction and recruitment of invertebrate stocks and possible linkages to the environment.
* What is the cause of the recent high lobster landings? Exploration of hypotheses dealing with the physical environment, food availability and predation are sought.
* Effect of temperature variability on the catchability of lobster and crab.
* The relationship between variability in finfish and invertebrate stocks. For example, have invertebrates replaced reduced groundfish abundance on the Newfoundland shelves?
* Importance of circulation patterns on larval drift and the role of larval behaviour.

A total of 18 presentations were reviewed, 15 of which were accompanied by working papers.

6.2 Presentations

6.2.1 Krill

D. Sameoto presented an overview of the krill on the Scotian Shelf. It has received recent attention because of a proposal for an experimental fishery targeting *Meganyctiphanes norvegica*. This species matures at age 1, breeding in late June-early July. They normally live to age 2 with some reaching age 3. On the Scotian Shelf and in the Gulf of Maine they are primarily concentrated in the deep basins and channels, such as Emerald and Georges Basins, as well as along the outer edge of the Scotian Shelf and in the Laurentian Channel. The fishery is requesting approximately 1000 tons annually, primarily from Emerald and LaHave Basins during March through June. The requested biomass is considered insignificant (1%) compared to the total available biomass. Concern over the fishery is primarily for the amount and type of by-catch, especially fish larvae, that will occur in the fine mesh nets that are used in the fishery.

6.2.2 Shrimp (Pandalus borealis)

P. Koeller reported on a study of the effects of temperature and predator abundance on northern shrimp. Using 1977 to 1996 data from four areas (Gulf of Maine, Scotian Shelf, Gulf of

St. Lawrence and Newfoundland Shelf), significant negative correlations were found between shrimp catch per unit effort (CPUE) measured in kg/hr and cod abundance. Negative correlations were also significant for turbot in the Gulf of St. Lawrence and on the Newfoundland Shelf, as well as for redfish and American plaice in the Gulf of Maine. The only temperature index of several used that correlated with any of the shrimp abundance estimates was the mean temperature of the cold intermediate layer in the Gulf of St. Lawrence, although sea surface temperatures and shrimp catches were also negatively correlated in the Gulf of Maine when all available information was used (1955-1996). Information on seasonal temperature changes and shrimp distribution patterns indicate that shrimp on the Scotian Shelf do not undergo large scale inshore migrations in winter to seek cooler, shallower water as in the Gulf of Maine, but rather undergo more local migrations to avoid extreme cold water nearshore during spring. While predation appears to be the important determinant of shrimp abundance in all areas, temperature may play a synergistic or modifying role in the Gulf of St. Lawrence and the Gulf of Maine.

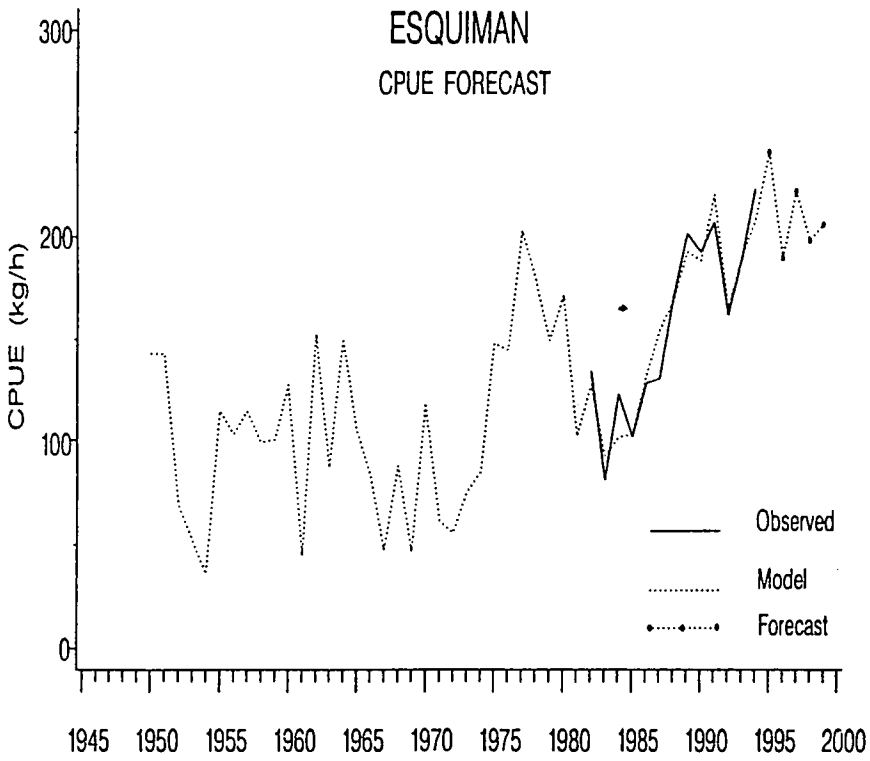

Fig. 12. The model and observed CPUE of shrimp in the Esquiman Channel.

J Plourde presented an environmentally-driven predictive model of the annual catch of shrimp CPUE in the Gulf of St. Lawrence. He first modelled nitrate levels prior to the onset of the spring bloom. Nitrate is assumed to be dependent upon the depth of the surface mixed layer in winter (estimated from temperature observations and assumed to be spatially uniform over the

Gulf) and the freshwater discharge (estimated from runoff from the St. Lawrence, Ottawa and Saguenay Rivers [RIVSUM] and considered to be spatially dependent). The available nitrates are further assumed to be the primary factor influencing the major component of the total annual primary production. Stepwise multiple regression analysis was undertaken to predict shrimp CPUE for the Esquiman Channel, Anticosti and the St. Lawrence Estuary separately from the depth of the mixed layer and RIVSUM lagged up to 5 years. High correlations were observed with all three shrimp stocks (Esquiman stock, r=0.92 depending primarily on the depth of the mixed layer lagged 3 y; Anticosti stock, r=0.96 depending mostly upon the depth of the mixed layer lagged 3 y and also the winter runoff lagged 4 y; and the Estuary stock, r=0.78 depending mostly upon the summer runoff lagged 3 y but also the depth of the mixed layer lagged 3 y). The 3 y lag suggests the effects occur during the shrimp's first year of life. Because the shrimp CPUE lags the environmental input data, the model can predict catches up to three years in advance. In the Esquiman Channel, continued high catches are predicted through to at least 1999 (Fig. 12).

6.2.3 Squid (Illex illecebrosus)

E. Dawe spoke on possible environmental effects on short-finned squid. Squid have a one year life cycle. They spawn throughout the year with a peak in winter. Their spawning grounds are located south of Cape Hatteras probably in or near the Gulf Stream. As they grow, they are transported northward by the Stream. In the spring, large juveniles are found in the vicinity of the front between the shelf waters and offshore slope waters. Squid catches from directed surveys in May-June on the southwest slope of the Grand Bank are generally associated with onbank incursions of the shelf/slope front. However, correlation analysis found abundance (as measured by commercial catch) on both the Scotian Shelf and off Newfoundland to be significantly higher during years when the shelf/slope water front was displaced further seaward (southward) and lower when it was closer inshore (northward). This is thought to be related to variations in the strength of the advection as a southward displacement occurs when the Stream transport increases (through geostrophy). Population variability of squid increases from south to north, perhaps indicating northward expansion during high abundance years and southward contraction during low abundance years.

6.2.4 Scallop (Placopecten magellanicus)

S. Smith re-examined the relationship between sea temperatures and annual landings of scallops off Digby. A study in the mid-1950s by Dickie had found a high correlation between catch per boat and autumn bottom temperatures 6 yrs earlier. The lag suggested an effect on pelagic larval stages. In the late 1970s, Caddy published a paper in which he suggests both confirmation of the relationship using an additional 20 yrs of data (up to 1971) and a cyclic periodicity of order 9 yrs. Black and co-workers analyzed catch data between 1921 and 1983 using Fourier analysis, stating they confirmed the near 9 yr fluctuation as well as an additional spectral peak near 21 yrs. In the revaluation of these studies the correlation between catch per boat (1936-1952) and bottom temperature lagged by 6 yrs was confirmed but at a slightly lower level of significance. However, no significant autocorrelation beyond 2 yrs for catch, catch rate, or temperature over the period 1921 to 1971 as reported by Caddy and Black et al. could be found. Also, there was no evidence of

significant periodicities in the fishery data when the starting year was set to 1936/37, the point afterwhich the scallop fishery is considered to be fully developed. Future work will include updating the temperature/catch rate relationship.

6.2.5. *Snow crab (Chionoecetes opilio)*

D. Swain described research on the geographical distribution of snow crab in the Gulf of St. Lawrence. Results show that the distributional response of the snow crab to variations in abundance differs with size class of mature males. For the larger (>95 mm carapace width) males, an increase in abundance results in an expansion of their geographical range and a decrease in their concentrations. For the smaller (<95 mm) males, no such relationship was found. Through the years 1988 to 1995, abundance and the geographic range of the larger males has generally been increasing. For the smaller males, the peak in the abundance occurred in 1992 but the range has showed a general increasing trend from 1988 to 1995.

E. Wade (no working paper) described a study being carried out in collaboration with Ecole Polytechnique in Montreal to examine the feasibility of using a co-kriging technique which would improve the accuracy of the snow crab assessment. The co-kriging technique (Markov-Bayes kriging) uses direct density estimates from yearly snow crab trawl surveys along with complementary depth, sediment and temperature information for areas that were not trawled. The final report of this feasibility study is scheduled to be published in 1997.

E. Dawe examined possible environmental factors affecting snow crab yearclass strength in the Newfoundland region using a 15-y (1982-1996) time series of catch rates of prerecruit males. They tested the hypothesis that density independent factors regulate yearclass strength at the larval stage by lagging catch rates of prerecruits (60-75 mm carapace width and those who are expected to achieve legal size after two additional annual molts). Correlation analysis showed no statistically significant relationship with sea surface temperatures (as measured at Station 27 off St. John's) 7 years earlier although it was noted that the recent high snow crab abundance was produced during a time of high sea surface temperatures. No negative relationship was found between catch rates of prerecruits lagged 6 years and estimates of cod, skate or total groundfish biomass suggesting groundfish predation on the early juveniles is not important. It was suggested that density dependence may possibly be an important factor, perhaps regulating a 7 year cyclic pattern in the population abundance but the time series is too short to confirm such a regular occurrence.

6.2.6 Lobster (Homarus americanus)

S. Waddy presented results from a study of temperature regulation of growth and reproduction in lobsters. The process appears to rather complex with a combination of threshold and cumulative phenomena that vary seasonally and with other factors. For example, the time of the year, thermal history and whether a certain threshold temperature has been reached, all influence the temperature response of lobster. It was suggested that dramatic physiological changes occur at both the autumn equinox and the winter solstice (and likely spring equinox and summer solstice) that affect how larvae, juveniles and adults respond to temperature. With the change of the

seasons, temperatures inadequate for reproduction and growth become favourable and the number of days required for larval development and ovarian maturation at a given temperature can be reduced by as much as 50%. This indicates that scientists must take into account time of the year when considering preferred temperature environments and the conditions required for molting and egg production. It also helps to explain phenomena such as why lobsters do not enter premolt in the autumn even though temperatures are more favourable than in the spring.

P. Ouellet (no working paper) described the general objectives of the lobster larval component of the High Priority Lobster Research Program and specifically field work and modelling activities undertaken at the Institute Maurice Lamontagne in 1996. The main objectives of the larval program are to describe the vertical and horizontal distributions and vertical migratory behaviour of larvae around both the Magdalen Shallows and off SW Nova Scotia, to couple this information with circulation models to explore possible drift/retention scenarios and to verify model results based on current meter data as well as tracking of drift buoys and larvae. During this past year numerical simulations suggest retention of those larvae that were below the thermocline even under realistic wind conditions. Those at the surface were dispersed away from the Magdalen Islands, however. Results from the 1996 summer field season were also described. Observations were focused on resolving the vertical and horizontal larval distributions for model simulations. Drifter buoys were released and tracked, data that will be used in future model evaluations.

R. Miller examined spatial differences in the productivity of lobster along the Atlantic coast of Nova Scotia. The density of ovigerous females (a proxy for egg production), postlarvae, and recruits to the fishery were measured in seven adjacent areas spanning 190 km of Nova Scotia coast west from Halifax. The relative ranking of the densities in these areas persisted from year-to-year showing consistent spatial differences in productivity. The density of ovigerous females and hence egg production was highest in the eastern most region. Postlarvae and fishery recruits were low in those areas but increased steadily towards the southern tip of Nova Scotia where egg production was lower. Based upon the spatial trends it was concluded that areal recruitment levels were related to post larval survival. Assuming only local egg production contributes towards recruitment, it was suggested that different levels of egg production may be needed to maintain an equal level of recruitment. Larval survival was also found to be highest in areas where hatching occurred late in the season.

M. Comeau and K. Drinkwater presented results from a study of the relationship between wind, mean daily water temperature and catch per unit of effort of lobster in lobster fishing area (LFA) 23 along the south shore of Baie des Chaleurs and the northern coast of New Brunswick. The lobster and temperature data were collected during 1994-1996. A strong positive correlation was found between the mean daily temperature and the lobster catch rates within the Baie des Chaleurs but no correlation was observed along the New Brunswick coast. Temperature variability along the southern Baie des Chaleurs at periods of 5-10 d is dependent almost solely upon the alongshore (east-west) component of the wind in the classical Ekman sense. That is, westerly winds produce warmer temperatures (downwelling) and increased catches whereas easterly winds

produce colder temperatures (upwelling) and decrease catches. At 2-3 d periods both components of the wind are important in producing temperature fluctuations.

M. Comeau compared the catch rates (CPUE) between a spring fishery (LFA 24, northern Prince Edward Island) and one conducted in the autumn (LFA 25, eastern New Brunswick). Since 1985, LFA 24 has experienced increasing landings whereas in LFA 25 they have been decreasing or relatively steady. In general, a good relationship was found between the mean daily temperature and the CPUE along the northern shore of PEI in spring. On the other hand there was no relationship between temperature and CPUE along the eastern shore of New Brunswick during the autumn fishery. The later is most likely due to the temperatures being well within the "preferred" temperature range for high lobster activity and catchability.

J. Tremblay and K. Drinkwater examined seasonal changes in catchability and temperature for the spring lobster fishery in eastern Cape Breton (Aspy Bay to Petit de Grat). Two approaches were used. First was an analysis of spatial and temporal coherence in temperature and catch rate and secondly, an analysis of seasonal tag returns. Lobster catch rate trends were similar in northeast Cape Breton (Aspy Bay to Main-a-Dieu) but dissimilar to those along the Atlantic coast of Cape Breton (Louisbourg to Petit de Grat). Temperature variability is highly coherent for periods >2 d and is strongly related to wind in the classical Ekman sense. Southerly winds along the east coast of Cape Breton produced upwelling, northerly winds downwelling. Temperature events appear to propagate southward along the eastern coast of the Island. Initial results showed no significant relationship between temperature and catch rate but further analysis was considered necessary to confirm this. Tagged lobster recaptures showed no trend relative to untagged lobsters in most cases, suggesting the catchability of unmarked lobsters could be inferred from that of tagged lobsters. Unlike earlier studies, seasonal catchability did not increase with temperature, probably because lobsters become less catchable as they prepare to molt. The increased catchability with increasing seasonal temperature shown in earlier studies may be due to an artefact of tagging.

M. Hanson discussed the interactions between demersal fish (especially cod) and lobster in the southern Gulf of St. Lawrence. It has been suggested that cod prey upon lobster. A similarity in cod and lobster abundance indices was noted which is not consistent with a predator-prey interaction. Stomach samples from over 30,000 cod collected since 1955 failed to detect any predation of lobster by cod. Furthermore, concentrations of lobster and cod are spatially separated for most of the year. Stomach analysis of the other dominant commercial species, American plaice, also showed no evidence of predation on lobster. On the other hand, the non-commercial species of shorthorn sculpin, did show evidence of feeding upon lobster and may be an important prey species. The extent of such predation, both seasonally and geographically, remains to be determined.

D. Pezzack (no working paper) discussed the concept of metapopulations in the Gulf of Maine. Traditionally the Gulf lobster population has been thought of as a single large population

with complete mixing of adult and larval stages. Preliminary results of a re-analysis of lobster mark recapture data show a mixture of long distance movement and limited exchange over short distances between some adjacent areas. This suggest that it could be viewed not as a single population but as a metapopulation. Metapopulations are a collection of local populations loosely connected by migration with most of the individuals staying in their natal patch. The local populations may differ in size and degree of emigration, immigration, local adaptation and fishing pressure. The existence of lobster metapopulations would have major implications on how we manage the resource. Future research includes answering the following questions. Do lobster metapopulations exist? What are the exchange rates? What causes isolation? How persistent are they? Future work will include development and analysis of a Gulf of Maine lobster tagging database, including relating movements to temperature and bottom characteristics, and relating larval movements predicted from oceanographic models to the observed adult metapopulation structure.

6.2.7. Physical Characteristics

S. Smith presented a paper on acoustical determination of bottom type as a means to improving stratified surveys for offshore clams. Although the offshore clam fishery has been operative on the Grand Banks and Banquereau Bank since the mid to late 1980s, there is still little information on the size of the resource and hence whether the present high harvesting rates can be maintained. A combined DFO and industry study was undertaken to define strata for a random survey based upon bottom classification. Using acoustical methods calibrated with commercial catch rates from the Grand Banks, bottom type was classified as Clams (high probability of clams), Clam Ground (moderate probability), Seed and Shell (low probability), Soft Bottom (no clams) and Hard Bottom (no clams). Initial results from the Banquereau acoustic survey taken between 1994 and 1996 were provided. A total of 133 sets were successfully completed, 124 in strata defined acoustically. While surf clams were abundant in Clams and Clam Ground strata, they were also encountered quite often in the other strata as well. Approximately 15% of the sets had no clams with most of these in the Hard Bottom stratum. A small gain in survey efficiency was obtained by the bottom type stratification but this was offset by the allocations of the trawl sets by stratum. This was because the commercial fishery targeted the clam and clam grounds whereas for a scientific survey proportionately more sets are needed in the other stratum.

M. Lanteigne informed the FOC about the development of a client-driven nearshore temperature database at the Gulf Fisheries center in Moncton. In 1994, based upon requests by lobster fishers, DFO began a Coastal Water Temperature Monitoring (CWTM) Program in the southern Gulf of St. Lawrence. The temperature monitoring was a component of the Index-Fisher Logbook Program in which volunteer fishers installed temperature recorders in lobster traps. The objectives were to study the effect of temperature on lobster catchability. Problems with lack of recording of trap position and concern by fishers of decreased catch in traps with recorders resulted in fixed stations being established and maintained during 1995 and 1996. Recovery rates were 65% in 1995 and only 48% in 1996 but the data that was recovered was of good quality.

6.3 Discussion

Following the talks a brief discussion was held. The Chairman summarized the presentations. They included 1 paper on biomass estimates (krill), 3 papers on distributional aspects (shrimp, snow crab and lobster), 3 on catchability (lobster), 1 on growth (lobster), and 8 on abundance (shrimp, squid, scallops, snow crab, and lobster). Two additional papers were presented focusing upon physical characteristics, one on bottom type associated with clam surveys and the other on temperature collected by lobster fisheries. Strong associations between the environment and shrimp abundance were found and are being used to predict future yields. Predation also appears to be affecting shrimp abundance based on the results of another study. It was suggested that groundfish abundance should be included as a potential explanatory variable in the Plourde model to rule out the possibility of a spurious environmental effect due to its correlation with predator abundance. Catchability of lobster was also shown to be affected by wind-driven temperature fluctuations along the southern shore of Baie des Chaleurs and northern PEI but not along New Brunswick and Cape Breton. The reason for these differences is unclear. No predation of lobster by cod or plaice in the Gulf of St. Lawrence was observed but sculpins do eat lobster. The importance of predation by sculpins in controlling abundance is unknown, however. Other research results are suggestive of possible environmental effects on abundance (temperature effects on snow crab off Newfoundland; shelf/slope front movement [as a proxy for transport] on squid) but data sets are too limited to be able to confirm this statistically. Temperature definitely affects growth rates of lobster but the relationship is complex and varies seasonally.

Participants expressed the feeling that the session was useful with interaction between scientists from several disciplines. It was hoped that this interaction would continue and further studies on the environmental affects on invertebrates would be undertaken.

7. General Business

7.1 Establishment of Working Groups

A discussion on the future role of the FOC was conducted. It was generally agreed that the FOC should become more proactive and aggressive in tackling some of the important environmental issues facing fisheries. While theme sessions at the FOC annual meeting have helped to focus certain issues and encouraged interaction and interdisciplinary co-operation, the Committee felt that we should be doing more. It was therefore decided to form working groups to tackle issues brought forward either by the regional RAPs, Ottawa or internally-generated within the FOC. Each working group would report annually to the FOC at which time their mandate would be revisited. Two working groups were established. The first was a Cod Growth Working Group (CGWG) to be initially chaired by K. Drinkwater. A number of recent papers have shown certain cod stocks exhibit temperature dependent growth rates. Questions have also arisen as to the relative role of density dependence on growth rates. The FOC recommended the formation of the CGWG to undertake a systematic investigation and comparison of temperature and density dependence on the growth rates of all major commercial Canadian cod stocks. The working group

will also make recommendations for future work. An environmental indices working group (EIWG) was also formed. Its objective is to review the main indices published in the overviews, detail how each are calculated and attempt to standardize methods for calculation of indices. This stemmed from comments that details of how the indices are estimated are not always available. Also it was noted that at times the same index will appear to differ from author to author or paper to paper. F. Page agreed to chair this working group. It will also include those directly involved in preparing the overviews (E. Colbourne, D. Gilbert and K. Drinkwater) and any other interested parties. It is the responsibility to the chairmen to organize their respective working groups, ensure their progress and report back to the FOC.

7.2 Conferences and Workshops

The chairman brought to the attention of the FOC three upcoming ICES meetings in 1997 that may be of interest to the FOC members and participants. They are (1) ICES/GLOBEC workshop on Prediction and Decadal-Scale Ocean Climate Fluctuations of the North Atlantic to be held in Copenhagen in early September, (2) another ICES/GLOBEC workshop on Applications of Environmental Data in Stock Assessment to be held in Bergen, in the autumn and (3) the ICES Symposium on Recruitment Dynamics of Exploited Marine Populations: Physical-Biological Interactions to be held in Baltimore in September.

7.3 Stock Status Reports

The Chairman presented his suggestions for the Stock Status Report for the State of the Ocean: Northwest Atlantic based upon revisions on last year's version. The FOC provided suggestions and agreed upon the wording to be used. The Chairman is to produce the final version and submit it to Ottawa. As discussed under the Overview Session, draft SSRs for the regions are requested to be available for review at the FOC meeting beginning next year.

7.4 Reports from other Research Programs

At the present time there are a number of important fisheries oceanographic programs underway including work conducted under GLOBEC, High Priority programs, JGOFS, etc. It was suggested that in order to keep the FOC up to date on the research being conducted that representatives of these programs be invited to make summary presentations on objectives and recent results where appropriate. The Chairman will invite individuals involved in these programs to make presentations at next year's meeting.

7.5 Possible Themes for the Next FOC Meeting

It was generally agreed that the theme for the next FOC meeting would be on growth and reproduction. Papers will be sought on these topics for both vertebrate and invertebrate species. The FOC chairman will develop a list of more specific items under this general framework in the

months to come. While the FOC is particularly interested in environmental influences, papers will also be encouraged to compare the relative importance of the environment with other possible influences on both growth and reproduction such as density dependence, selective fishing and food availability. It was also suggested that a keynote speaker be invited who would outline the problem and issues associated with the theme session. The FOC agreed this was a good idea with the responsible for the selection and arrangement falling to the chairman.

7.6 Date of the Next FOC Meeting

The next annual meeting will be held at the Bedford Institute of Oceanography in Dartmouth, N.S. during the last week of February, 1998.

Appendix 1: Agenda
FOC Annual Meeting, February 25-27, 1997
Miramichi Room, 5th Floor
Gulf Fisheries Center, Moncton, N.B.

Agenda

Authors who presented the papers are underlined. WP indicates working paper provided.

Tuesday, Feb. 25

9:00 Introduction and administrative details
-Chairman

1996 Environmental Overviews

Physical Environment

9:15 Ken Drinkwater, Roger Pettipas and Liam Petrie
Overview of Meteorological and Sea Ice Conditions off Eastern Canada in 1996. (WP)

9:45 Eugene Colbourne
Oceanographic Conditions in the Newfoundland Region during 1996 with comparisons to the 1961-1990 average. (WP)

10:15 Break

10:30 Denis Gilbert, Bernard Pettigrew, Doug Swain and Peter Galbraith
État du Golfe du Saint-Laurent: conditions océanographiques en 1996. (WP)

11:00 Fred Page, Randy Losier and Jeff McRuer
Overview of 1996 hydrographic sampling effort and near-bottom water temperature and salinity conditions during the Canadian spring research vessel groundfish surveys conducted within NAFO areas 4VsW and 5Z. (WP)
Overview of 1996 hydrographic sampling effort and near-bottom water temperature and salinity conditions during the Canadian spring research vessel groundfish surveys conducted within NAFO areas 4VWX. (WP)

11:30 Ken Drinkwater, Roger Pettipas and Liam Petrie
Physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine during 1996. (WP)

12:00 Lunch

Biological Environment

13:00 Doug Sameoto, Mary Kennedy and Norman Cochrane
Zooplankton changes along the Halifax and Louisbourg Transects in 1996. (WP)
13:30 Jeff Runge (presented by Patrick Ouellet)
Zooplankton biomass in the Lower St. Lawrence Estuary, 1994-1996. (WP)
13:45 John Anderson and Edgar Dalley
*Plankton and nekton of the northeast Newfoundland Shelf and Grand Banks, 1994 and 1995** (WP)
* Paper from the General Environmental Session presented as background for the following paper by Dalley and Anderson.
14:15 Edgar Dalley and John Anderson
Plankton and nekton of the northeast Newfoundland Shelf and Grand Banks in 1996, compared to 1994 and 1995. (WP)
14:45 Recommendations and Discussion of Overview Session

15:00 Break

General Environmental Session

15:15 Fred Page, Jeff McRuer, Peter Smith and Michele Ringuette
Temperature conditions during the 1995 and 1996 redfish fishery.
15:40 Glen Harrison and Doug Sameoto
An update on the development of plankton "indices". (WP)
16:05 Erica Head and Leslie Harris
Observations of the ecology of Calanus spp. on the Scotian and Newfoundland shelves and adjacent deep oceans.
16:30 Doug Swain, Ghislain Chouinard, Rod Morin, and Ken Drinkwater
Seasonal variation in the temperature distribution of southern Gulf cod and plaice. (WP)
16:55 Doug Swain
Changes in cod distribution in the southern Gulf of St. Lawrence: effects of environmental change or change in environmental preferences? (WP)

Wednesday, Feb. 26

8:30 *Proposal for an east coast Zonal Monitoring Program* (WP)
-Special Presentation by Jean-Claude Therriault
(Chairman, Zonal Monitoring Committee)
9:30 Questions and Discussion of Zonal Monitoring Proposal

10:15 Break

Theme Session: Environmental Effects on Invertebrate Stocks

10:30 Introduction
-Chairman

10:45 Doug Sameoto
Euphausiids on the eastern continental shelf. (WP)

11:15 Peter Koeller and Ken Drinkwater
Environmental versus ecological influences on the population dynamics of northern shrimp (Pandalus borealis). (WP)

11:45 Jacques Plourde and Jean-Claude Therriault
Relationship between climate variability and shrimp landings in the Gulf of St. Lawrence. (WP)

12:15 Lunch

13:00 Earl Dawe and Eugene Colbourne
Trends in abundance of short-finned squid (Illex illecebrosus) and environmental conditions in the Northwest Atlantic. (WP)

13:30 Steve Smith and Mark Lundy
Another look at the relationship between annual landings of the Digby scallop fishery and average autumn temperatures. (WP)

14:00 Dale Roddick and Steve Smith
Acoustic determination of bottom type to improve stratified surveys for offshore clams. (WP)

14:30 Elmer Wade, Denis Marcotte and Mikio Moriyasu
Co-kriging of snow crab density and depth, temperature and substrate in the southern Gulf of St. Lawrence.

15:00 Break

15:30 Earl Dawe, Dave Taylor and Eugene Colbourne
Effects of environmental conditions on snow crab year-class strength in the Newfoundland region. (WP)

16:00 Susan Waddy and D.E. Aiken
A temperature model for lobster growth and reproduction. (WP)

16:30 Patrick Ouellet and Denis Lefaivre
Presentation of the DFO-Science High Priority project, Atlantic Zonal Lobster Research Program: Transport of lobster larvae - observations and models.

17:00 Bob Miller
Spatial differences in the productivity of American lobster in Nova Scotia. (WP)

Thursday, Feb. 27

Invertebrate Theme Session Continued

8:00 Michel Comeau and Ken Drinkwater
The interaction of wind, temperature and catch rate of lobsters on the Acadian Peninsula. (WP)

8:30 Michel Comeau, Pierre Mallet and Guy Robichaud
Comparison of the relationship between lobster catch rates and temperature between a spring (LFA 24) and a fall (LFA 25) lobster fishery in the Gulf of St. Lawrence. (WP)

9:00 John Tremblay and Ken Drinkwater
Temperature, catch rate and catchability during the spring lobster fishery off eastern Cape Breton. (WP)

9:30 Mark Hanson and Marc Lanteigne
Interactions between demersal fishes and lobster in the southern Gulf of St. Lawrence: what are the facts? (WP)

10:00 Break

10:30 Doug Pezzack
Lobster meta populations in the Gulf of Maine: structure and relationship to oceanographic conditions.

11:00 Doug Swain and Elmer Wade
Annual variation in geographic range of snow crab in the southern Gulf of St. Lawrence. (WP)

11:30 Marc Lanteigne
Developing a client-driven nearshore temperature database. (WP)

12:00 Lunch

13:00 Summary and Recommendations from Theme Session
- -Publication of papers

13:30 General Business of FOC
- -Structure of FOC (where do we go from here)
  - -Discussion on the possible formation of FOC Working Groups
- -Stock Status Reports of Environmental Information
  - -Discussion and Recommendations
- -Other Business
  - -Reports from Research Programs (GLOBEC, HP Projects, etc.)
- -Next year's meeting
  - -Theme Sessions
  - -Date and Location

Appendix 2: Working Papers

1. *Overview of Meteorological and Sea Ice Conditions off Eastern Canada in 1996.*
   -Ken Drinkwater, Roger Pettipas and Liam Petrie
2. *Oceanographic Conditions in the Newfoundland Region during 1996 with comparisons to the 1961-1990 average.*
   -Eugene Colbourne
3. *État du Golfe du Saint-Laurent: conditions océanographiques en 1996.*
   -Denis Gilbert, Bernard Pettigrew, Doug Swain and Peter Galbraith
4. *Overview of 1996 hydrographic sampling effort and near-bottom water temperature and salinityconditions during the Canadian spring research vessel groundfish surveys conducted within NAFO areas 4VsW and 5Z.*
   -Fred Page, Randy Losier and Jeff McRuer
5. *Overview of 1996 hydrographic sampling effort and near-bottom water temperature and salinity conditions during the Canadian spring research vessel groundfish surveys conducted within NAFO areas 4VWX.*
   -Fred Page, Randy Losier and Jeff McRuer
6. *Physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine during 1996.*
   -Ken Drinkwater, Roger Pettipas and Liam Petrie
7. *Zooplankton changes along the Halifax and Louisbourg Transects in 1996.*
   -Doug Sameoto, Mary Kennedy and Norman Cochrane
8. *Zooplankton biomass in the Lower St. Lawrence Estuary, 1994-1996.*
   -Jeff Runge
9. *Plankton and nekton of the northeast Newfoundland Shelf and Grand Banks, 1994 and 1995*
   -John Anderson and Edgar Dalley
10. *Plankton and nekton of the northeast Newfoundland Shelf and Grand Banks in 1996, compared to 1994 and 1995.*
    -Edgar Dalley and John Anderson
11. *An update on the development of plankton "indices".*
    -Glen Harrison and Doug Sameoto
12. *Seasonal variation in the temperature distribution of southern Gulf cod and plaice.*
    -Doug Swain, Ghislain Chouinard, Rod Morin, and Ken Drinkwater
13. *Changes in cod distribution in the southern Gulf of St. Lawrence: effects of environmental change or change in environmental preferences?*
    -Doug Swain
14. *Euphausiids on the eastern continental shelf.*
    -Doug Sameoto
15. *Environmental versus ecological influences on the population dynamics of northern shrimp (Pandalus borealis).*
    -Peter Koeller and Ken Drinkwater

16. *Relationship between climate variability and shrimp landings in the Gulf of St. Lawrence.*
    -Jacques Plourde and Jean-Claude Therriault
17. *Trends in abundance of short-finned squid (Illex illecebrosus) and environmental conditions in the Northwest Atlantic.*
    -Earl Dawe and Eugene Colbourne
18. *Another look at the relationship between annual landings of the Digby scallop fishery and average autumn temperatures.*
    -Steve Smith and Mark Lundy
19. *Acoustic determination of bottom type to improve stratified surveys for offshore clams.*
    -Dale Roddick and Steve Smith
20. *Effects of environmental conditions on snow crab year-class strength in the Newfoundland region.*
    -Earl Dawe, Dave Taylor and Eugene Colbourne
21. *A temperature model for lobster growth and reproduction.*
    -Susan Waddy and D.E. Aiken
22. *Spatial differences in the productivity of American lobster in Nova Scotia.*
    -Robert J. Miller
23. *The interaction of wind, temperature and catch rate of lobsters on the Acadian Peninsula.*
    -Michel Comeau and Ken Drinkwater
24. *Comparison of the relationship between lobster catch rates and temperature between a spring (LFA 24) and a fall (LFA 25) lobster fishery in the Gulf of St. Lawrence.*
    -Michel Comeau, Pierre Mallet and Guy Robichaud
25. *Temperature, catch rate and catchability during the spring lobster fishery off eastern Cape Breton.*
    -John Tremblay and Ken Drinkwater
26. *Interactions between demersal fishes and lobster in the southern Gulf of St. Lawrence: what are the facts?*
    -Mark Hanson and Marc Lanteigne
27. *Annual variation in geographic range of snow crab in the southern Gulf of St. Lawrence.*
    -Doug Swain and Elmer Wade
28. *Developing a client-driven nearshore temperature database.*
    -Marc Lanteigne

Appendix 3: Meeting Participants

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** Some e-mail addresses have changed since the meeting. Up-to-date e-mail addresses are provided.

Appendix 4: Summary of Environmental Conditions off Eastern Canada in 1996

Atmospheric and Sea Ice Conditions

During 1996, a significant change occurred in the large-scale atmospheric circulation pattern. The Icelandic Low, which for over a decade had been more intense than the long-term average, weakened. The Bermuda-Azores High also weakened. This resulted in a decline in the NAO index, indeed the single largest annual decrease on record in over 100 years. Associated with the weakening of the Icelandic Low, northwest winds would have been weaker-than-normal over the Labrador Sea which would account for the observed wintertime air temperatures being, on average, warmer-than-normal and the warmest in approximately a decade. Warmer air temperatures and weaker northwest winds resulted in later-than-normal ice formation, less areal extent of ice than normal and a shorter duration of ice, over much of the Labrador/Newfoundland shelves and in the Gulf of St. Lawrence/Scotian Shelf. In turn, the warm temperatures, weak winds and less ice all contributed towards a large reduction in the number of icebergs reaching the Grand Banks in 1996 relative to 1995 and the earlier years of the 1990s. During spring, air temperature anomalies continued to remain above normal, consistent with a weaker Icelandic Low and weaker northwest winds over the Labrador Sea. During the summer and autumn, air temperatures tended to fluctuate about their long-term means.

Hydrographic Conditions off Newfoundland

The anomalously cold water temperatures in recent years along the east coast of Newfoundland finally were replaced by warmer-than-normal waters. Positive temperature anomalies were observed throughout the water column at Station 27 over most of the year with maximum anomalies of 2°C at mid-depths during the summer. This represents the warmest waters at Station 27 in over a decade. Salinities at Station 27 were generally below normal throughout the year with the greatest departures from the long-term mean appearing near 100 m in the late summer. The areal extent of the cold intermediate layer (CIL), as defined by temperatures less than 0°C, along the Bonavista Line in summer was below-normal for the second consecutive year. The CIL area did, however, increase slightly relative to 1995. During the annual autumn groundfish survey, bottom temperatures increased significantly from the extensive cold temperatures observed during the 1991-1994 period. Observations south of Newfoundland in areas 3Ps and 3Pn indicate water temperatures there also moderated from the very cold period that began in the mid-1980s and extended into the 1990s. In 1996, near bottom temperatures in these areas had returned to near normal values.

Hydrographic Conditions in the Gulf of St. Lawrence

Colder-than-normal temperatures were observed for the 12th consecutive year in the depth range of 30-100 m which corresponds to the CIL in the Gulf of St. Lawrence. The minimum temperature in the CIL in mid-summer was approximately -0.5°C, up slightly from 1995 but still

below normal. Cold bottom waters continued to cover the Magdalen Shallows in September during the annual groundfish survey in the southern Gulf. The areal extent of the Shallows covered by waters less than 0°C and less than 1°C decreased relative to 1995 but remained high compared to most years during the 1970s and 1980s. The thickness of the CIL throughout the Gulf, as defined by waters less than 0°C, decreased by approximately 10 to 20 m on average compared to 1995. In the 100-200 m depth layer, the temperature was below normal everywhere in the Gulf, similar to 1995. Deep waters (200-300 m) in the Gulf, including in and around Cabot Strait, ranged between 4 and 6°C and were near their long-term normals.

Hydrographic Conditions on the Scotian Shelf and in the Gulf of Maine

Waters below the upper mixed layer (>30 m) on the northeastern Scotian Shelf continued to be colder-than-normal, extending the trend that began around the mid-1980s. Similar cold conditions were observed along the Atlantic coast of Nova Scotia and off southwest Nova Scotia. The deep waters (>150 m) in Emerald Basin remained relatively high and are consistent with conditions found in the deep basins of the Gulf of Maine. These deep waters originate offshore and are transported onto the shelf through cross-shelf exchange processes. Bottom temperatures observed during the annual July groundfish survey support this pattern of colder-than-normal in the northeastern Shelf and off southwest Nova Scotia and warmer-than-normal in Emerald Basin and the deep basins of the Gulf of Maine. Compared to 1995, temperatures warmed in the northeast and off southwest Nova Scotia but cooled slightly in Emerald Basin. Warm bottom temperatures seen in the central Gulf of Maine in July were typical of deep water conditions in the Gulf of Maine through most of the year, based upon data collected at the hydrographic station at the mouth of the Bay of Fundy, Prince 5, and an XBT transect across the Gulf from Massachusetts Bay to Cape Sable. Warm waters were also seen from coastal sea surface temperatures at Boothbay Harbor in Maine and St. Andrew's, New Brunswick. Of significant note were the low salinities recorded throughout the year at Prince 5, the lowest on record in over 70 years. This parallels freshening events observed in the deep waters of the central Gulf of Maine. Cause of this freshening is unknown but may be related to an intrusion of offshore slope water.

Brief Summary of Meteorological and Hydrographic Conditions

Significant changes in the large scale circulation pattern over the northern North Atlantic lead to a low NAO index and a weakened Icelandic Low. Over the Labrador Sea this resulted in weakened northwest winds in winter, warmer-than-normal air temperatures, less ice and warm sea temperatures. This represents a significant change from the cold conditions of the last decade. In contrast to the significant warming over the Labrador and Newfoundland waters, oceanographic conditions in the Gulf of St. Lawrence, the Scotian Shelf and the Gulf of Maine remained similar to recent years. This included colder-than-normal conditions at intermediate depths (30-200 m) in the Gulf of St. Lawrence, on the northwestern Scotian Shelf, along the Atlantic coast of Nova Scotia and off southwest Nova Scotia although temperatures in these

areas are beginning to moderate. Relatively warm conditions continued in the deep basins of the Scotian Shelf and the Gulf of Maine.

Zooplankton Conditions

Zooplankton sampling along the Halifax and Louisbourg standard sections during 1996 show that macrozooplankton (euphasiid and to a lesser extent amphipod) levels tend to be higher along the Halifax Line. In Emerald Basin, *Calanus finmarchicus* populations during 1996 were at their lowest levels since 1985 when data collection began. Both euphasiids and fish populations in the Basin gradually increased between 1984 and 1994, followed by a steep decline in 1995 and then a subsequent sharp increase in the euphasiid population during 1996 back to previously high levels.

A zooplankton survey in the Lower St. Lawrence Estuary undertaken since 1994 showed that zooplankton biomass in 1995 and 1996 was significantly lower than in 1994. Krill biomass was lower by a factor of 10 in 1996 relative to 1994 while total plankton biomass is down by a factor of 2 and *Calanus* biomass is lower by a factor of 3. No explanation for these decreases is available at this time.

During the past three years, an extensive survey for zooplankton and nekton was also carried out during August-September over the northern Newfoundland shelf and the Grand Banks. In 1996, the mean total zooplankton biomass collected in bongo tows was significantly higher than 1994 and similar to 1995. However, the mean wet nekton biomass, with or without jellyfish, was significantly lower in 1996 than other years. The mean catch of pelagic 0-group Arctic cod was significantly lower in 1996 than in 1994 but similar to 1995. The number of Atlantic cod decreased in 1996 from 1995, which in turn was down from 1994. The amount of biomass of squid also decreased but significantly more sculpins, seasnails and white hake were observed in 1996 compared to the past two years. It is not clear whether these changes are part of the natural year-to-year variability or if they represent a longer term trend. Longer time series of the zooplankton biomass will help to answer such questions.