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Final Report of the Fisheries Oceanography Committee 2006 Annual Meeting

29-31 March 2006

Bedford Institute of Oceanography
Dartmouth, Nova Scotia

Mike Sinclair (Chairperson)

Fisheries and Oceans Canada
Maritimes Region
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

January 2007

Rapport final de la réunion annuelle 2006 du Comité océanographique des pêches

du 29 au 31 mars 2006

Institut océanographique de Bedford
Dartmouth (Nouvelle-Écosse)

Mike Sinclair (président)

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Foreword

The purpose of these proceedings is to archive the activities and discussions of the meeting, including research recommendations, uncertainties, and to provide a place to formally archive official minority opinions. As such, interpretations and opinions presented in this report may be factually incorrect or misleading, but are included to record as faithfully as possible what transpired at the meeting. No statements are to be taken as reflecting the consensus of the meeting unless they are clearly identified as such. Moreover, additional information and further review may result in a change of decision where tentative agreement had been reached.

Avant-propos

Le présent compte rendu fait état des activités et des discussions qui ont eu lieu à la réunion, notamment en ce qui concerne les recommandations de recherche et les incertitudes; il sert aussi à consigner en bonne et due forme les opinions minoritaires officielles. Les interprétations et opinions qui y sont présentées peuvent être incorrectes sur le plan des faits ou trompeuses, mais elles sont intégrées au document pour que celui-ci reflète le plus fidèlement possible ce qui s’est dit à la réunion. Aucune déclaration ne doit être considérée comme une expression du consensus des participants, sauf s’il est clairement indiqué qu’elle l’est effectivement. En outre, des renseignements supplémentaires et un plus ample examen peuvent avoir pour effet de modifier une décision qui avait fait l'objet d'un accord préliminaire.

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ABSTRACT

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans met at the Bedford Institute of Oceanography (Dartmouth, Nova Scotia) from 29-31 March 2006, to review multi-species survey data related to the composition and abundance of fish and invertebrates from each of the regions, in order to characterize the structure and function of the various systems. This was step one of a multi-year plan intended to culminate in a series of regional Ecosystem Status Reports.

For the Newfoundland and Labrador shelf seas, overall biomass estimates have declined since the 1980s, in both the commercial and non-commercial species. In some areas, the non-commercial species show declines a few years prior to the commercial species suggesting that environmental factors are important influences in community level temporal changes. Various indices of community level response to environmental change and fishing pressure were explored, with the so-called “abundance-biomass comparison” (ABC) plot showing promise.

Similar decreases in the demersal fish biomass were observed in the northern Gulf of St. Lawrence due to declines in cod and redfish. Three to five species account for about 80% of the total biomass in this geographic area. Community change was also evident in the southern Gulf of the St. Lawrence. The present fish community is characterized by smaller sized cold-water species which generally spawn in the winter months, not impacted by commercial fishing. Biomass estimates of several macro-invertebrate species have increased from 1985 to present. Note that the southern Gulf survey is unique in having systematically quantified both commercial and non-commercial invertebrates.

On the eastern Scotian Shelf, the biomass of large demersal species has steadily declined over three decades with a lack of compensation in the other demersal fish species. Major increases in the biomass of small pelagic species and macro-invertebrates have been seen. For the western Scotian Shelf, the estimates of biomass of the larger sized demersal species have been steady over three decades, although there have been major changes in relative abundance (e.g., cod, haddock down and dogfish up). There are many similarities between trends on the western Scotian Shelf and those observed on Georges Bank, including the increase in elasmobranch species. Comparisons amongst the regional analyses of the multi-species trawl surveys was found hindered by a number of factors and it was recommended that a zonal review of the objectives of the regional trawl surveys be undertaken followed by the standardization (within surveys at least) of protocols; training is also required amongst regions to ensure minimal requirements are met (e.g., species identification). FOC is currently discussing the merits of a common outline for the regional Ecosystem Status Reports, including indices from the single species stock assessments and the identification of analyses required of AZMP in support of the comparative ecosystem analyses. Planning for Year 2 objectives of the multi-year plan is also underway.

RÉSUMÉ

Le Comité océanographique des pêches (COP) du ministère des Pêches et des Océans (MPO) s'est réuni à l'Institut océanographique de Bedford (Dartmouth, Nouvelle Écosse) du 29 au 31 mars 2006 afin d'examiner les données de relevés plurispécifiques sur la composition et l'abondance des communautés de poissons et d'invertébrés dans chacune des régions, dans le but de caractériser la structure et la fonction des divers écosystèmes. Cette réunion constitue la première étape d'un plan pluriannuel visant à produire une série de rapports régionaux sur l'état des écosystèmes.

Pour les étendues marines de Terre Neuve et du Labrador, les estimations de la biomasse totale des espèces commerciales et non commerciales ont baissé depuis les années 1980. Dans certains secteurs, les espèces non commerciales ont accusé un déclin quelques années avant les espèces commerciales, ce qui suggère que les facteurs environnementaux ont une incidence importante sur le plan des changements à l'échelle des communautés au fil du temps. Divers indices de la réponse aux changements environnementaux et aux pressions de la pêche à l'échelle des communautés ont été étudiés, et la méthode de comparaison abondance biomasse est prometteuse.

Des baisses semblables de biomasse ont été observées chez les populations de poisson de fond du nord du golfe du Saint Laurent, ces baisses étant dues aux déclins des populations de morue et de sébaste. De trois à cinq espèces comptent pour environ 80 % de la biomasse totale dans cette région géographique. Des changements à l'échelle des communautés ont également été observés dans le sud du golfe du Saint Laurent. La communauté de poissons actuelle est caractérisée par des espèces d'eaux froides de plus petite taille qui fraient généralement à l'hiver et qui ne sont pas touchées par la pêche commerciale. Les estimations de la biomasse de plusieurs espèces de macroinvertébrés ont augmenté de 1985 à aujourd'hui. Il convient de noter que le relevé du sud du golfe a ceci de particulier qu'il quantifie systématiquement les invertébrés commerciaux et non commerciaux.

Dans la partie est de la plate forme néo écossaise, la biomasse des espèces de poisson de fond de grande taille a diminué de façon constante pendant trois décennies sans être compensée chez les autres espèces de poisson de fond. D'importantes hausses de la biomasse ont été observées chez des espèces pélagiques de petite taille et chez des espèces de macroinvertébrés. Dans la partie ouest de la plate forme néo écossaise, les estimations de la biomasse des espèces de poisson de fond de grande taille ont été constantes pendant trois décennies, mais il y a eu d'importants changements sur le plan de l'abondance relative (p. ex. baisse chez la morue et l'aiglefin, et hausse chez les aiguillats). Il existe de nombreuses similitudes entre les tendances dans la partie ouest de la plate forme néo écossaise et celles observées sur le banc de Georges, y compris la hausse chez les espèces d'élasmobranches. Les comparaisons entre les analyses régionales des relevés plurispécifiques au chalut ont été entravées par un certain nombre de facteurs, et un examen zonal des objectifs des relevés au chalut régionaux suivi de la normalisation (à tout le moins dans le cadre des relevés) des protocoles ont été recommandés; une formation est également nécessaire dans les régions afin d'assurer la satisfaction des besoins minimaux (p. ex. identification

des espèces). Le COP discute présentement des mérites d'un modèle commun pour les rapports régionaux sur l'état des écosystèmes, y compris des indices tirés des évaluations de stock visant une seule espèce et la détermination des analyses requises du PMZA à l'appui des analyses comparatives des écosystèmes. La planification des objectifs de la deuxième année du plan pluriannuel est également en cours.

1.0 INTRODUCTION

The Fisheries Oceanography Committee (FOC) of the Department of Fisheries and Oceans (DFO) met at the Bedford Institute of Oceanography (Dartmouth, Nova Scotia) from 29-31 March 2006. The incoming chairperson (Mike Sinclair) gave some opening remarks outlining the change in direction of the work of the committee that had been initiated at the 2005 meeting.

It had been concluded that the annual environmental reviews would be the responsibility of the Atlantic Zone Monitoring Committee (AZMP), and that FOC would not review the documentation and analyses. Nevertheless, it was highlighted that coordination between the work of FOC and AZMP is essential, with a need for overlapping meetings on occasion. The new focus of FOC is to be on upper tropic levels. A proposal had been developed by Ken Frank, Martin Castonguay, Doug Swain, and Fran Mowbray to develop descriptions of the diverse continental shelf ecosystems in the Atlantic Zone, from the Labrador Shelf to the Gulf of Maine areas. It was also concluded that the membership of FOC be reviewed, as there has been excessive overlap with AZMP, and additional specialists in ecosystem level studies and fisheries ecology are required to achieve the new multi-year workplan.

The Terms of Reference (ToR) for FOC were also revised during the 2005 meeting and accepted by the Atlantic Science Directors Committee (ASDC). The new ToR focuses on: (1) application and integration of environmental and ecosystem level knowledge to distribution, and production of marine and diadromous exploited species; and (2) evaluation of environmental factors and ecosystem processes on migration, spawning times, stock definition, etc. It is to be a forum for integration of ecosystem modeling, fisheries science, and oceanography across regions to enhance understanding of changes in productivity, ecosystem structure, and availability of living marine resources to commercial fisheries. The full text of the revised ToR is provided in Annex 1.

During the discussion of the 2005 FOC report by ASDC there was support for re-directing the mandate of FOC to address research, monitoring, and data management issues in support of integrated management and associated aspects of the Oceans Act. There was consideration of a change in the name of FOC to reflect the re-direction of the mandate (e.g., Ecosystem Oceanography Committee), as well as the option of making FOC a national rather than a regional committee. These issues were forwarded to FOC for their comment. ASDC supported the draft multi-year workplan on comparative ecosystem dynamics and the associated requirements for a membership review. There was also discussion of zonal integration of multi-species trawl data, with support for aggregation of data from these surveys on an annual basis. It was agreed that all survey data should be accessible in Oracle format, and that timely access of data to the public is a priority. Funding from the National Data Management Committee (NDMC) to facilitate data access was subsequently provided to the Newfoundland and Labrador Region.

There are parallel initiatives underway that are relevant to the new direction of FOC. The Cooperative Institute for Climate and Ocean Research (CICOR) of the Woods Hole Oceanographic Institution held a workshop in January 2005, on planning of marine research in support of ecosystem based management (EBM). The recommendations on modelling are relevant to FOC:

- Assess coverage of climate and ecosystem issues of the shelf seas off northern USA (and Atlantic Canada) by present models.
- Assess horizons of predictability with emphasis on evaluating the degree to which models provide “skilful predictions”.

The new DFO Centre of Expertise, the Centre for Ocean Modelling and Data Assimilation (COMDA), is expecting to provide operational oceanographic hindcasts, nowcasts, and some forecasts for the Atlantic Zone. Finally, a new (2006) project at Memorial University of Newfoundland (MUN) of GIS work on DFO multi-species trawling survey and oceanographic data has been funded by Geoconnections. FOC needs to consider the degree to which it will interact with both the MUN GIS project, as well as with the modelling initiatives on shelf seas ecosystem dynamics by COMDA and potentially CICOR funded projects.

In closing his opening remarks, the chair thanked Patrick Ouellet, the outgoing chairperson, for his excellent job of the past three years and his efforts to re-direct the efforts of FOC towards the emerging priorities of DFO under the Oceans Act.

The agenda was outlined by the meeting co-chair Ken Frank and accepted without modification (Annex 2).

The co-chair of the meeting (Ken Frank) summarized the goals of the meeting in relation to the multi-year plan. The first two years (2006 and 2007) involved regional compilation of multi-species trawl survey and associated ecological and oceanographic time-series data by both FOC and AZMP participants. The focus is to be on evaluation of the relevant data sets with respect to their utility in describing decadal scale trends in the regional shelf seas ecosystems. Year 1 (2006) provides summarization of data related to the composition and abundance of fish and invertebrates from each of the regions. This is essentially an identification of the community types characteristic of each region, as well as their temporal and spatial dynamics. It was anticipated that a variety of descriptors of the communities, such as species richness, dominance structure, species, and functional diversity, etc., would be developed. The resultant comparative approach was expected to yield considerable insight into the structure and function of the various systems. Following the regional syntheses of the multi-species surveys, it is planned to provide a common outline/structure for the regional so-called Ecosystem Status Reports, as well as to reflect on next steps for comparative ecosystem dynamics amongst the shelf seas areas analysed.

2.0 FOC CORE-MEMBERSHIP AND PARTICIPATION

Whilst participation in the activities of FOC are open to all, the committee formally consists of a number of core-members whose responsibilities are to disseminate information to their respective laboratories and to provide a leadership role within the committee. At the time of the 2006 annual meeting, the FOC core-members were:

Eugene Colbourne*	Northwest Atlantic Fisheries Centre (NWAFC)
Mariano Koen-Alonso	Northwest Atlantic Fisheries Centre (NWAFC)
Fran Mowbray	Northwest Atlantic Fisheries Centre (NWAFC)
Claude Savenkoff	Institut Maurice-Lamontagne (IML)
Jacques Gagné*	Institut Maurice-Lamontagne (IML)
Patrick Ouellet	Institut Maurice-Lamontagne (IML)
Hugues Benoît	Gulf Fisheries Centre (GFC)
Joel Chassé	Gulf Fisheries Centre (GFC)/Bedford Institute of Oceanography (BIO)
Doug Swain*	Gulf Fisheries Centre (GFC)
Bob Branton	Bedford Institute of Oceanography (BIO)
Ken Frank	Bedford Institute of Oceanography (BIO)

Brian Petrie	Bedford Institute of Oceanography (BIO)
Mike Sinclair	Bedford Institute of Oceanography (BIO)
Don Clark	St. Andrews Biological Station (SABS)
Kim Schmidt*	Headquarters (HQ), DFO

*Not present at 2006 BIO meeting

The list of participants is provided in Annex 3.

3.0 ECOSYSTEM CHANGE ANALYSES BY REGION

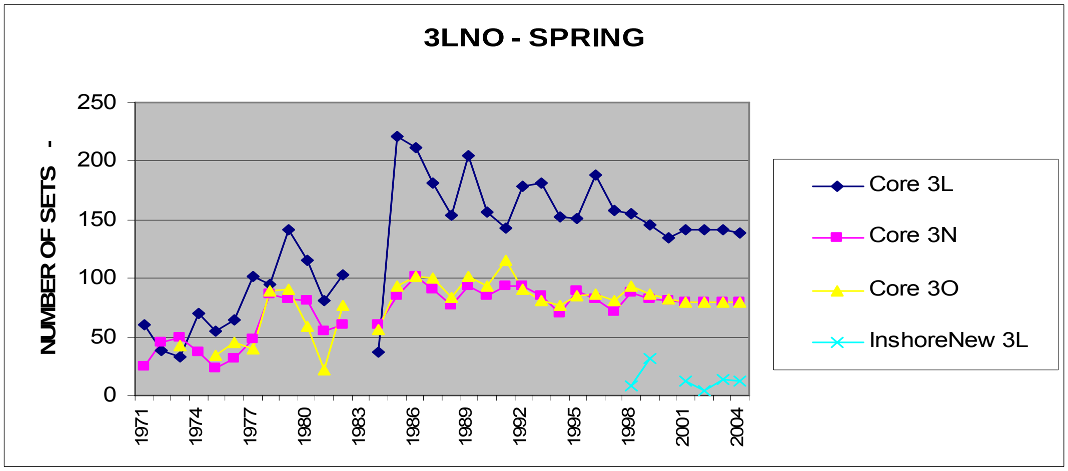
3.1 Newfoundland and Labrador Region

Three presentations were made. Fran Mowbray presented a paper entitled "Some considerations for using NAFC bottom-trawl survey data in the development of ecosystem metrics" (F. Mowbray, Rebury, T. Clarke, and M. Clark).

The suitability of bottom-trawl survey data from Newfoundland Region for the development of ecosystem metrics such as species diversity, abundance and species mean weight of catch was investigated. Efforts were concentrated on two survey series: spring surveys in NAFO Divisions 3LNO and fall surveys in Divisions 2J3KLNO. Specific attributes such as timing, spatial distribution of survey effort and speciation effort, were also examined for surveys in 3P and 3M, as well as for redfish surveys in 3P and 4Vn. Due to variations in coding of survey type and catch handling practices, it was ascertained that only survey set types 1 and 2 should be used or this analysis. The number of sets could be substantially increased in some cases (certain stratum only), if sets identified as tagging or comparative fishing were also included. However, due to the inconsistency in the treatment of non-commercial species in these sets, inclusion would only be advisable when the hypothesis tested dealt exclusively with commercial groundfish species.

Within both of the main surveys series examined, the number of sets and area covered was found to increase considerably over time. This is due in part to the expansion of the fall survey of 2J3K into 3L in 1981, and 3NO in 1996, as well as the creation of new inshore and deepwater strata in 1996. However, during the earlier years, the number of survey sets also increased within the "core" or consistently surveyed strata (Fig.1). As a result, it is recommended that for the fall survey only core areas from 1981 on be used in the development of ecosystem metrics; and for the spring survey only core stratum from 1985 onward be included. Gear changes with no correction for catchability of non-commercial species is also an issue in these data series. Until the fall of 1995, the survey employed an Engels trawl, but then switched to a Campelen 1600. The Campelen trawl had a higher catchability for small fish than did the Engels, resulting in the sudden appearance in the time series of small fishes rarely or infrequently sampled in the prior years. In addition, larger proportions of small individuals of species that regularly occurred in the survey were observed. Consequently, it is advised that any analysis be divided into separate time series for each gear type.

Species coding of catches was also identified as an issue. It was found that a substantial number of records, in some divisions and years up to 20%, were not recorded to species. This lack of taxonomic rigor was attributed to both time constraints and workload issues, as well as a lack of on-board taxonomic expertise. Common higher taxonomic levels found in the database included both genus and family, and occasionally, order. In both spring and fall series the proportion of records not to species tended to increase during the 1990s, during the period when the Engels trawl was employed, and jumping dramatically with the start of the use of the Campelen trawl, and declining slightly during the last few years (Fig. 2). Lack of speciation was more common in the deep water strata with both gears, although with the Campelen trawl series the problem is common throughout the whole survey area. This is due to the inclusion of both new smaller species in the catches and also smaller younger fish of species were usually identified when only the larger individuals of the same species were caught (Fig. 3). In order to best use the data, new "designated" species codes were developed for species where a mix of taxonomic levels were evident in the database. In some cases, this meant that a given species was recoded to the genus or family level, in other cases where only one species of a particular group occurred within the survey area, observations at higher taxonomic levels were recoded as species. It is recommended that any biodiversity of abundance estimations of non-commercial species refer to the "designated" species codes.



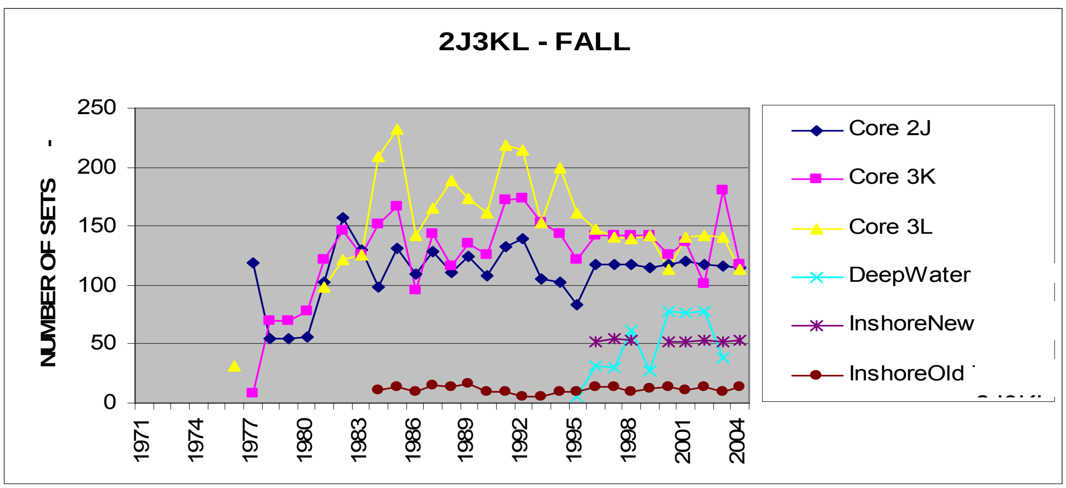
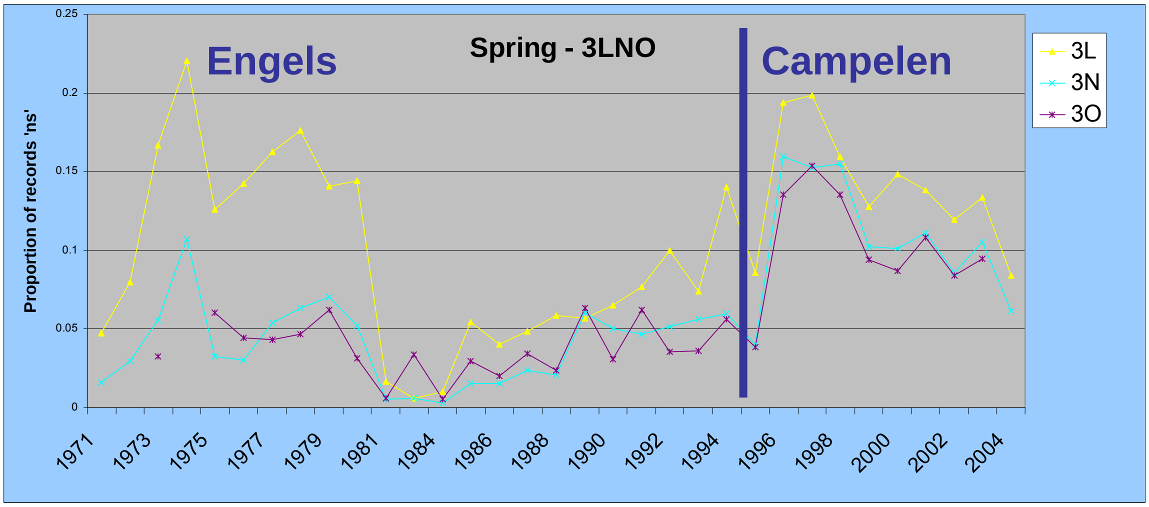


Figure 1. Number of sets by division and strata grouping for spring and fall surveys.



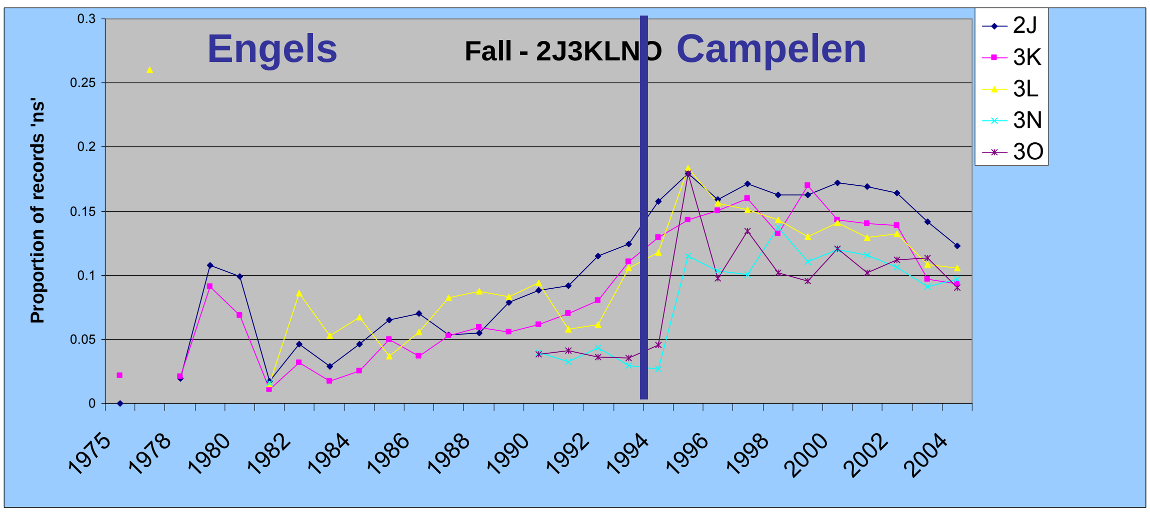


Figure 2. Proportion of records not recorded to species in each NAFO division during spring and fall surveys.

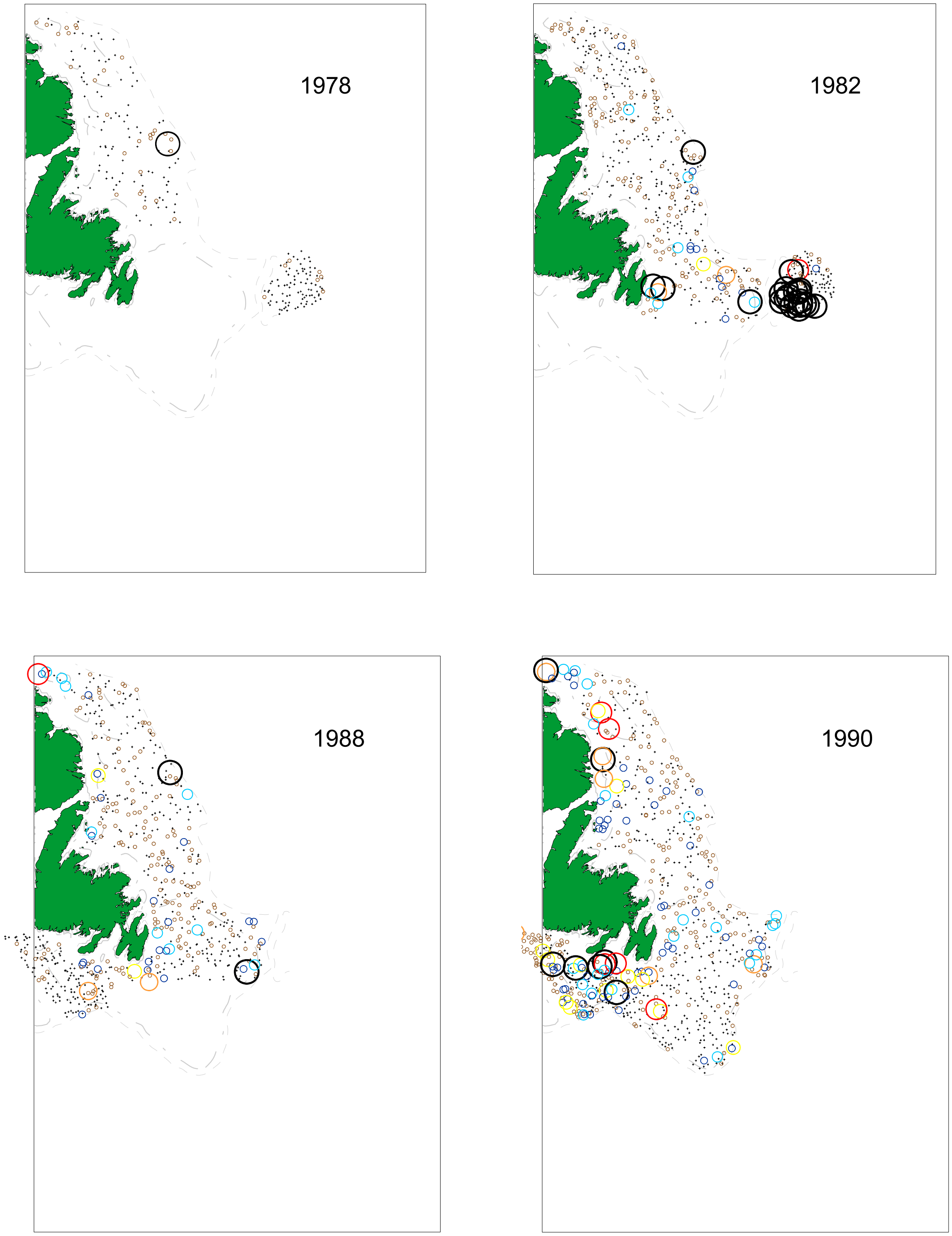


Figure 3. Percent of records not recorded to species during fall surveys in 2J3KLNO and 3P (selected years). Circle size increases with proportion of unspeciated catch records.

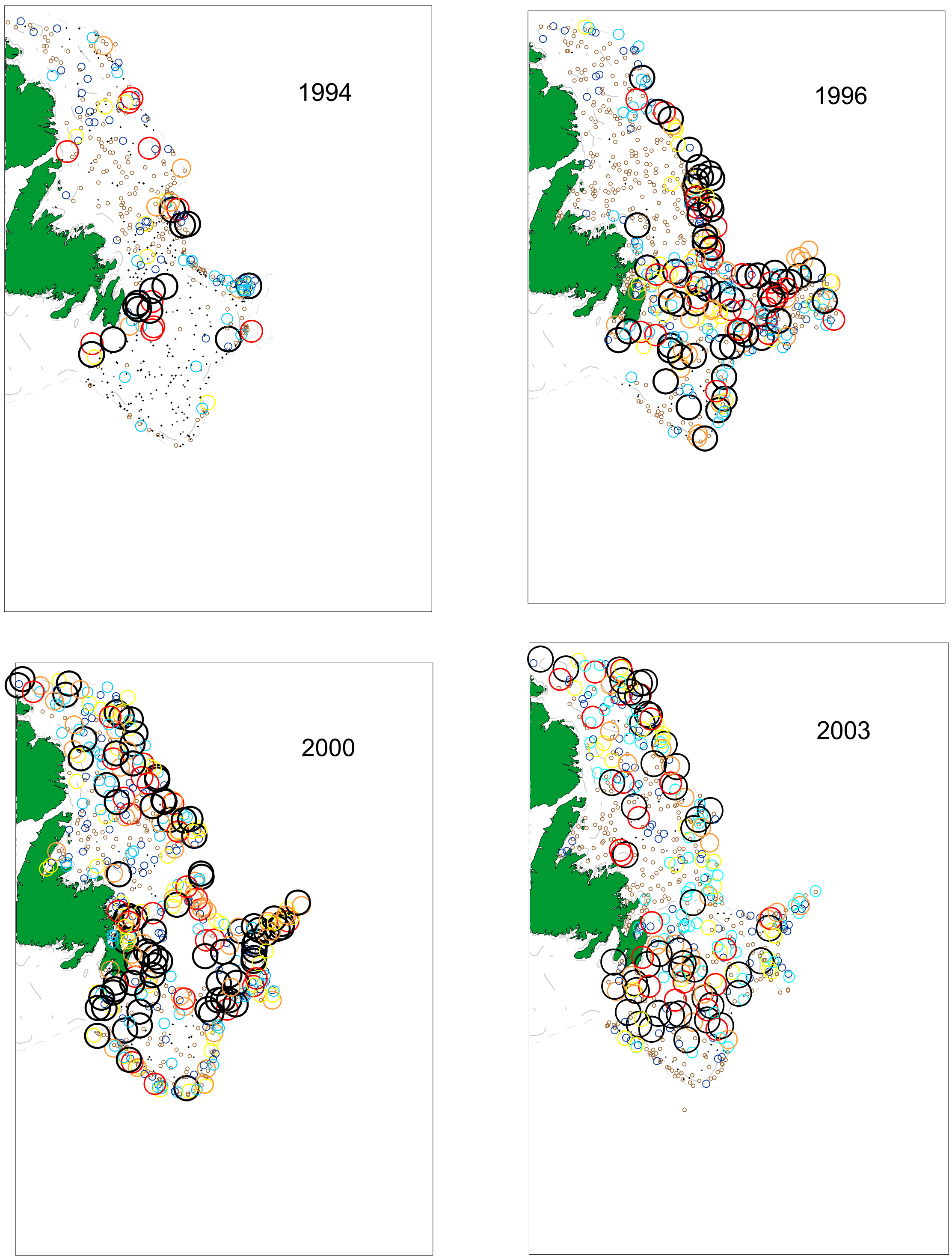


Figure 3 (continued). Percent of records not recorded to species during fall surveys in 2J3KLNO and 3P (selected years only). Circle size increases with the proportion of unspeciated catch records.

The second paper entitled "Changes in the fish community of the NAFO Divisions 2J3KLNO in the period 1981-2004: Searching for signals and trends from the Newfoundland Region multi-species trawl survey" (M. Koen-Alonso, F. Mowbray, and G. Lilly) was presented by Mariano Koen-Alonso.

Introduction

The marine ecosystem off Newfoundland and Labrador underwent dramatic changes in the last 30 years. These changes involved, among others, the collapse of major commercial fish stocks like northern cod and American plaice, and the dramatic increase of some shellfish species like northern shrimp and snow crab. The cause of these changes is still under debate, although most hypotheses identify one (or combinations) of the following factors: overfishing and selective fishing (i.e., fishery driven changes in the genetic composition of the stocks), environmental forcing (cold and warm periods with the related contraction or expansion of species ranges), and trophic interactions (cultivation-depensation, predation release by large fish, and predation increase by seals).

During this period, the Newfoundland Region of the Department of Fisheries and Oceans carried out bottom-trawl surveys originally intended for stock assessment of the main commercial fish stocks. However, the scope of these surveys changed along time. Since mid-1990s, they became “multispecies surveys”, and more attention was given to other fish and invertebrates, including commercially-important shellfish species. Among some of the major changes of the survey, we can mention the incorporation of nearshore, and deep water strata at different points in time, the redefinition of the strata moving from fathoms to meters, vessel changes, and the change in gear occurred in 1995-96, where the Engels trawl was replaced by the Campelen trawl. Unlike the Engels, the Campelen is a shrimp trawl which performs much better at catching small fish and invertebrates.

In this context, our intention here was to perform a preliminary analysis of the trawl survey database with two basic objectives in mind: a) explore the changes in the fish community beyond the major commercial species; and b) identify possible trends and indices that can be useful for tracking and/or early signalling of changes in the fish community.

Materials and Methods

Before any analysis, an extensive quality control of the data was performed. This process involved the definition of operational species (minimum taxonomic level at which the information was consistently recorded over time) and the selection of core strata (strata that were consistently sampled along time). The details about this process are described above in the material presented by Mowbray and collaborators.

Besides considering only core strata, the analysis was divided in two geographical regions and two time periods. The geographical regions were the NAFO Divisions 2J3K (Newfoundland Shelf) and 3LNO (Grand Banks). To maximize consistency and time coverage, the 2J3K region was assessed using the fall survey, while the 3LNO was assessed using the spring survey. Regarding time periods, the analysis was divided by gear, where the earlier period (1981-94, in 2J3K; and 1985-95, in 3LNO) corresponds to the use of the Engels trawl, and the recent period (1994-2004, in 2J3K; and 1995-2004, in 3LNO) corresponds to the Campelen trawl. This distinction was necessary due to the current lack of conversion factors for non-commercial species between these two fishing gears. The survey coverage and the number of sets corresponding to these four series are presented in Figure 4.

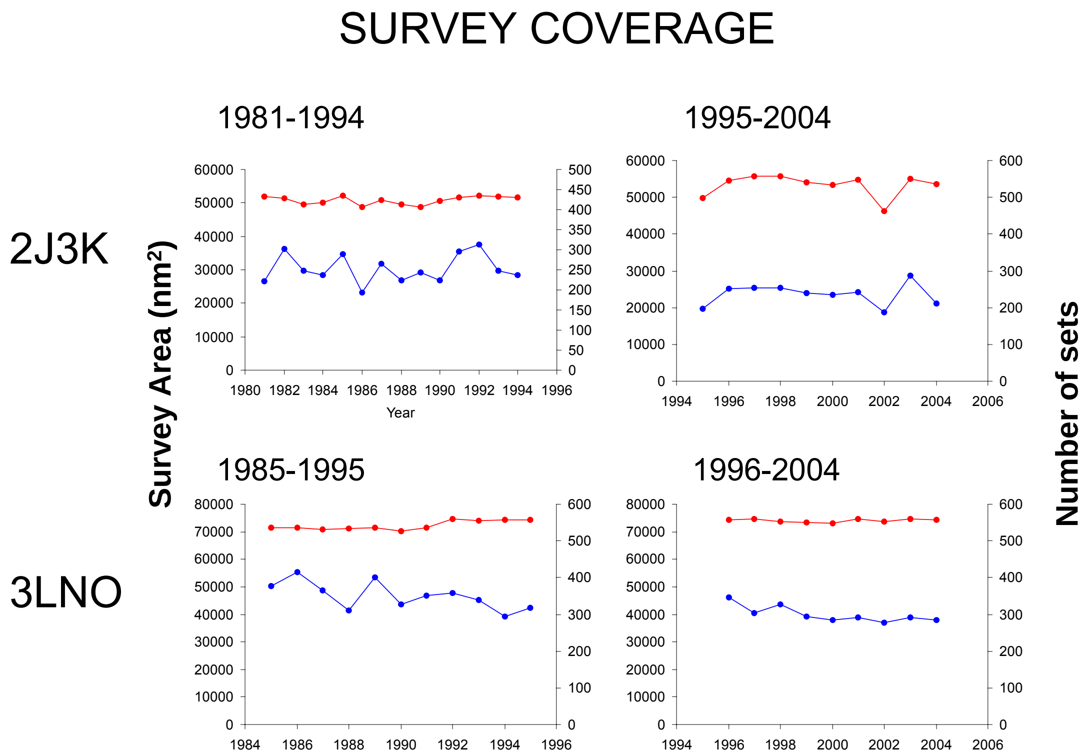


Figure 4. Survey coverage and number of sets per year for the core strata considered in this study.

The basic survey indices calculated were total biomass, total abundance, and the biomass over abundance ratio (BA ratio), which provides an idea of average size. Biomass and abundance were calculated as standard stratified random sampling estimates, while the BA ratio was calculated as total biomass over total abundance. The variance for the BA ratio was approximated using the delta method and the estimated variances for biomass and abundance. These indices were calculated by operational species and by functional groups (e.g., large demersals, small demersals, etc.).

Finally, the biomass and abundance estimates were used to explore the potential utility of some classical diversity indices for detecting and/or tracking the changes in the fish community. The diversity indices considered were species richness (S) and Shannon-Wiener (H’). We also produced k-dominance plots based on biomass and abundance, and compared them graphically (ABC plots). A synopsis of these comparisons was produced using the W statistic (Clarke 1990).

<u>Results</u>

A total of 173 different operational species were recorded in the core strata of Div. 2J3KLNO. Unsurprisingly, the species richness per year was lower with the Engels (59.58±6.30, mean ± standard deviation) than with the Campelen (89.55±4.98). This difference is due to the higher catchability of the Campelen trawl (as a rule of thumb it can be expected that for any given species the catchability of the Campelen will be equal or higher than the Engels). Within each gear series, there were no differences in species richness between the Newfoundland Shelf (2J3K) and the Grand Banks (3LNO).

Overall, there was a large reduction in fish biomass and abundance in the period 1985-95, and a lack of recovery since then (Fig. 5). The BA ratio also showed a negative trend (Fig. 6).

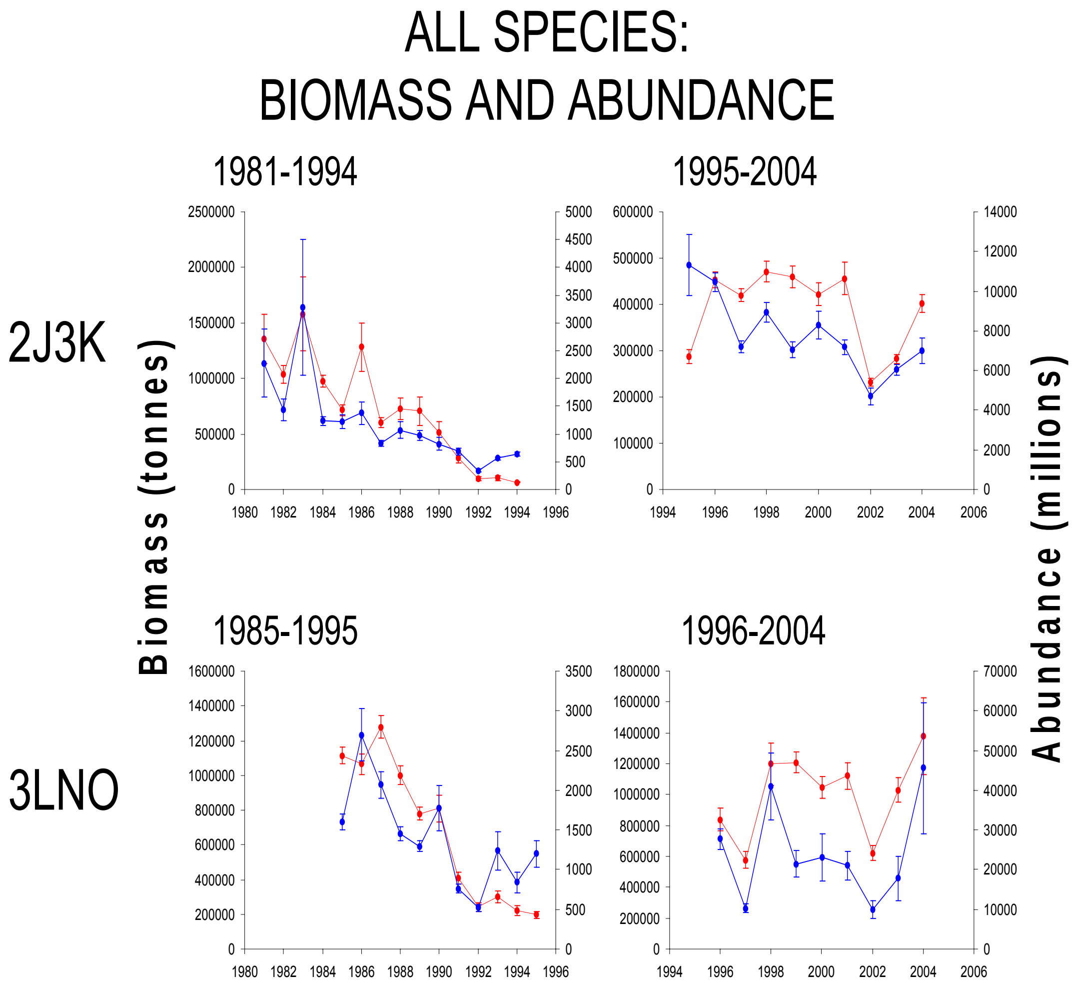


Figure 5. Total biomass (red) and total abundance (blue) for all fish species in the bottom-trawl survey.

Although the Engels (left) and the Campelen (right) series cannot be directly compared due to catchability issues, when considering all species together, the scale of biomass provides a hint to relate both series; all the dynamic in the Campelen years coarsely corresponds to the lower biomass levels in the last Engels years. All error bars correspond to one standard deviation.

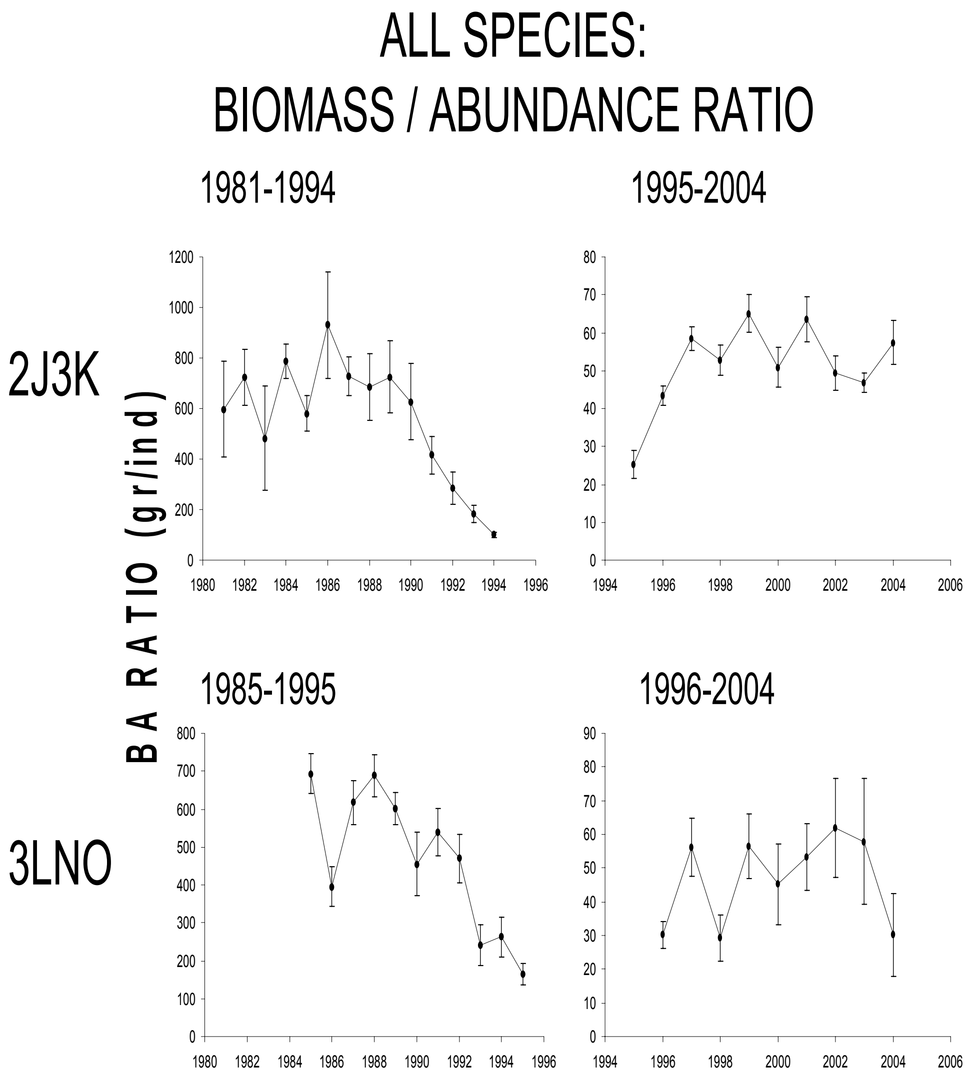


Figure 6. BA ratio for all fish species in the bottom trawl-survey. Although a bit nosy, this index shows a consistent reduction in the average fish from the late 1980s to the mid-1990s. This signal is clearer in 2J3K.

The observed declined in total biomass and abundance is not just driven by the main commercial species. Considering only large demersal species, a functional group of 65 operational species which includes ellpouts, wolfishes, grenadiers, flatfishes (others than American plaice, Greenland halibut, and yellowtail flounder), among others, the decline is also clear (Fig. 7). Furthermore, in 2J3K this functional group shows signals of decline much earlier than northern cod, reducing its biomass and abundance indices by almost half between 1984 and 1986. The decline also occurs in 3LNO, but becomes evident later in time. After the collapse, this functional group shows no sign of recovery. The BA ratio of large demersal species also showed a reduction in average size during the last collapse, but also showed a short-lived increasing trend in the 1985-89 period (Fig. 8). Before 1985, the BA ratio had a declining trend in 2J3K, the only region with available data. After 1995, this index does not show any clear trend.

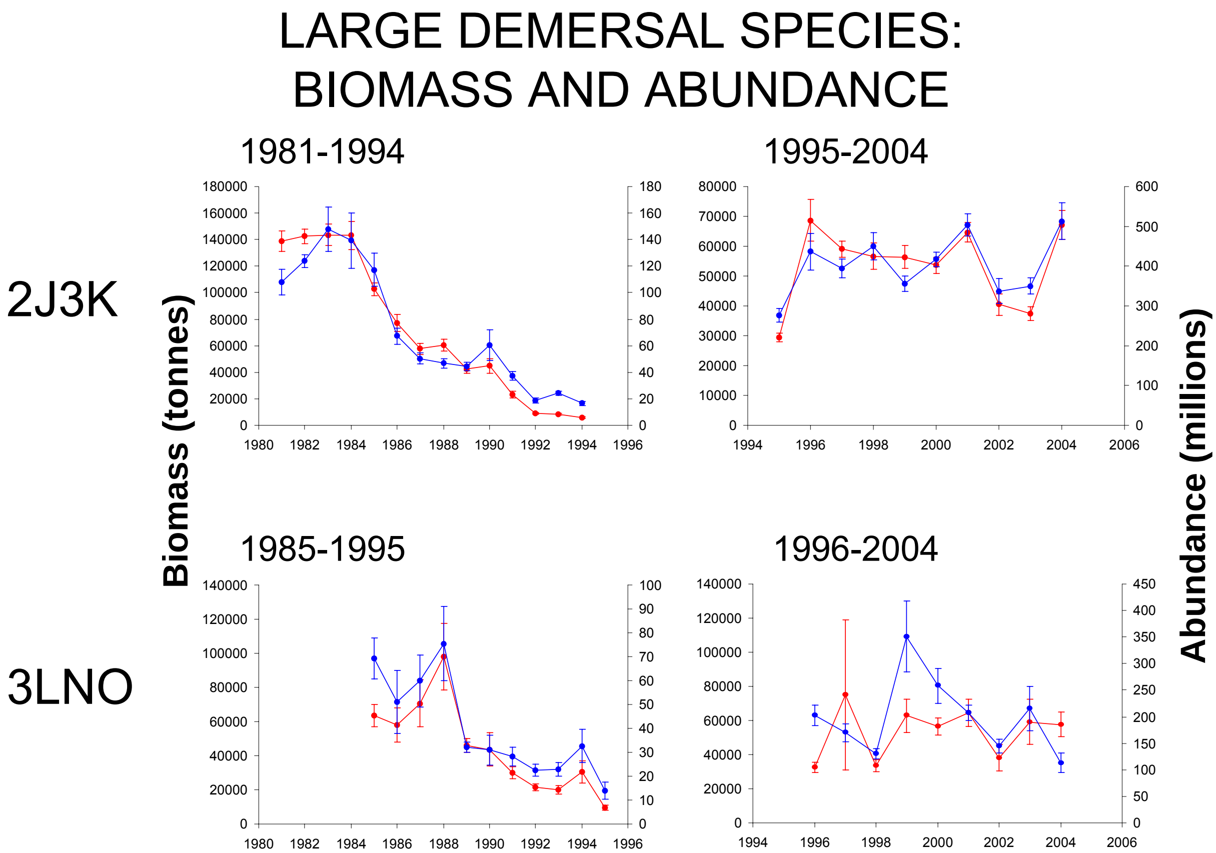


Figure 7. Total biomass (red) and total abundance (blue) for large demersal species in the bottom-trawl survey. All error bars correspond to one standard deviation.

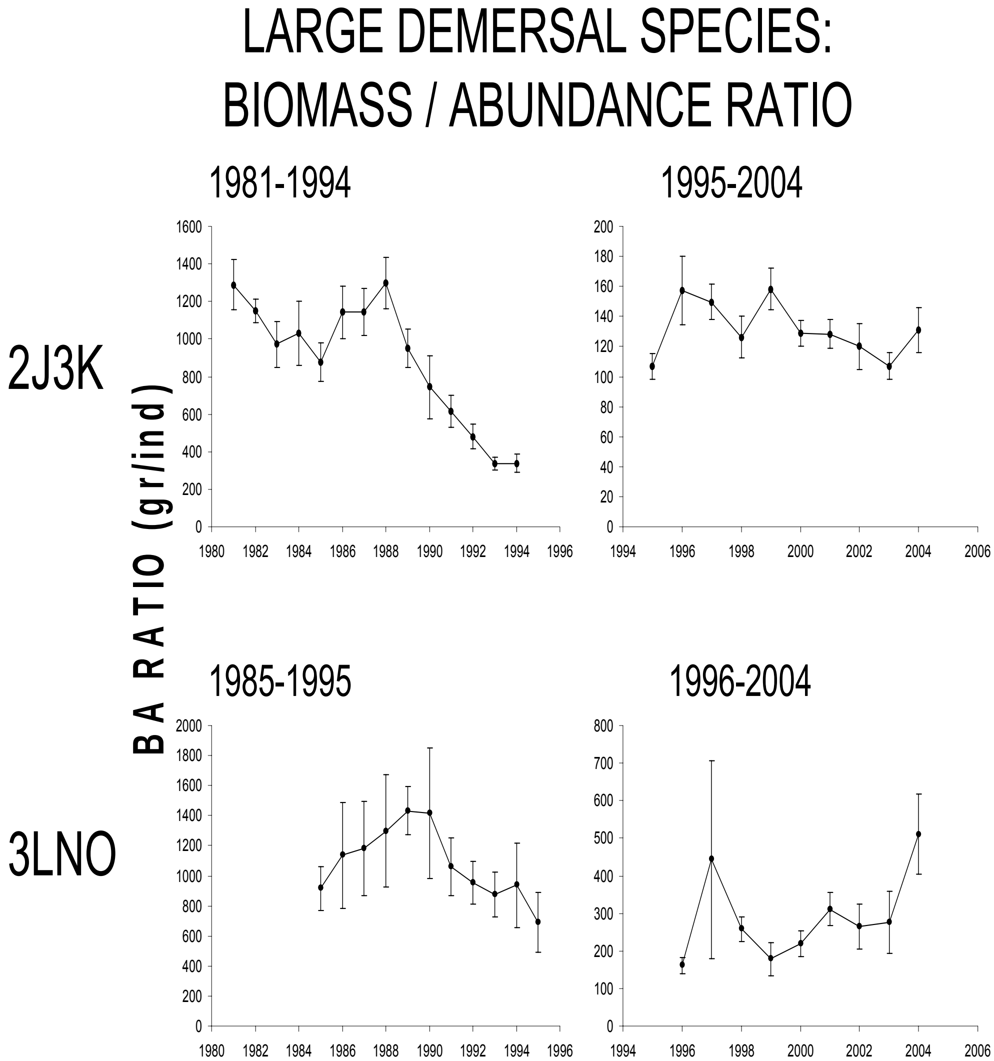


Figure 8. BA ratio for large demersal species in the bottom-trawl survey. All error bars correspond to one standard deviation.

Unlike large demersal species, the small demersals functional group showed less dramatic changes. This group is composed by 94 fish species, and includes alligator fishes, sculpins, blennies, and seasnails, among others. In the 1981-95 period, the total biomass of the group showed no clear trend in 2J3K, but decreased (although with a noisy signal) in 3LNO (Fig. 9). On the other hand, abundance showed a positive trend in the Newfoundland Shelf and a decline in the Grand Banks. Since 1995, there is no clear trend in biomass in both regions, but although abundance does not show any clear signal in 2J3K, appears to continue declining in 3LNO.

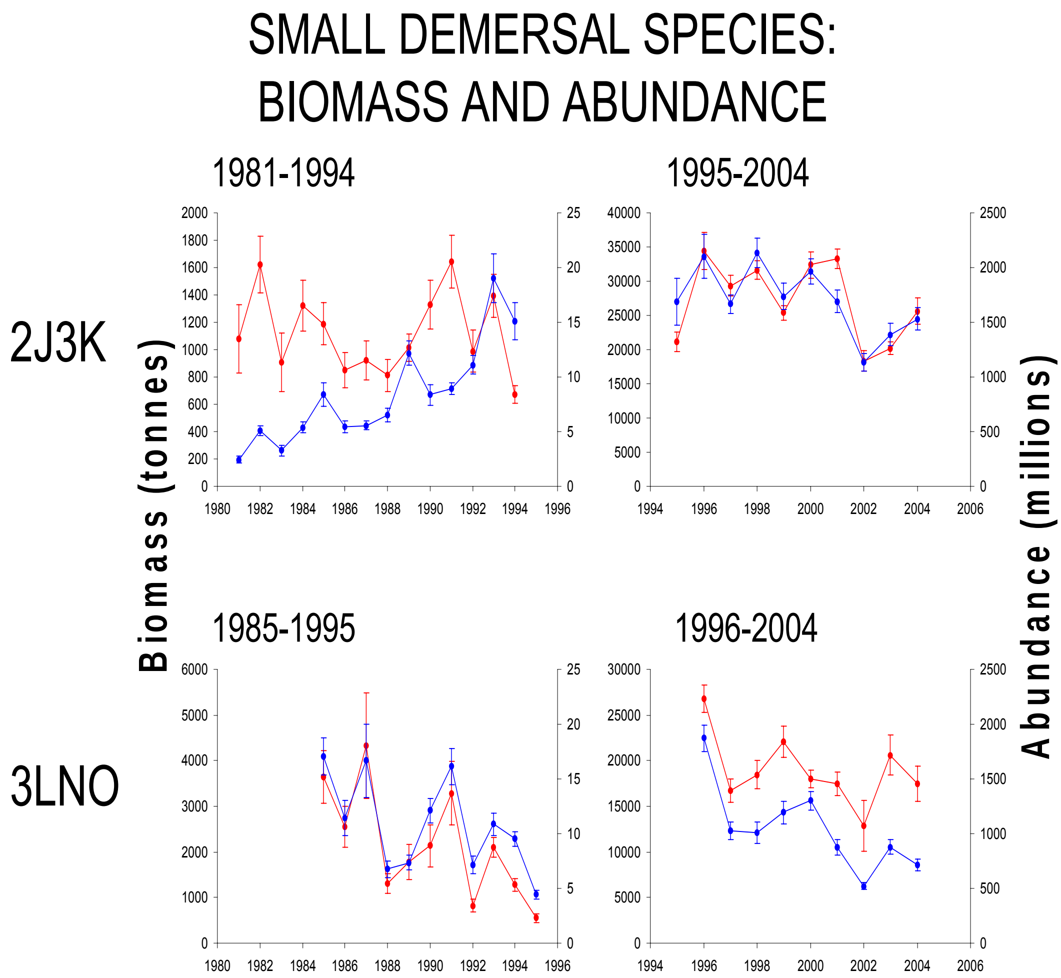


Figure 9. Total biomass (red) and total abundance (blue) for small demersal species in the bottom-trawl survey. All error bars correspond to one standard deviation.

Although, as a group, the small demersals showed comparatively less changes than large demersals or commercial species, some components of this group did show dramatic changes. For example, northern alligator fish increased dramatically during the 1981-95 period, and declined since then (Fig. 10).

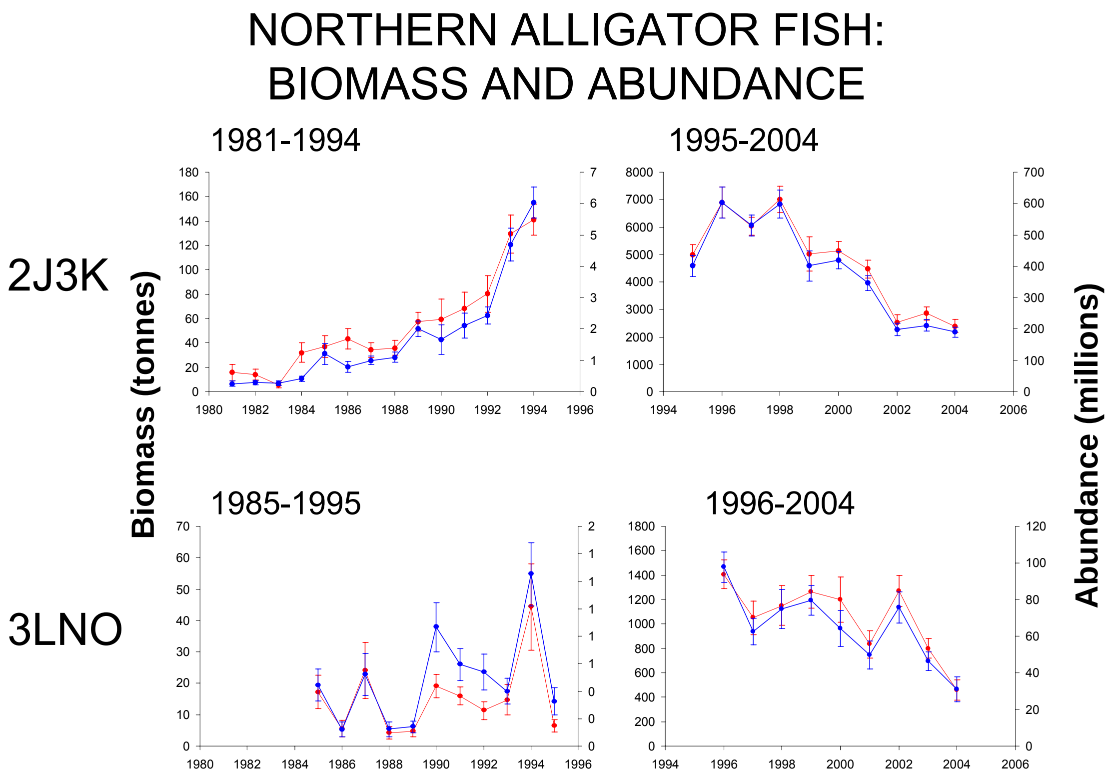


Figure 10. Total biomass (red) and total abundance (blue) for northern alligator fish in the bottom-trawl survey. All error bars correspond to one standard deviation.

Regarding pelagic species like capelin and Arctic cod, it is obvious that a bottom-trawl survey is not the best way for assessing their status. Nevertheless, and with all the necessary warnings, the signals from the bottom-trawl survey suggest that Arctic cod increased in the 1981-95 period, and declined after that. On the other hand, the capelin signal in the survey is extremely noisy, showing peaks of high abundance and biomass, followed by very low values. Overall, there is no clear trend for this species, but based on the amplitude of the peaks, a potential decline in 3LNO during the 1985-91 period could be suggested.

As aggregate indicators, the two diversity indices examined did not show any clear trend (Fig. 11), regardless of the strong changes observed in the fish community. The lack of changes in species richness could be seen as an indication that, in spite of all the perturbations and changes, the community did not lose species. On the other hand, the lack of signal in the Shannon-Wiener index, which considers both number of species and relative abundance/biomass, clearly suggests that the sensitivity of this index for detecting changes like the ones observed in the Newfoundland system is extremely poor. In either case, the potential of these indices for becoming useful indicators of ecosystem status appears extremely low. However, they appear to be more useful when they are disaggregated in space (see the material presented next by Kulka).

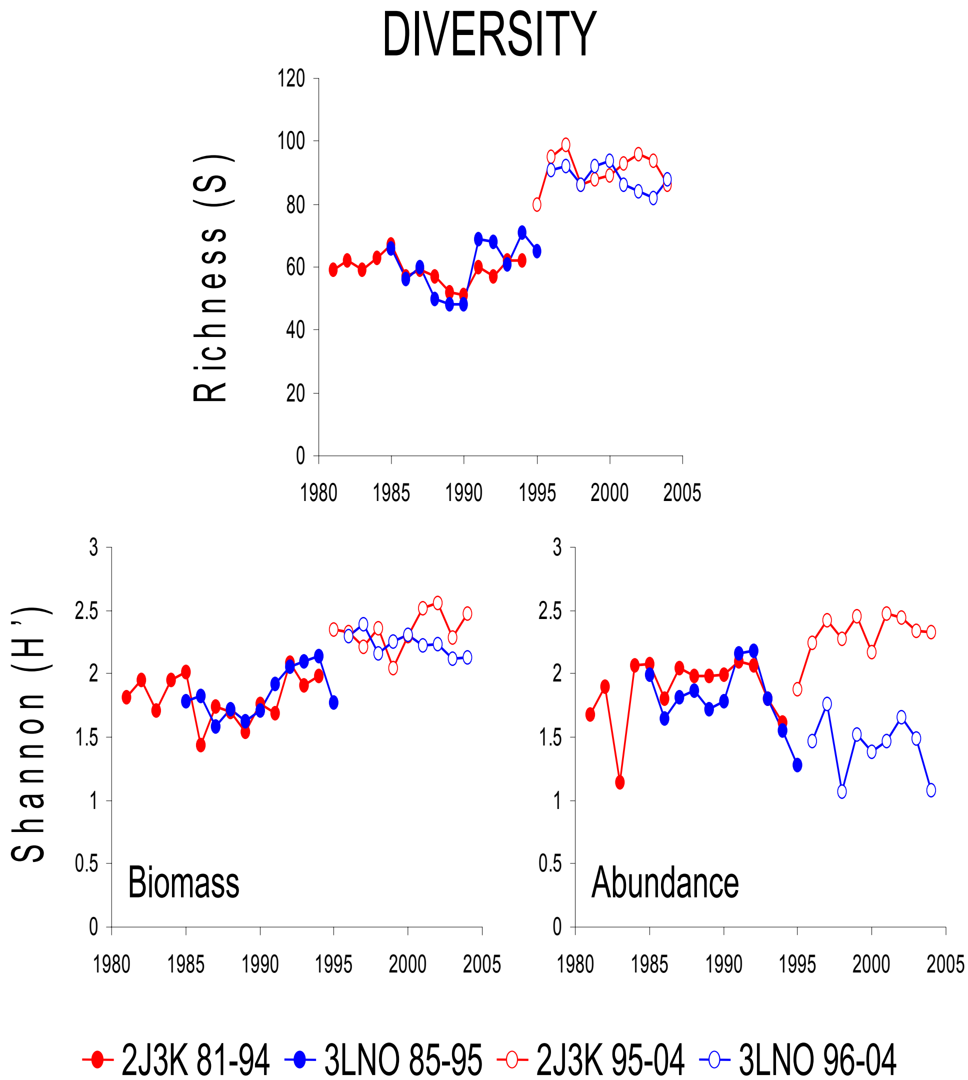


Figure 11. Species richness and Shannon-Wiener diversity index calculated in biomass and in abundance for the two regions and periods considered in this study.

Since k-dominance curves reflect diversity in a bi-dimensional plot instead of collapsing all the information into a single number, they have better chances to capture the changes in the structure of the community. When these curves are calculated by abundance, biomass, and plotted together, they constitute the so-called “abundance-biomass comparison” plots or ABC plots (Warwick 1986). The relative position between the abundance and dominance k-dominance curves in an ABC plot has been used as a graphical indicator of the level of disturbance/pollution of the system (Clarke and Warwick 2001). ABC plots are more informative than simple diversity indices (Fig. 12), but since one plot per sample (year and region) is produced, the evaluation of trends and patterns can become cumbersome very quickly. To address this issue, the W statistic, a single summary statistic, can be calculated to represent the difference between the abundance and biomass k-dominance curves (Clarke 1990, Clarke and Warwick 2001). In our case, plotting W by year provides a synoptic view of how the relationship between abundance and biomass k-dominance curves varied along time. Unlike simple diversity indices, the W statistic appears to track the changes in the fish community along time (Fig. 13).

Although the interpretation of this pattern requires further examination before any robust conclusion can be drawn the fact that the W statistic captures it, suggests that it has potential for becoming a useful diversity-based indicator of the status of the community.

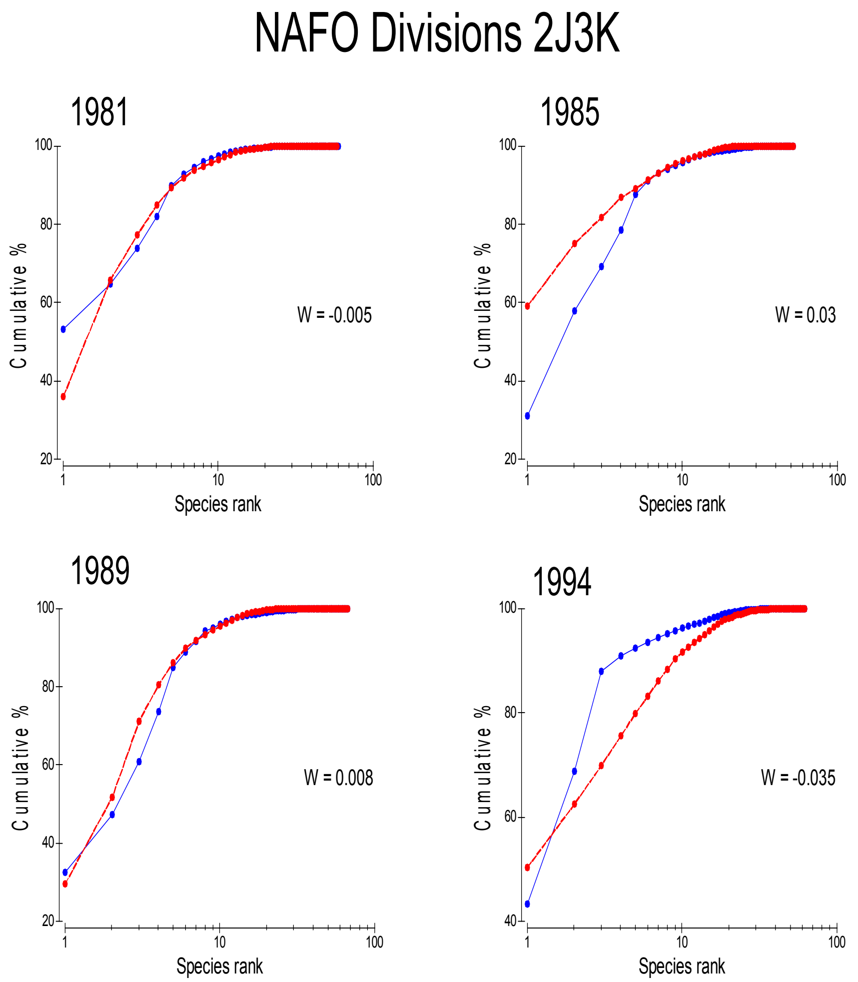


Figure 12. Illustrative ABC plots for the Newfoundland Shelf (2J3K) corresponding to the following years: 1981, 1985, 1989, and 1994. The biomass k-dominance curve is in red and the abundance one is in blue. The W statistic which appears in each plot is a signed measure of the difference between the two plots.

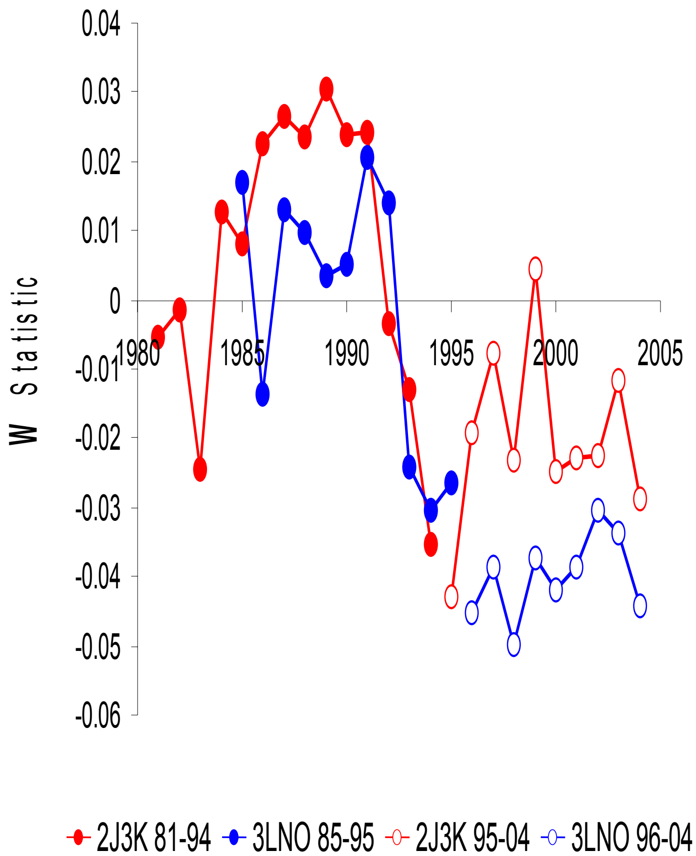


Figure 13. Temporal changes in the relative position of abundance and biomass k-dominance curves, summarized through the W statistic, for the two regions and two periods considered in this study.

<u>Conclusion</u>

This preliminary analysis highlights the fact that the collapse in the main commercial fish stocks observed during the late 1980s and beginning of the 1990s, was accompanied and occasionally preceded, by similar collapses in the non-commercial large demersal species. These collapses were also characterized by a general reduction in the overall mean weight of fish. Since then, no major recovery of the fish community has been observed.

This lack of recovery does not mean that the fish community has achieved some sort of "stability". Some small demersals (e.g., northern alligator fish) and Arctic cod, which clearly increased when the major fish stocks were collapsing, are now clearly declining. The fish community is still undergoing changes.

Regarding indicators of ecosystem status (more precisely, status of the fish community), the basic analyses performed here suggest that no single survey index performs well in isolation, but when examined together they may become useful flags or early warnings for major changes in community structure.

Diversity indices when calculated as aggregates (i.e., without any spatial consideration) appear to be extremely poor indicators of community changes. However, synoptic summary statistics from ABC plots like the W statistic, show potential for becoming useful indicators of changes in the community structure and deserve further examination.

In any case, all these indicators without understanding the processes that make them change, only provide a rudimentary base for management advice. Stand-alone indicators (i.e., without process understanding) are of little use for comparisons among alternative management scenarios. Understanding the processes behind their changes must become a priority if we want to seriously move towards ecosystem-based approaches to fishery management.

The third paper contributed by the Newfoundland Region was entitled “Biodiversity mapping in the Newfoundland and Labrador Region”. It was prepared and presented by Dave Kulka.

Measures of biodiversity are generally interpreted over broad areas such as eco-regions with no attention to the discreet spatial patterns. However, ecological measures of diversity may vary spatially over time at much smaller scale than eco-region. Small scale variation over time is useful in identifying ecological shifts at the scale of the species.

The data used in this study comprised demersal species captured during the spring and fall surveys of the Newfoundland and Labrador Region. The mapping methodology used convert point data to surfaces is described in Kulka (1998). Spatial patterns on the Grand Banks, northeast Newfoundland and Labrador shelves were compared for two periods 1978-84 and 1990-95, the former a period of relatively high abundance of demersal fish species and the latter a period when the abundance of most commercial species were at a minimum.

Spatial patterns were highly variable among areas, and over time, for all indices mapped, namely richness, Shannon-Weiner, number/tow, number of individuals/species, average weight, and species richness (number species/set), underwent a considerable reduction over much of the range of the survey (Fig. 14). Greatest reductions were observed broadly over the northeast Newfoundland Shelf, except along the outer shelf edge. Lesser reductions were observed on the Grand Banks, particularly the northern extent of the Grand Banks. Koen-Alonso (this report) noted that the measure of richness over the entire area was relatively stable over time. This spatial analysis indicates that a similar level of richness was consistent between periods over only a limited extent of the entire area.

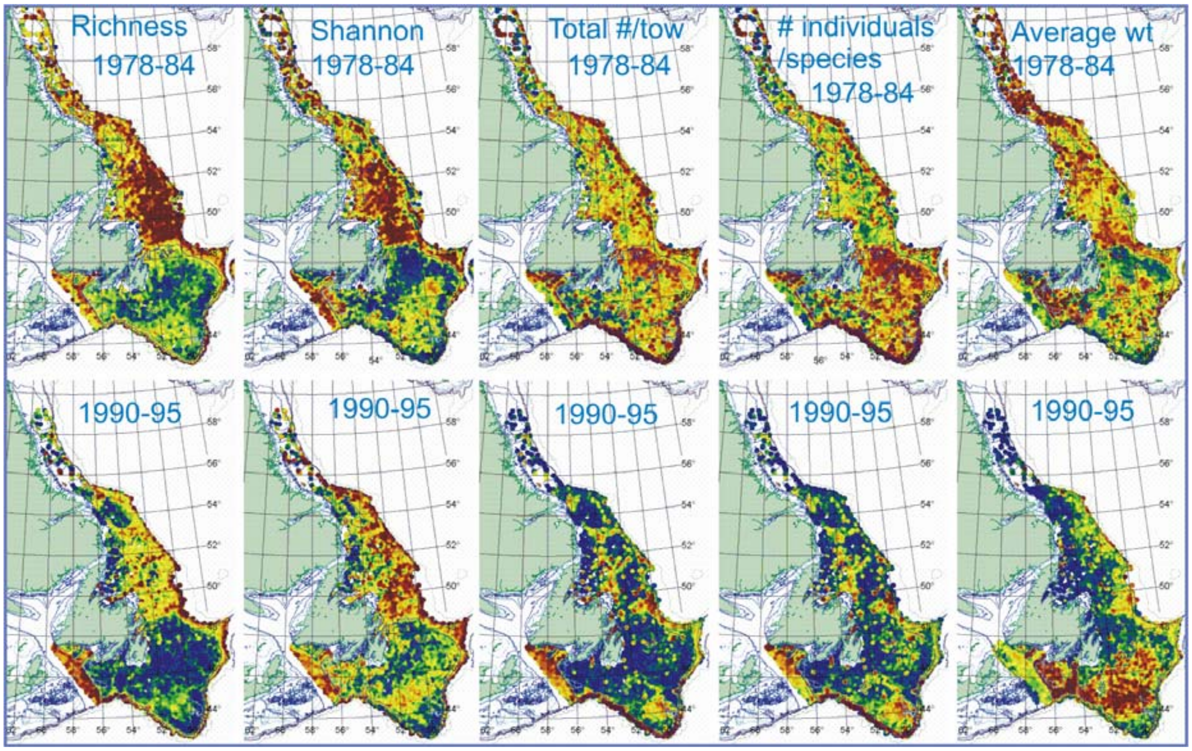


Figure 14. Different measures of biodiversity for marine fish taken in research trawl surveys (1978–1984 and 1990–1995) off Newfoundland and Labrador using Engel trawl gear. From left to right: richness (species count), Shannon-Weiner (richness and dominance), total number per tow (showing distribution of total abundance), number of individuals per species (dominance), and average weight (total weight/total count of individuals).

Two equitability (evenness)-richness (species count) indices, Shannon-Weiner and Simpson showed a spatially high degree of similarity, with moderate similarity to richness. Thus, only Shannon-Weiner is represented in Fig. 14. This index underwent the greatest reduction on the shallowest parts (the banks) of the northwest Newfoundland and Labrador shelves, particularly the coastal banks adjacent to Labrador, but remained relatively high in the deep troughs between banks and along shelf edge. Reductions were less on the Grand Banks and Laurentian Channel.

Total numbers per tow (spatial representation of abundance) underwent a dramatic reduction over much of the area surveyed (Fig. 14), concurrent with the reduction in total abundance for the area surveyed, as reported previously by Koen-Alonso. Abundance was more homogeneous during 1978-84, but with hot spots along the shelf edge and on the inner northern Grand Banks, off the northeast coast of Newfoundland and the western extent of the south coast of Newfoundland. Abundance remained relatively high at only a few, mainly deeper, locations in 1990-94; namely the central troughs of the northeast Newfoundland Shelf, the Bonavista Corridor, and the Laurentian Channel.

Total abundance remained high at one shallow location on the southern Grand Banks in the vicinity of the Southeast Shoals. The greatest change (reduction) between periods occurred on the northern Grand Banks; consistently the coldest location of the entire survey area.

Number of individuals per species (evenness) also underwent reductions (Fig. 14). The pattern of change was spatially very similar to total abundance, the greatest reductions occurring on the on the northern Grand Banks, and the least change in the deeper areas, the troughs and shelf edge, and on the southern Grand Banks.

The locations where the highest average weights (total weight/total count of individuals) underwent a significant shift between the two periods are shown in Figure 14 as the red areas. In 1978-94, the largest animals were distributed to the north on the Labrador Shelf and parts of the northeast Newfoundland Shelf, particularly the area just north of the Grand Banks (Bonavista Corridor). Large fish were also observed on the St. Pierre Bank during that period. During 1990-95, large fish were located mainly on the central part of the Grand Banks and St. Pierre Bank. Smallest fish were observed on the northern Grand Banks and the inner extent of the northeast Newfoundland and Labrador shelves.

The three biodiversity indices: richness, Simpson, and Shannon-Weiner were highly correlated with bottom temperature, such that higher temperature was associated with higher biodiversity (Fig. 15). Future research will examine changes in the distribution of biodiversity (richness and equitability) over time in relation to the environment, particularly bottom temperature and depth.

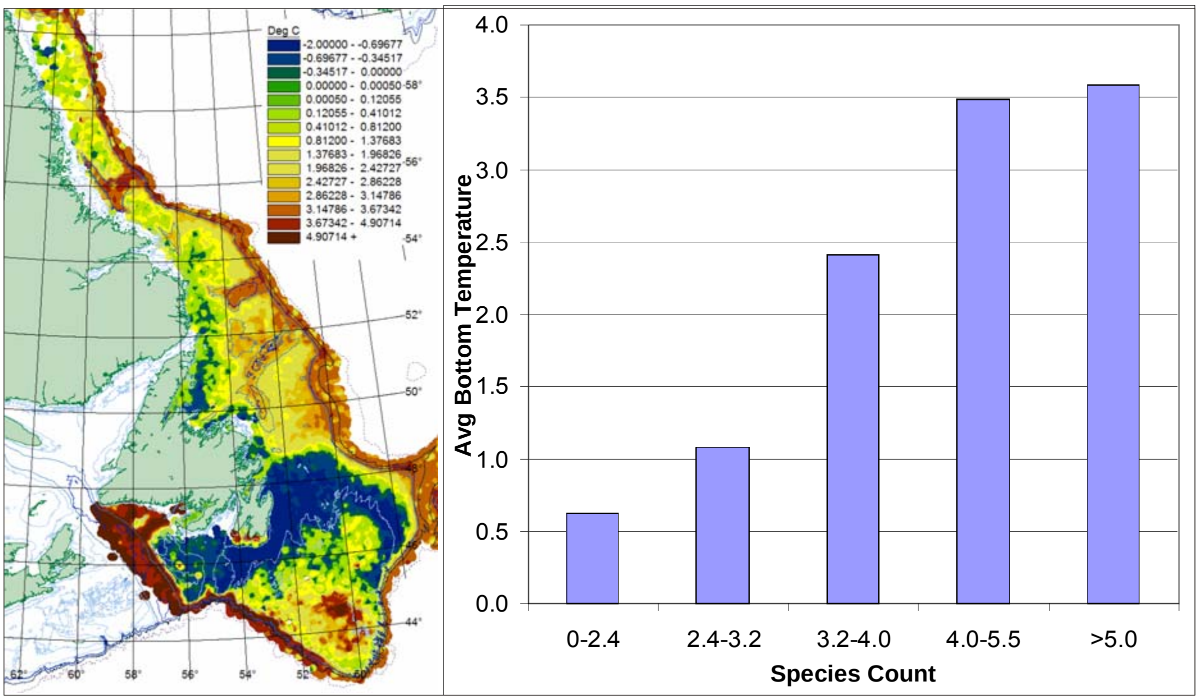


Figure 15. Bottom temperature (left panel) in relation to species count (right panel).

Examples of distribution of individual species were also presented (Fig. 16) to illustrate different associations among species with respect to depth and bottom temperature. Bottom temperatures within the study area generally range between -2ºC and 6ºC. Examples of species associated with “warm-water” (average associated bottom temperature >3ºC) *vs.* cold-water (<~1ºC) conditions and deep (average depth >700m) *vs.* shallow (<200m) were shown.

Based on 30 species examined, several have been found to have highly overlapping distributions with respect to temperature (Fig. 16) and depth (Fig. 17), such as: pollock *Pollachius virens* and haddock *Melanogrammus aeglefinus* (warm); spatulate sculpin *Icelus spatula*, northern alligatorfish *Leptagonus decagonus* and moutsache sculpin *Triglops murrayi* (cold); longhorn sculpin *Myoxocephalus octodecemspinosus* and yellowtail flounder *Limanda* *ferruginea* (shallow); and roundnose grenadier *Coryphaenoides rupestris* and black dogfish *Centroscyllium fabricii* (deep).

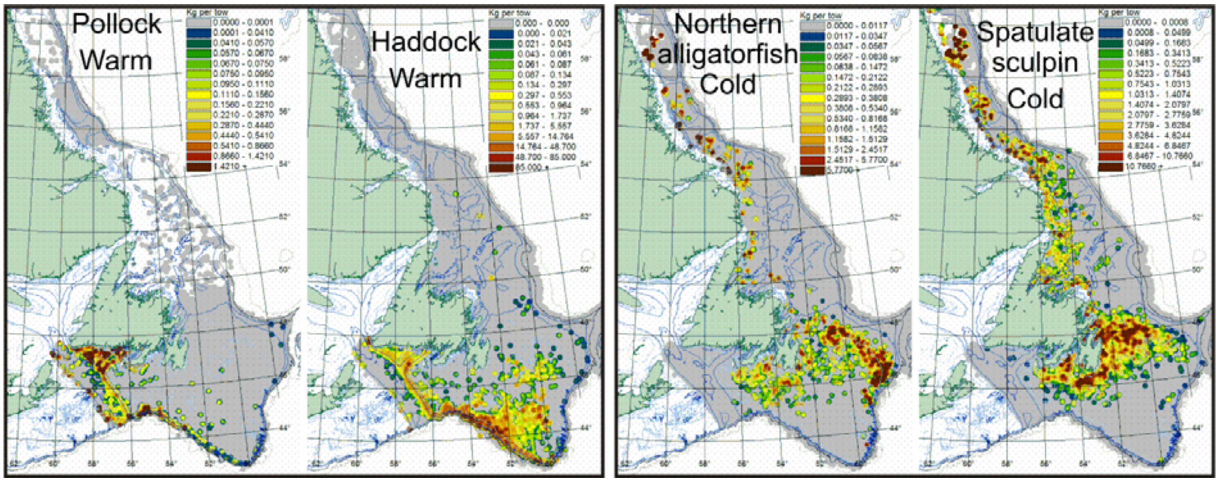


Figure 16. Examples of closely associated species in relation to bottom temperature.

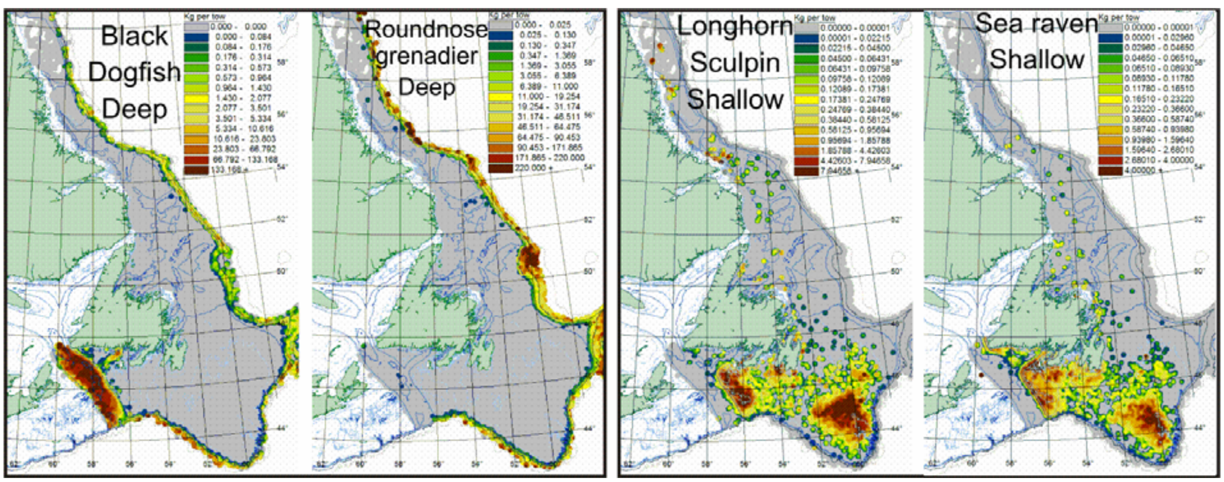


Figure 17. Examples of closely associated species in relation to depth.

Other species were observed to have very high spatial association (e.g., smooth skate *Malacoraja senta* and four-bearded rockling *Enchelyopus cimbrius*) comprising several well separated aggregations that appeared to bear little relationship to either depth or bottom temperature. In some but not all cases, the species were taxonomically closely related.

The changes in abundance over time will be examined for a sample of ‘warm-water’ *vs.* cold-water species. Preliminary analyses suggest very different trajectories of population abundance during an apparent “ecological shift” that occurred during the 1980s, and early 1990s. Also apparent from these preliminary analyses was a fairly consistent pattern of smaller average size in the cold-water species. A time series of matrices of temperature and depth association by size will illustrate these relationships across all species examined. This hypothesis needs to be investigated. Species associations and changes in abundance of associated species constitute some of the future work with respect to spatial changes in biodiversity and the environment.

3.2 Quebec Region

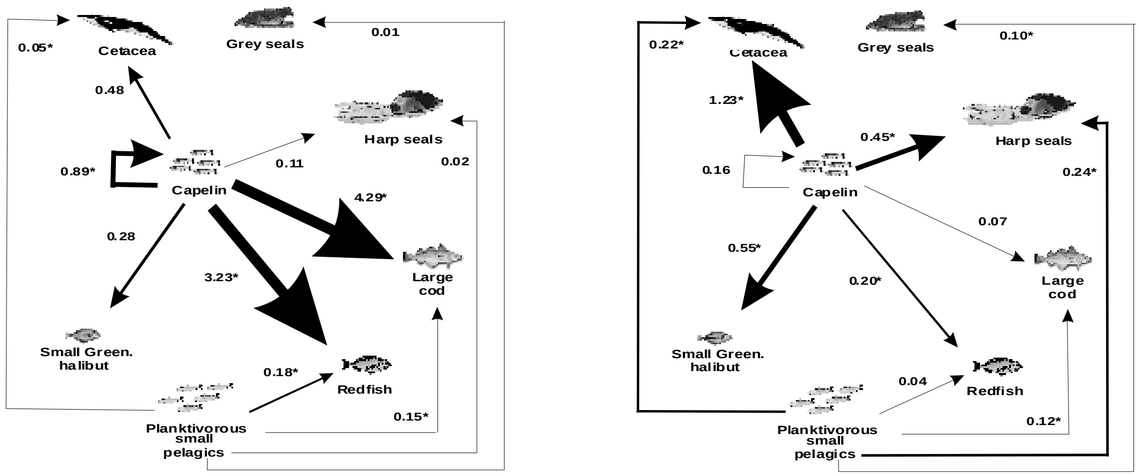
Claude Savenkoff presented a paper entitled "Overview of composition, abundance, and biomass of fish and invertebrates in the northern Gulf of St. Lawrence" (C. Savenkoff, P. Ouellet, and J. Gagné).

Mass-balance models, using inverse methodology, have been constructed for the northern Gulf of St. Lawrence for the mid-1980s, the mid-1990s, and the early 2000s to describe ecosystem structure, trophic group interactions, and effects of fishing and predation on the ecosystem for each time period (CDEENA 2003). Overfishing removed a functional group in the late 1980s, i.e., large piscivorous fish (Atlantic cod *Gadus morhua* and redfish *Sebastes* spp.), which has not been replaced 10 years after the cessation of heavy fishing. This has left only marine mammals as top predators during the mid-1990s, and marine mammals and small Greenland halibut (*Reinhardtius hippoglossoides*) during the early 2000s. Capelin (*Mallotus villosus*) and northern shrimp (*Pandalus borealis*), the main prey of the ecosystem in each period, showed an increase in biomass over the three periods. A switch in the main predators of capelin from cod to marine mammals occurred while Greenland halibut progressively replaced cod and redfish as shrimp predators (Figs. 18 and 19). These changes were accompanied by a decrease in total commercial landings and a transition in the fishery from long-lived and piscivorous groundfish toward planktivorous pelagic fish and invertebrates (Fig. 20).

In the northern Gulf, presently the research survey data includes: (1) the *Gadus Atlantica* (winter 1978-94; Engel trawl) and the *Lady Hammond* series (summer 1984-89; Western IIA trawl); and (2) the *Needler* (summer; URI 81/114trawl) from 1990 to 2003, and 2005 (no survey in 2004), and the *Teleost* data (summer; Campelen 1800 trawl) from 2004 to 2005. Except for the *Needler* surveys, the survey datasets require catchability correction for vessel and gear used. A few months ago, Jean-Denis Dutil and colleagues conducted a full review of the fish data in the annual bottom-trawl research surveys in order to determine whether species identifications and reporting have been reliable and consistent throughout. Several problems have been flagged and need to be addressed, some are minor and others not (e.g., not all the fish were identified and not all catches were recorded; some species were identified at specific years when specialists were aboard; identification of certain families such as Cottidae, Liparidae, and Zoarcidae was inadequate, etc.). Their report, including recommendations, is currently under peer review. For pelagic species, all bottom trawls used seem very inefficient for estimating distribution and relative abundance or biomass (e.g., mean weight values too low to account for landings).

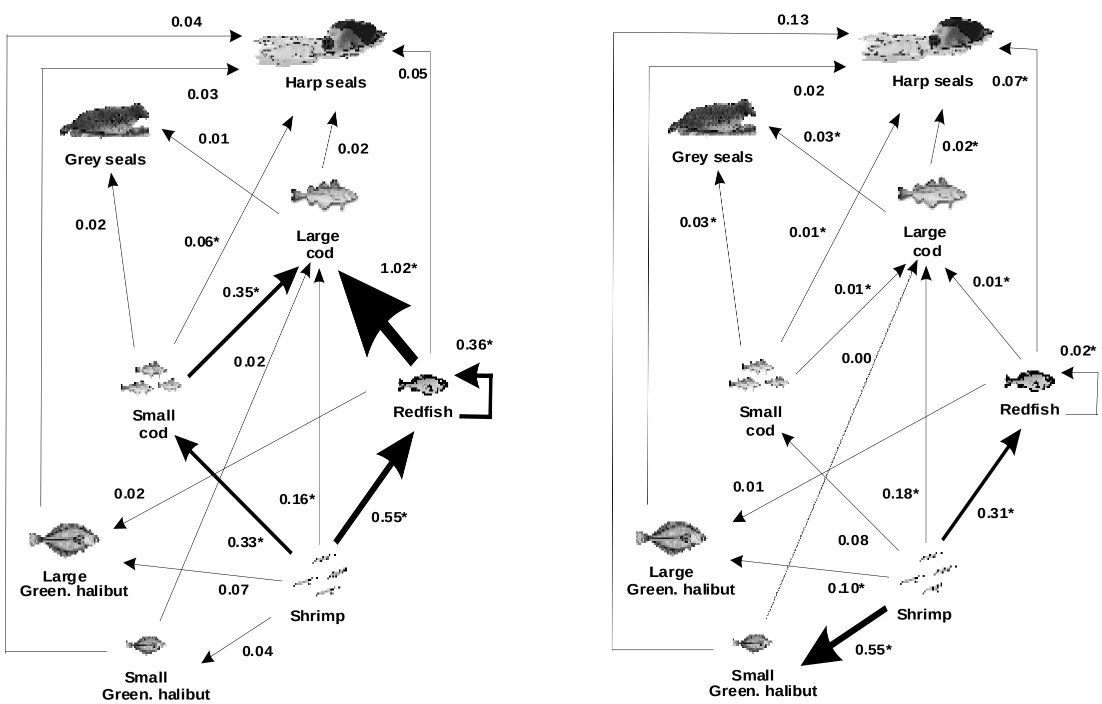
Based on the *Needler* data, only three to five species (redfish, capelin, Greenland halibut, Atlantic cod, and black dogfish *Centroscyllium fabricii*) out of 80 accounted for at least 70% of the total fish abundance and biomass (Fig. 21). There were general decreases in fish biomass and landings from the early 1990s, to the early 2000s, related to the net decrease in redfish and cod stocks. In contrast, biomass of Greenland halibut and northern shrimp increased over the same time period. Since the 1990s, an increase in cetacean and seal biomass was also observed (Fig. 22). There was also a general temperature increase during the 1990s, in the deeper layers (100-200 and 200-300m deep).

The future plans include: (1) validation of the data set (before the 1990s, and since 2004: quality control and catchability correction for vessels and gears used); (2) use of 2004-05 *Teleost* data for estimating composition and diversity (all specimens identified); (3) dominance and ordination analyses; and (4) result comparisons with other ecosystems.



Mid-1980s Early 2000s

Figure 18. Main predation flows (t km-2 y-1) on capelin and planktivorous small pelagic feeders (mainly Atlantic herring) estimated for each time period in the northern Gulf of St. Lawrence (NAFO Division 4RS).



Mid-1980s Early 2000s

Figure 19. Main predation flows (t km-2 y-1) on main demersal species (Atlantic cod, redfish, Greenland halibut, and northern shrimp) estimated for each time period in the northern Gulf of St. Lawrence (NAFO Division 4RS).

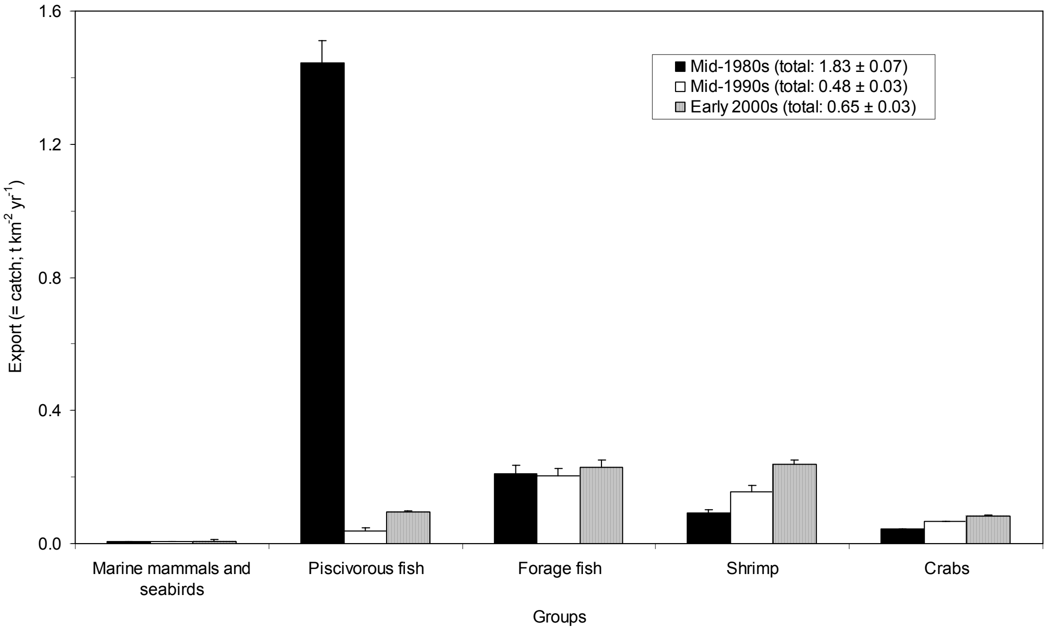


Figure 20. Distribution of catches by trophic group for each time period in the northern Gulf of St. Lawrence (NAFO Division 4RS). SD is shown.

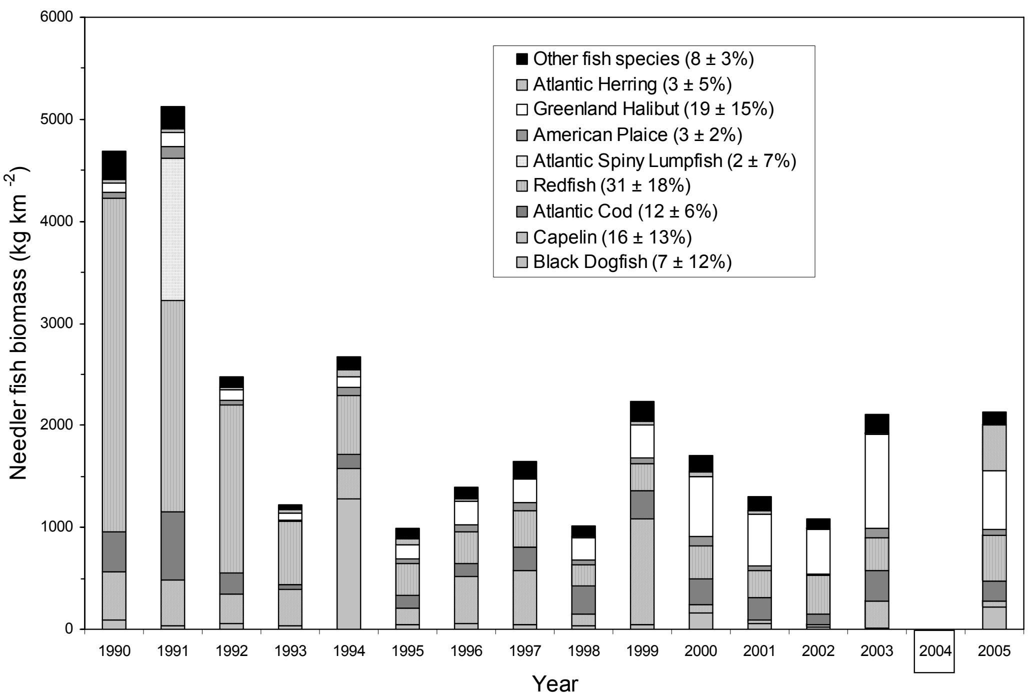


Figure 21. Main fish biomass in the northern Gulf of St. Lawrence (NAFO Division 4RS) based on Needler data (no survey in 2004).

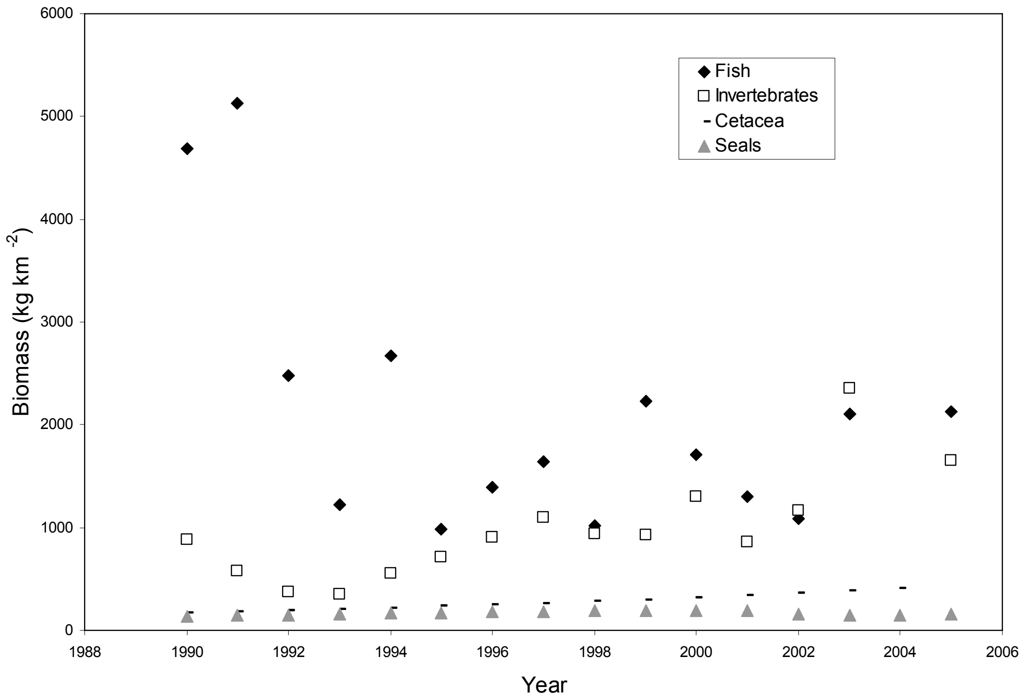


Figure 22. Main vertebrate and invertebrate biomass in the northern Gulf of St. Lawrence (NAFO Division 4RS) since the early 1990s.

3.3 Gulf Region

Hughes Benoît presented a paper entitled "Dramatic changes in the southern Gulf of St. Lawrence ecosystem coincident with the decline of large demersal fishes" (H.P. Benoît, D.P. Swain, S. Ancelet, and E. Parent).

The direct and indirect effects of fishing on marine ecosystems are attracting increasing attention worldwide. Understanding the impacts on non-target species and disentangling ecosystem responses to fishing and climate change remain particular challenges.

Using data from an annual survey of commercial and non-commercial fish abundance and a multi-variate analysis incorporating the ecological traits of each species, we identify strong and rapid responses in the southern Gulf of St. Lawrence marine fish community that we infer results from both fishing and changing oceanographic conditions. The species composition of this community has been in steady flux over a 32-year period, with abundance increasing and then declining for a succession of species. This has resulted in a system that is becoming increasingly dissimilar from its initial state at the onset of monitoring in 1971 (Fig. 23). At that time, the fish community was principally composed of larger-bodied species associated with temperate waters. Many of these species were directly affected by commercial fisheries, either as targeted or incidentally captured species. Following a prolonged period of cooling of the waters covering the bottom of much of the southern Gulf, and the collapse of several commercially-important species, the community has shifted to one dominated by small-bodied, cold-water species that are not considerably directly impacted by fisheries, and that spawn principally in the winter. At the aggregate community level, this has meant a shift in the composition of functional groups, with an increase in the proportion of pelagic fishes in the system since the mid-1980s, as well a change in the overall community size-composition resulting from a fishing-induced decrease in large-bodied fish and an increase in small-bodied fish believed to result from a trophic release.

In 2005, collaboration was initiated with statistical scientists in France to analyze data on the abundance and distribution of macro-invertebrates collected during the annual survey since the mid-1980s. The objective of the project is to use spatially explicit state-space models to try to disentangle the direct (trawling impacts) and indirect (trophic release) effects of fishing, and the impacts of a changing climate on the spatio-temporal population dynamics of several invertebrate taxa. By focusing on species that are either sessile, or that have limited mobility, we hope to assess the relative importance of these three factors. This work is ongoing and expected to be completed within two years, as part of the PhD. program of one of the collaborators.

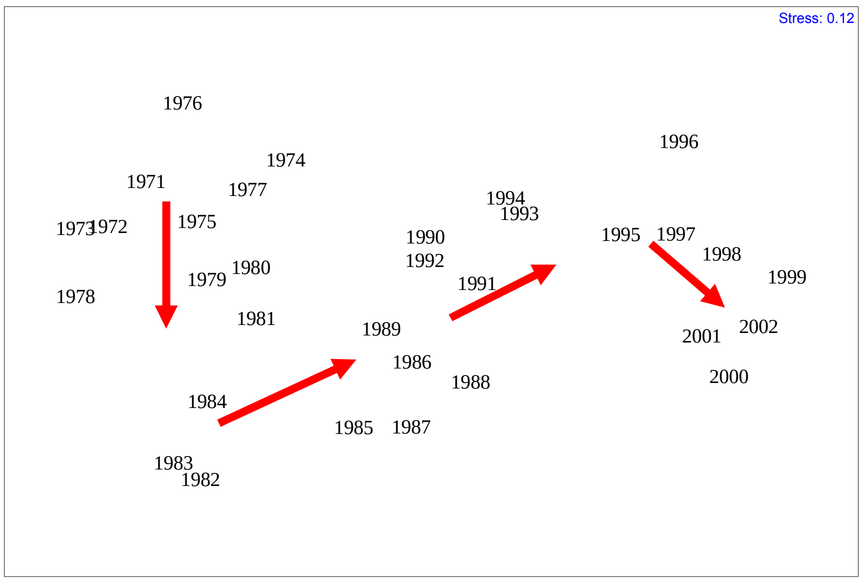


Figure 23. Non-metric multi-dimentional scaling plot of the southern Gulf of St. Lawrence marine fish community, 1971-2002, based on the standardized abundance of 59 species.

3.4 Maritimes Region

Two papers were developed by the team of Nancy Shackell, Ken Frank, B. Petrie, and J.S. Choi. The first paper entitled “Changes in community structure on the eastern (Div. 4VW) and western (Div. 4X) Scotian Shelf during the past forty years”, is summarized below. Nancy Shackell made the presentation.

The groundfish community on the eastern half (NAFO 4VW) of the Scotian Shelf collapsed in the early 1990s. Despite a similar historical exploitation regime (Fig. 24), the traditional groundfish community on the adjacent western (NAFO 4X) Scotian Shelf continues to support a commercial fishery – a unique situation in Canadian Atlantic waters. We explored the differential resilience of the two areas by comparing biomass trends (Fig. 25), temporal stability, compensatory dynamics (Fig. 26), and species evenness (not shown) among four functional groups. Biomass of all eastern groups (large and medium-sized groundfish, flounders, elasmobranchs) has declined since the 1990s, with little or no species compensation within any group. Conversely, all western groups showed some evidence of compensation, with the exception of large groundfish. Compensation among the three functional groups in the west was not due to more species per group, although a more equitable distribution of biomass may explain the lesser rate of decline observed in western large groundfish. Physiological condition (Fig. 27 and Table 1) and growth rates (Fig. 28) are declining in both regions; yet those species that showed a compensatory response in the west, or had slower rates of decline, had higher levels of condition than eastern populations. Although the west appears more stable, it is following a similar, but protracted trajectory as the east. The west's protracted response may be due to higher demographic rates in warmer waters. To foster the west's resilience, we should address the rapid pace of new fisheries, effects of size-selective mortality, and the diminishing number of natural refugia.

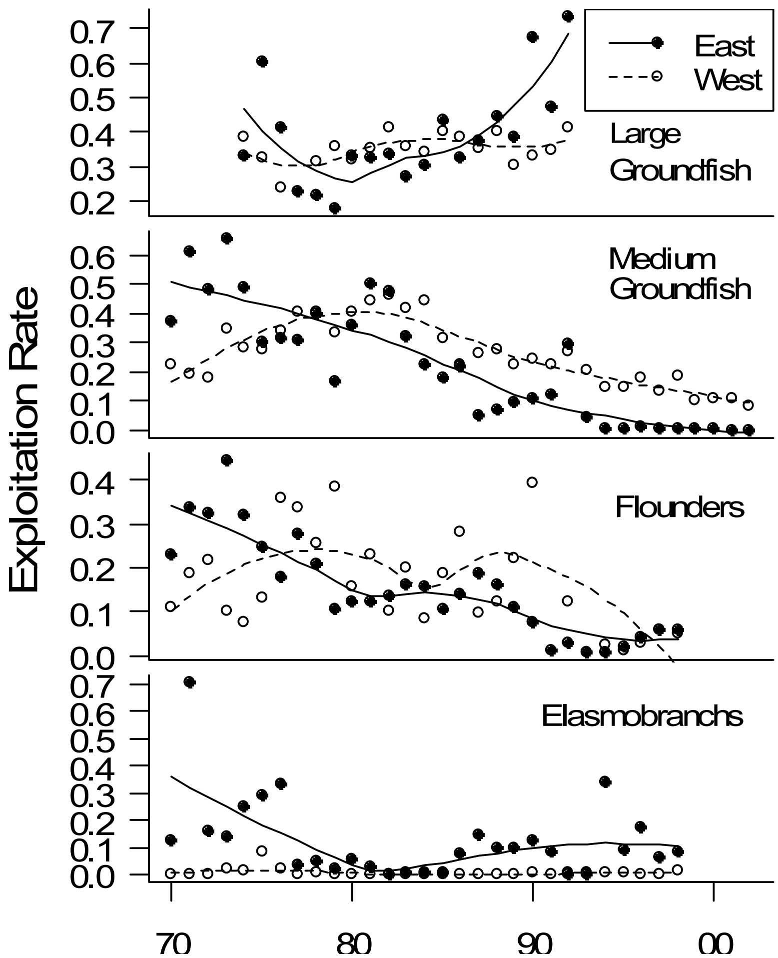


Figure 24. Exploitation rates of functional groups. We used fishing mortality estimates derived from Sequential Population Analysis for cod and haddock as representative exploitation rates of large and medium groundfish. Exploitation rates of elasmobranchs and flounders (American plaice) were calculated as reported fishery landings divided by survey biomass.

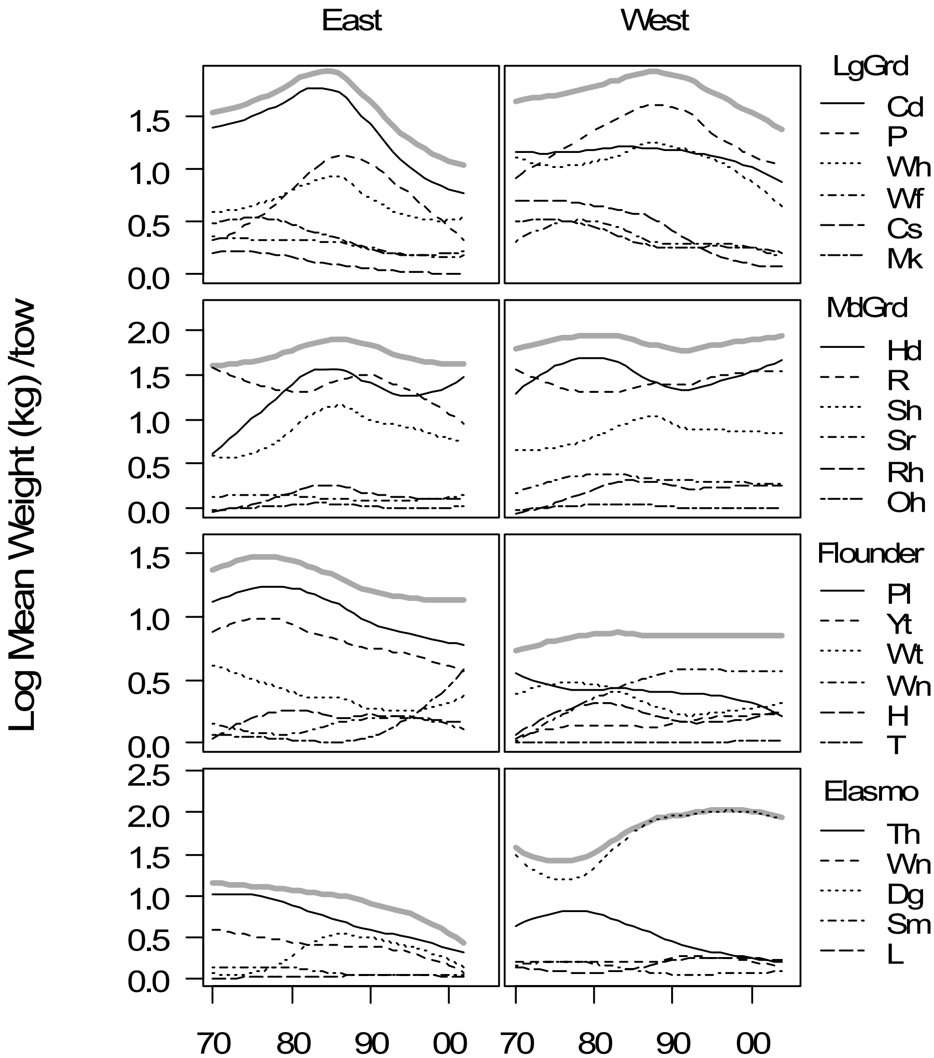


Figure 25. Smoothed (loess) log mean weight (kg) per tow, for each group. The aggregate biomass for each group is grey. LgGrd refers to large groundfish: Cd-cod; P-pollock; Wh-white hake; Wf-wolffish; Cs-cusk; Mk-monkfish. MdGrd refers to medium-sized groundfish: Hd-haddock; R-redfish; Sh-silver hake; Sr-sea raven; Rh-red hake; Oh-offshore hake. Flounders: Pl-plaice; Yt-yellowtail; Wt-witch; Wn-winter; H-halibut; T-turbot. Elasmo refers to Elasmobranchs: Th-thorny skate; Wn-winter skate; Dg-dogfish; Sm-smooth skate; L-little skate.

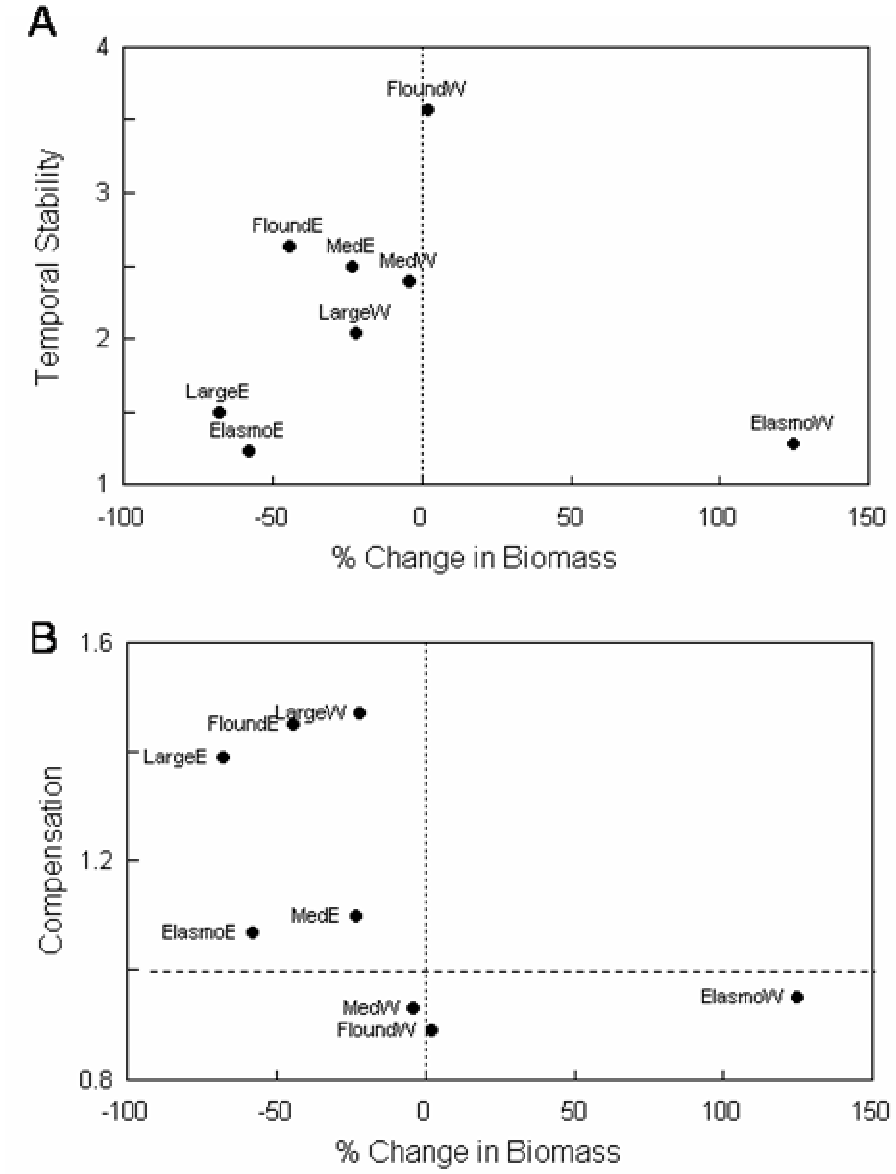


Figure 26. A. Temporal stability of the four functional groups from each region in relationship to percent change in biomass (group aggregate biomass before 1990 - group aggregate biomass after 1989)/group aggregate biomass before 1990). B. Compensation, measured by a variance ratio (sufficient negative covariance among species results in a ratio <1) in relation to percent change in biomass.

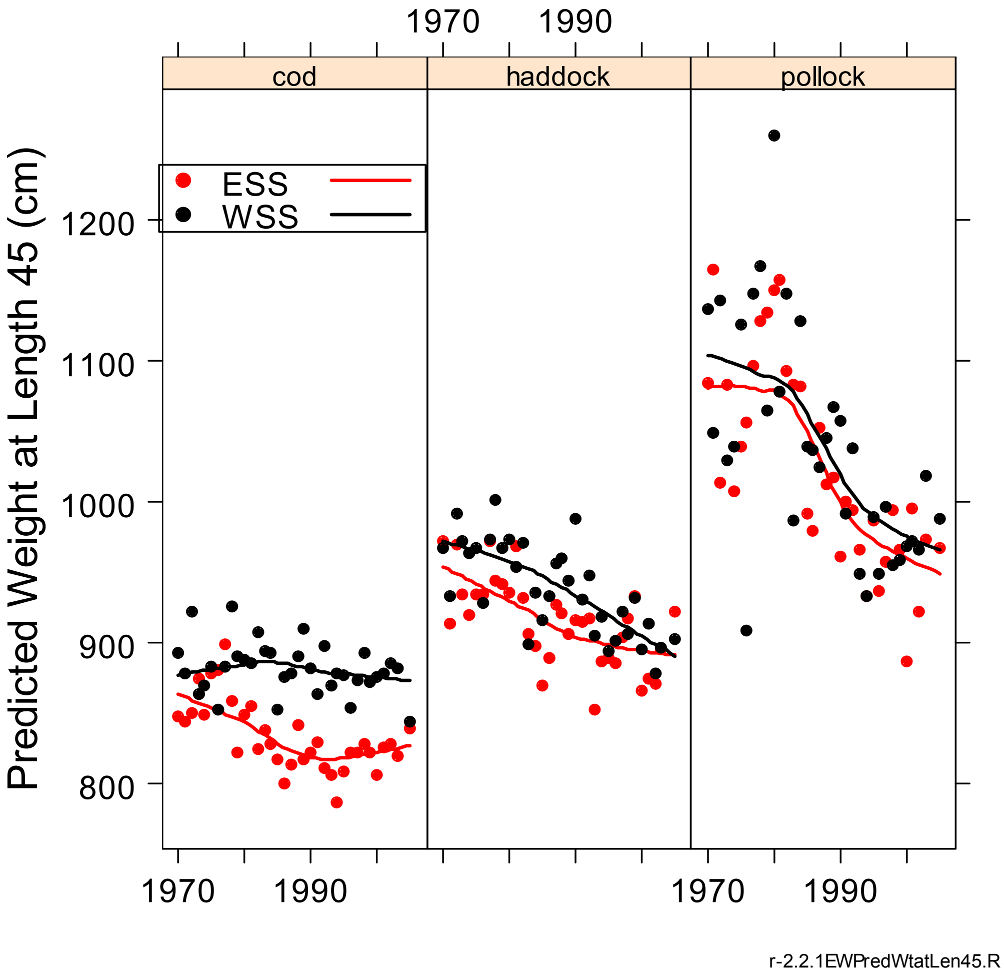


Figure 27. Predicted weight (g) at length of 45cm as a measure of condition for three select species out of 18 examined (see Table 1).

Table 1. Analysis of Covariance summary results for 18 species. Condition was response variable and modelled as a function of region with year (yr) as a covariate. Na is "not applicable", NS is not significant, Pr>F refers to probability more than the F statistic, coeff. refers to coefficient, and se refers to standard error.

Group/ Species	***Mult. R^2***	***Inter-action trend***	***Inter-action (yr* region) Pr>F***	***Factor (region) coeff. for West (se)***	***Factor (region) Pr>F***	***Covariate (yr) coeff. (se)***	***Covariate (yr) Pr>F***	***Result Type****
Large								
Cusk	0.06	Na	NS	0.05 (0.41)	NS	-0.002 (0.002)	NS	1
Wolfish	0.23	Na	NS	-.002 (0.013)	NS	-0.002 (0.0006)	<0.001	3
Pollock	0.46	Na	NS	0.013 (0.012)	NS	-0.005 (0.0006)	<0.001	3
White hake	0.16	Na	NS	-0.027 (0.009)	<0.00l	-0.0002 (0.0004)	NS	2
monkfish	0.11	Na	NS	-0.046 (0.019)	<0.05	-0.0006 (0.0009)	NS	2
Cod	0.69	Greater negative slope in east to lower level of condition	<0.05	Na	Na	neg.	Na	5
Medium								
Silver hake	0.03	Na	NS	-0.016 (0.014)	NS	-0.0007 (0.0007)	NS	1
Redfish	0.73	Na	NS	0.18 (0.014)	<0.00l	0.00009 (0.0007)	NS	2
haddock	0.53	Na	NS	0.025 (0.006)	<0.001	-0.003 (0.0003)	<0.001	4
Plaice	0.3	Na	NS	-0.03 (0.01)	<0.05	-0.003 (0.0005)	<0.001	4
Flounders								
Halibut	0.47	Na	NS	0.013 (0.013)	NS	-0.005 (0.0006)	<0.001	3
Winter	0.28	Na	NS	0.013 (0.12)	<0.00l	-0.005 (0.0006)	NS	2
witch	0.65	east initially higher but declines to similar levels	<0.05	Na	Na	neg.	Na	5
yellowtail	0.38	west initially higher but declines to lower level	<0.01	Na	Na	neg.	Na	5
Elasmo								
Winter skate	0.07	Na	NS	-0.022 (0.02)	NS	-0.002 (0.0009)	NS	1
little skate	0.07	Na	NS	0.003 (0.025)	NS	-0.0015 (0.001)	NS	1
Dogfish	0.16	Na	NS	0.00009 (0.05)	NS	-0.005 (0.002)	<0.05	3
Smooth skate	0.24	similar initial values but west declines at greater rate	<0.05	Na	Na	neg.	Na	5

** Result type refers to one of five (5) results: 1 - No difference between covariate slope within regions, no covariate trend, and no region effect; 2 - No interaction, parallel horizontal slopes, and difference between regions; 3 - No interaction, parallel slopes with trend, and no difference between regions; 4 - No interaction, parallel slopes with trend, and differences between regions; and 5 - Covariate slope differs between regions. If the region coefficient for the west was negative (and significant), the east had greater condition, and conversely, a positive coefficient implies the west had a greater condition (result types 2 and 4).*

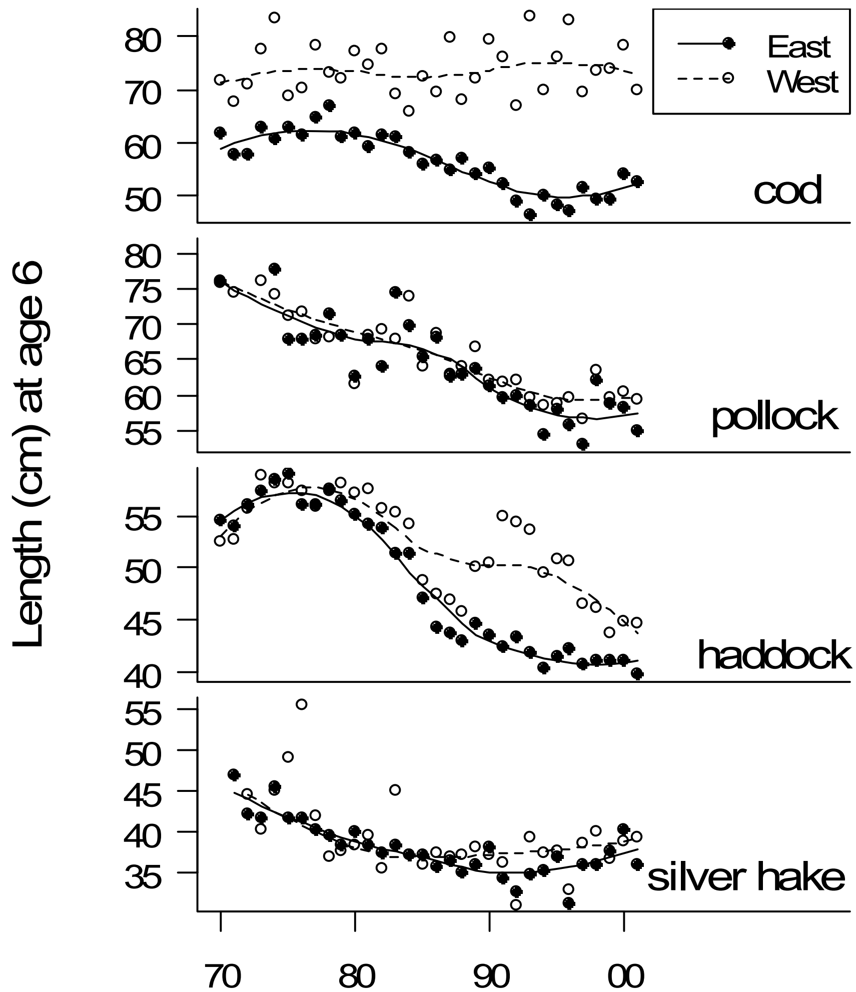


Figure 28. Growth rate (size-at-age) of cod, haddock, pollock, and silver hake in each region.

The second paper developed was entitled "An ecosystem status report for the western Scotian Shelf (Div. 4X)". The presentation was made by Nancy Shackell.

We examined the western Scotian Shelf (WSS) ecosystem (NAFO Div. 4X) over a period of 30+ years. We applied the concept of ecological succession as developed by Odum (Odum, E.P. 1969. Science 104: 262-270) and examined ecosystem traits that have a predicted response to stress to help identify potential forcing variables (Christensen, V. 1995. Ecological Modelling 77: 3-32). Using ordination techniques, we examined indices of oceanography, nutrients, lower trophic levels, invertebrates, fish community, ecosystem health, and human activities (Table 2). The method of principal component analyses assumes equal measurement error/weighting among variables. As well, the number of biological variables was greater than the number of oceanographic variables, which could have influenced our interpretation. Thus, we also examined oceanographic and biological sets separately (not shown). A summary is provided in bullet form, followed by results and figures from the ordination analysis, as well as a table explaining the variables used in the analysis.

Fishing

Fishing effort has transferred from higher (groundfish) to the lower (invertebrates) trophic levels. In addition to increased effort on scallops, soft-shelled clams, and lobster, landings of "underutilized" or "non-traditional" species increased or was initiated on a variety of species in the early 1990s.

Fish Community

The community structure of fish has changed. Out of nine dominant species making up 80% of the biomass in any year, four have declined (white hake, cod, cusk, and thorny skate). The total biomass of large-bodied groundfish has remained stable, or even increased slightly. However, when species are divided into groups: traditional groundfish biomass is somewhat stable, non-traditional larger groundfish are declining, and elasmobranchs (in particular, spiny dogfish), small demersals, and pelagic biomasses have increased. The number of small demersals species has increased, although their proportional biomass has not.

Health Indices

- Decline in average size of:
  - groundfish community;
  - porbeagle shark; and
  - berried lobsters in the Bay of Fundy.
- Decline in growth rates (length-at-age) of:
  - herring;
  - haddock;
  - hollock; and
  - silver hake.
- Cod length at age nine has not decreased, but the biomass of cod greater than 100cm has decreased since the mid-1990s.
- Condition of the groundfish community has declined.

Atmospheric/Climatic Indices

- Variation in Gulf Stream water onto the WSS may be related to increases in nitrate, and the recent slight increase in the proportion of the bottom area greater than 4°C (average bottom temperature was fairly stable), and the recent increase in saturated oxygen.
- North Atlantic Oscillation (NAO) index has increased. The NAO affects the Scotian Shelf largely through advection, although its influence is less in this area compared to the Grand Banks.

Trophic Pattern

Silicate decreased in the 1990s, while nitrate and the primary producers have increased. Large calanoid copepods have decreased whereas herring biomass has increased. Within the large demersal trophic level, not all species have responded similarly. Haddock is somewhat stable, cod has declined, and dogfish, and to a lesser extent, barndoor skate and little skate have increased. The exploitation rates are related to these patterns. The exploitation rate of the increasing dogfish was less than the somewhat stable haddock, which in turn was less than that of the declining cod.

Conclusions

Both the eastern Scotian Shelf (ESS-Div. 4VW) and the western Scotian Shelf (WSS-Div. 4X) have experienced intensive fishing, yet the ESS groundfish fishery has effectively collapsed and shows few signs of recovery. The WSS, while experiencing significant change, has not yet collapsed. It is generally believed that the warmer waters of the WSS may confer an increased resilience through increasing demographic rates (e.g., Sinclair et al. 1997, pp.23-25 *in* Developing and sustaining world fisheries resources: The state of science and management. 2nd World Fisheries Congress Proceedings. Australia: CSIRO; Zwanenburg et al. 2002, pp. 105-159 *in* Large marine ecosystems of the North Atlantic: Changing states and sustainability (eds. K. Sherman, H.R. Skjoldal)). As well, warmer waters allow potential compensating top predators (e.g., dogfish) to increase at a faster rate. Perhaps, as a result, the WSS has not yet experienced a trophic cascade, as has been observed on the ESS. However, and importantly, the downwards trends in health indices reported herein were similar to those observed on the eastern Scotian Shelf (Choi et al. 2005. Oceanography and marine biology: An annual review 43: 47-67), and are a cause of concern.

Principal Component Results

The first eigenvector, accounting for 28.6% of the variability, was influenced largely by a decline in the health indices (e.g., average weight per individual, size, size at age for several species, and fish condition), abundance of large copepods, and the amount of water discharged from the St. John River. These declines were countered by an increase in dogfish/elasmobranch, pelagic, small demersal fish biomass (≤30cm), aquaculture, landings of traditional invertebrates and non-traditional crabs, fish and plants, as well as increases in variables related to the lower trophic levels: diatoms, nitrate, chlorophyll, holozooplankton, and dinoflagellates, and an increase in the proportion of bottom area that is above 4°C (Figs. 29 and 30).

The second eigenvector reflects an initial decline in proportion of the bottom area that is above 4°C, an increase then decrease in sea level anomalies, a decrease then increase in SST at Halifax, and saturated oxygen and nitrate (Figs. 31 and 32). These variables change rapidly in the early 1980s, and then fluctuate in a somewhat stable manner from late 1980s, through to the 2000s.

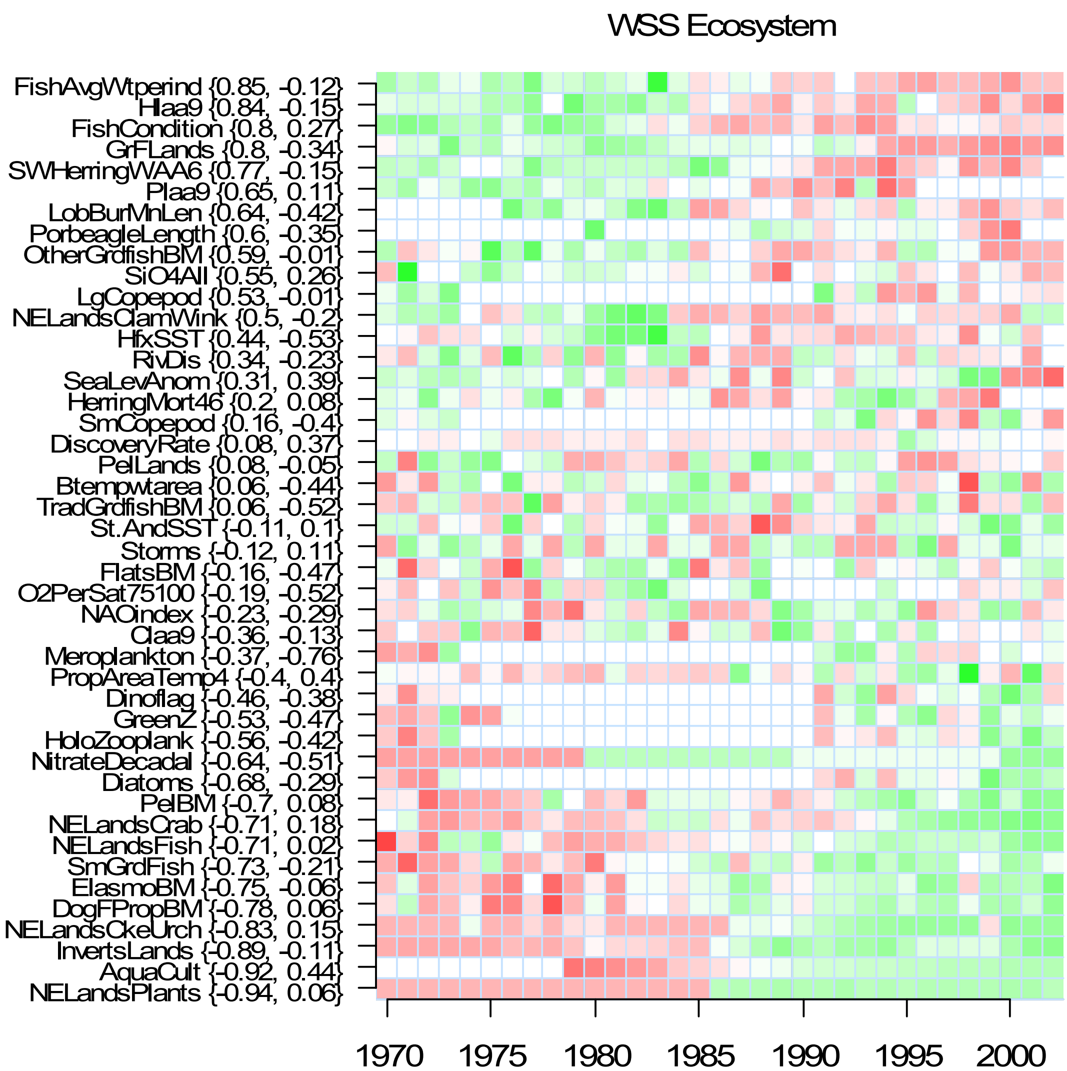


Figure 29. Standardised anomalies (standard deviation units) of variables included in ordination analysis. Variables are sorted by the factor loadings on the first eigenvector of a principal components analysis (28.5%). Factor loadings of the first two axes are in parentheses. Red – negative anomalies; green – positive anomalies.

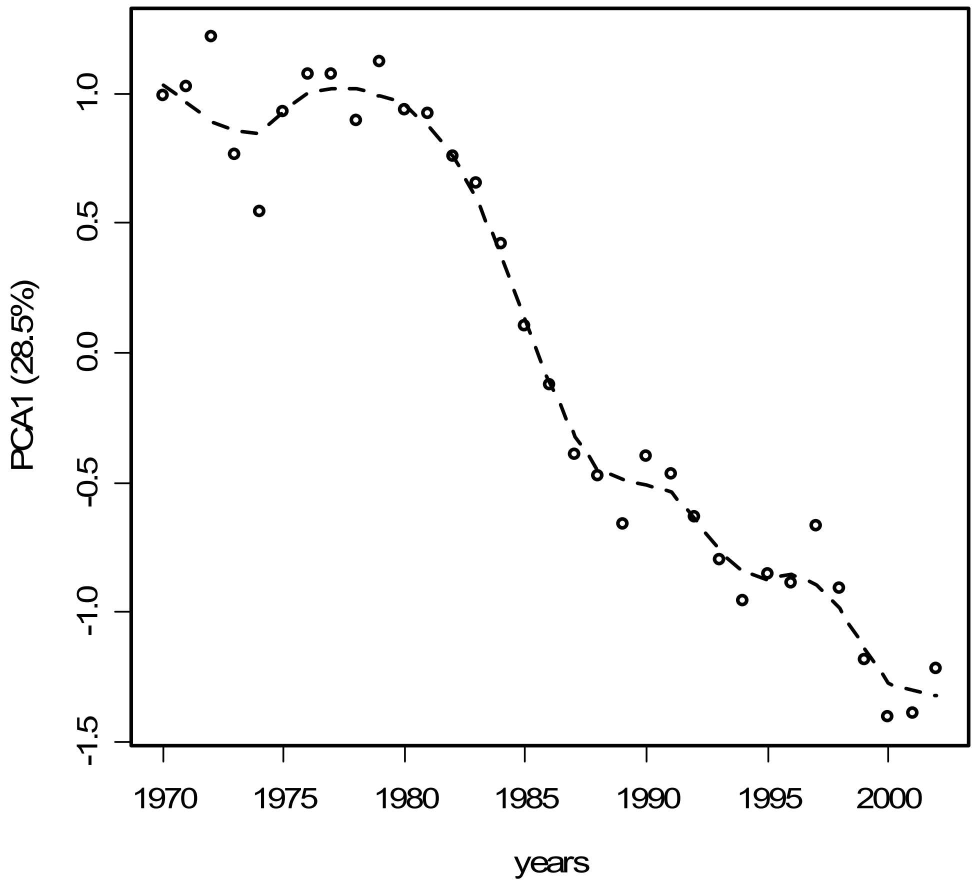


Figure 30. First principal component from 1970-2002.

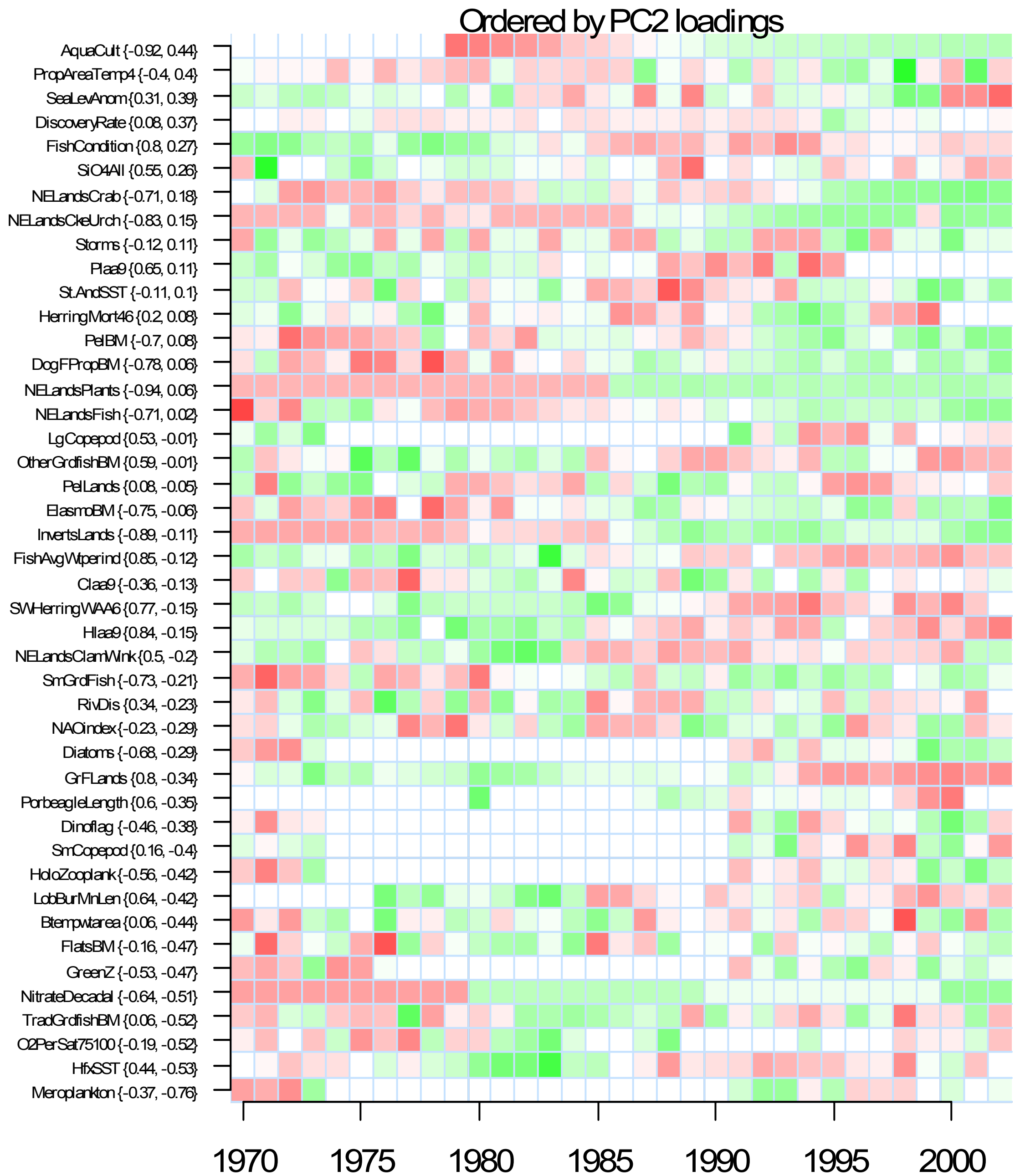


Figure 31. Standardised anomalies (standard deviation units) of variables included in ordination analysis. Variables are sorted by the factor loadings on the second eigenvector of a principal components analysis (8.6%). Factor loadings of the first two axes are in parentheses. Red – negative anomalies; green – positive anomalies.

Figure 32. Second principal component from 1970-2002.

Table 2. Indices used to assess the status of the western Scotian Shelf Ecosystem.

Index / Variable names	Variable Description
Physical	
RivDis	Discharge of Freshwater (m3/s) from Saint John, NB, into Bay of Fundy
NAOIndex	Annual anomalies of NAO (mb): anomaly of sea level atmospheric pressure difference between the Azores and Iceland. The index has been shown to be a broad-scale forcing variable through its influence on temperature and circulation patterns.
Storms	Sum of Hurricanes and Tropical storms affecting NS.
SeaLevAnom	Yarmouth Sea Level Anomaly.
Si04All	Silicate Level averaged over four locations throughout region.
NitrateDecadal	Nutrient data corrected for differential sampling on Scotian Shelf and EGM.
O2PerSat75100	Percent saturated Oxygen at 75-100m.
HfxSST, St.AndSST	Sea surface temperature at Halifax and St. Andrew's, NB.
PropAreaTemp4	Proportion of area that is above 4ºC.
Btempwtarea	Bottom temp calculated by weighting midintervals by area within interval.
Chlorophyll Index, Phytoplankton, Zooplankton	
GreenZ	Greenness Index from Continuous Plankton Recorder (CPR): relative colour index, a proxy for phytoplankton abundance
Diatoms, Dinoflag, LgCopepod (large calanoid copepods (>2mm));, SmCopepod (small calanoid copepods (<or = 2mm)), Meroplankton; HoloZooplank=Non Copeped Holozooplankton (e.g., euphausiacea, hyperiidea)	CPR original data (229 species) were divided into six functional groups and corrected for differential sampling effort among months years, to produce annual estimates.
Invertebrates	
LobBurMnLen	Mean length (mm) of berried females in LFA 35, 36, and 38; which is the Bay of Fundy. Sizes are measured in the port samples at four locations in BoF, where the fishermen (from whom the samples were taken) have pretty well fished in the same place year after year. Decline in size can either be a sign of overfishing large sizes, or of increased recruitment (Pezzack, Doug, pers.comm).
Fish Community	
DiscoveryRate	Discovery rate of newly discovered species = the number of species newly discovered divided by the number of sets.
PelBM	Sum of pelagic fish biomass/number of spp: Alewife, argentine, blueback, butterfish, capelin, herring mackerel, menhaden, sandlance, saury, scup, shad, and smelt.
TradGrdfishBM	Annual sum of tradition groundfish biomass/number of spp: cod, cusk haddock, offshore hake, pollock, redfish, red hake, silver hake, and white hake.
FlatsBM	Annual sum of flatfish biomass/ number of spp: fourspot, Gulf Stream flounder, halibut, plaice, turbot, windowpane, winter flounder, witch flounder, and yellowtail flounder.

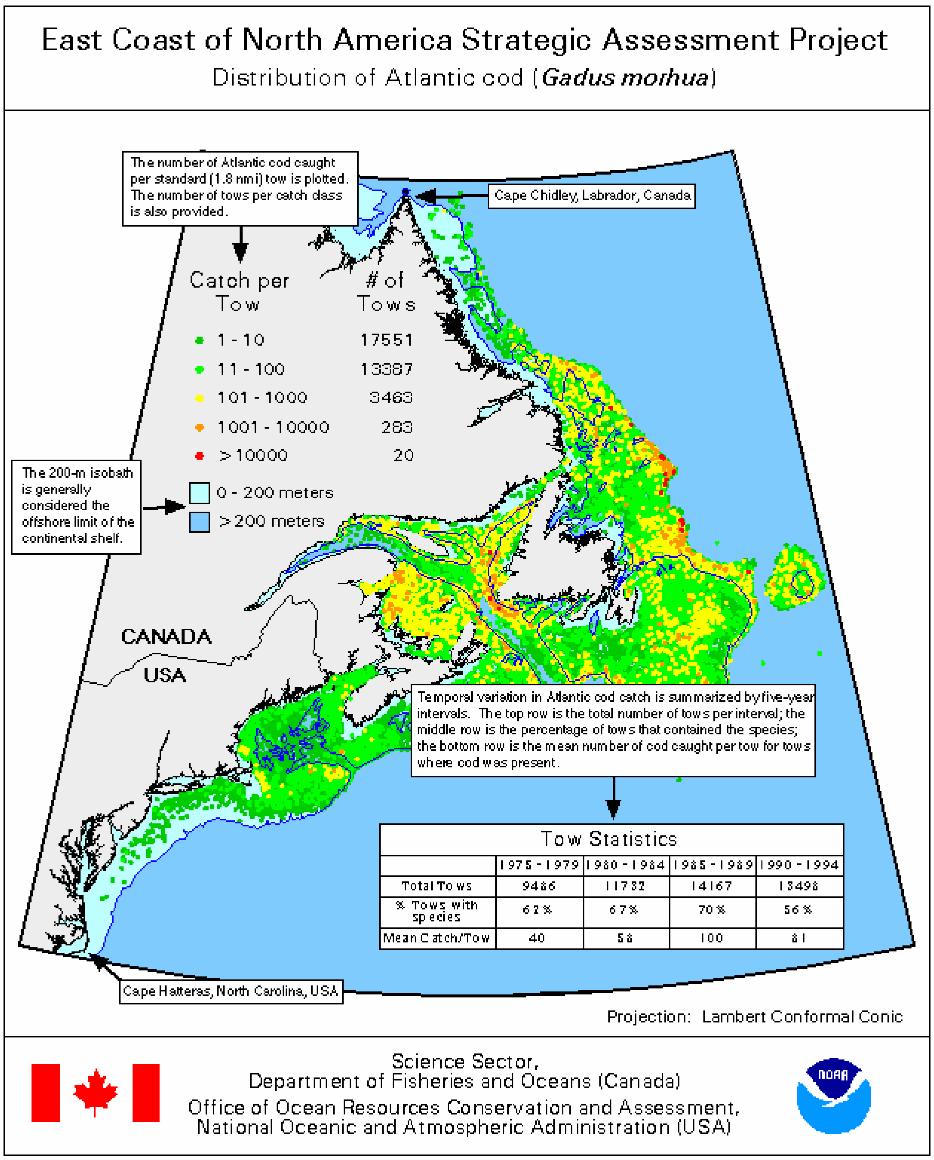
Index / Variable names	Variable Description
Fish Community (continued)	
OtherGrdfishBM	Annual sum of non-traditional larger groundfish biomass/ number of spp: hagfish, lumpfish, monkfish, pout, rock grenadier, roughhead grenadier, sea raven, soft pout, spotted wolffish, striped eel pout, wolf eel pout, worlfish, and torpedo.
ElasmoBM	Annual sum of elasmobranch biomass/ number of spp: barndoor skate, black dogfish, spiny dogfish, little skate, smooth skate, throny skate, and winter skate.
SmGrdFishBM	Annual sum of non-traditional smaller (<=30 cm) groundfish biomass/ number of spp (27 spp.).
DogFPropBM	Proportion of Total Biomass that is spiny dogfish.
Health	
FishAvgWtperind	Mean weight per individual using ALL species.
FishCondition	Condition of whole fish community, NB cv also has pattern that reflects that some conditions are not decreasing.
SWHerrwaa6	Average weight at age 6 for the SW Nova Scotia component of the 4WX herring fishery (weighted by fishery) for 1965 to 2001 values for 1979-83 are averages for the period 1968-78 as in Iles et al. 1984).
PorbgleLen	Fork length of porbeagle shark (mako fork length not used as there was a huge difference in length between two reporting countries; blue shark not used as two different vessels used in two diff time periods).
Hlaa9; Claa9, Plaa9	Haddock, cod, pollock length at age 9.
Human Activities	
GrFLands	Annual sum of traditional groundfish landings.
PelLands	Annual sum of pelagic landings.
InvertsLands	Annual sum of invertebrate landings (lobster, scallop, and sort-shelled clams).
AquaCult	Aqcultprod is sum of production (kt) of NB, NS, and Maine.
"NELandsCrab", "NELandsFish", "NELandsClamWink", "NELandsPlants", "NELandsCkeUrch"	Annual sum of landings for non-traditional fisheries divided into taxonomic groups: **Crabs**: red, jonah, queen snow, stone, rock, brachurian unsp.; **Fish**: monkfish, dogfish, hagfish, sculpins, roundnose grenadier, eel; **ClamsWink:** periwinkle, quahog, clams, bar, Stimpson surf, clams NS; **Plants**: rockweed, kelp, irish moss, nori moss, dulse; **CkeUrch:** sea cucumber, sea urchin.
HerringMort46	Southwest herring fishing mortality for ages 4-6.

3.5 Summary of East Coast of North America Strategic Assessment Project (ECNASAP)

Bob O’Boyle presented a summary of the ECNASAP. It was initiated in November 1993, to undertake biogeographic and assemblage analyses of the demersal fish communities off the east coast of North America and changes in these communities on a decadel time scale. In July 1995, the Cod Mortality Project, was initiated to examine the role of ecosystem changes in the collapse of the east coast cod populations. The two projects combined their efforts in August 1995. ECNASAP consisted of a team of about 15 scientists from DFO Scotia-Fundy, Gulf and Newfoundland regions, Environment Canada, and US NOAA Office of Ocean Resources Conservation and Assessment. The primary data set used in the project was that of the combined Canada and US east coast bottom-trawl surveys, which consisted of about 54,000 sets undertaken during 1975-94, covering the area from Cape Chidley to Cape Hatteras. At the onset of the project, effort was expended in preparing the data set for analysis, including species verification, and code standardization and set selection. The latter consisted of excluding species that did not meet the following criteria:

- Greater than 500 individuals caught during 1975-94;
- Represented in more than 5% of the 1975-94 sets; and
- Greater than 100 individuals caught in every five year block during 1975-94.

These criteria resulted in 66 species in about 40,000 sets being selected for the assemblage analysis. The products of the project were the ECNASAP data base, the biogeographic plus assemblage analyses which were documented in a number of reports, both primary and secondary, and a web-accessible atlas (see map below for example). It should be pointed out that ECNASAP endeavoured to compile information on bathymetry, oceanography, sedimentology and bird communities, although much of this information was not incorporated into the ECNASAP data base.



The biogeographic analyses consisted of examination of the change in species spatial distributions over time while the assemblage analyses consisted of classification of the demersal fish communities based upon visual inspection of the distribution maps, a Principal Component Analysis of the trawl data set by five year block and a Cluster Analysis of the trawl data set aggregated by narrow geographic bands defined perpendicular to the east coast. The biogeographic analysis discerned broad changes in the fish community, with cold-water species (e.g., Artic cod) expanding range south during 1975–94 and warm-water species (e.g., ocean pout and butterfish) first expanding north until 1990, and then contracting south thereafter. Regarding changes in the fish communities, the visual analysis identified the geographic distribution of nine groups, consisting of 108 species. These groups corresponded well with those identified by the PCA, which in turn was consistent with the findings of previous workers. As well, the PCA found that these assemblages, while only explaining 60% of the variance in the data and thus considered “loose” associations, were spatially coherent and persistent over time. The band analysis identified the same major transition points as those of Mahon (1985). In addition, there appeared to be a change in the position of the transition points from 1985-89 to 1990/94 with a shift of the northern transition points south and the southern ones north. The ECNASAP team speculated that this might be associated with changes in the North Atlantic Oscillation observed during this time period.

Overall, ECNASAP concluded that demersal fish assemblages exist but only as loose associations, although they appear to persist in time and space. There have been large scale changes in species-specific distributions, likely in response to ocean climate, which is also reflected at the community level, as changes in the transition points of these communities, perhaps again in response to ocean climate.

ECNASAP was one of the first attempts to compile and analyze fish community, and other biological data across a large geographic scale. A number of issues had to be resolved for the project to get as far as it did. These included jurisdictional issues on data access, definitional issues related to the data dictionary, data storage issues, and analytical issues. In regards to the latter, the ordination analyses undertaken had to be innovative as the software used as that time could not process extremely large matrices. Notwithstanding these issues, the project highlighted the value of undertaking collaboration at this large geographic scale, in that biological processes were observed that would not have been otherwise. There are still requests for access to the ECNASAP data set, 10 years after the project has been completed. Further information on ECNASAP can be found in Brown and O’Boyle (1995), Brown et al. (1996), Mahon (1997), and Mahon et al. (1998).

4.0 OTHER ISSUES

4.1 Data Access

Even though the regional synthesis of multi-species trawl survey data do not generally involve data access and interoperability problems (with the possible exception of the Newfoundland and Labrador Region), future work on comparative ecosystem dynamics and biogeographic studies will require aggregation of data sets across DFO regions and NOAA. In anticipation of these challenges involved in the across regional syntheses, Bob Branton presented two papers.

The first was entitled “OSISMD: A Global Change Master Directory Portal for Ocean Biodiversity Information System Metadata” (R. Branton and L. Bajona).

The Ocean Biogeographic Information System (OBIS www.iobis.org) is the public data access portal of the Census of Marine Life (CoML), a growing network of researchers in more than 45 nations engaged in a 10-year initiative to assess and explain the diversity, distribution, and abundance of life in the oceans - past, present, and future. The Global Change Master Directory's (GCMD gcmd.nasa.gov) is a public discovery portal holding more than 15,000 descriptions (e.g., metadata) of Earth science data sets and services covering all aspects of Earth and environmental sciences (Fig. 33). GCMD recognizes the importance of customization for partner organizations and is generating subset views of its directory through portals. Providing portals has made it easier for organizations to maintain and document their data in one place without duplicating the effort to create another online directory. The OBIS Master Directory (OBISMD gcmd.nasa.gov/KeywordSearch/Home.do?Portal=OBIS) developed with the assistance of Melanie Meaux at GCMD is such a portal.

GCMD's Home Page offers a variety of search strategies including: icons for searching by topics (e.g., Biosphere, Climate, Oceans), free text searches, and spatial/temporal searches. All metadata on GCMD is stored following the Directory Interchange Format (DIF) standard and can be expressed in Federal Geospatial Data Committee (FGDC) or International Standards Organization (ISO) forms. GCMD routinely exchanges metadata with Canada's Geoconnections and the USA Geospatial One Stop systems, which are both FGDC based. In addition to storing metadata, GCMD is also the international repository for numerous keyword list used by other systems. Our main purpose here is to demonstrate how the GCMD discovery portal can be used to find, map and download data currently on the OBIS data access portal. We start by showing 'Brief Record' and 'Attribute/Keyword' views of metadata recently developed for the *Canadian Maritime Cetacean Sightings* database at Saint Andrews (obis.marwhale).

We next show, using the GCMD 'Get Data' links to activate, the ACON mapper available on the OBIS Portal. This gives direct access to interactive maps as well as the underlying OBIS-formatted data products. Help using ACON are available by clicking the '?' at the bottom of the map. Next we show the GCMD Home Page and how to find the *Marwhale* metadata by clicking the 'Oceans' icon followed by selection of 'Marine Biology' and 'Marine Mammals' keywords and then refining by location keywords starting with the 'Atlantic Ocean' then 'North Atlantic', etc., and finally 'Bay Fundy', at which point GCMD provides a short list of two possible choices.

We next show the 'Full Record' view of metadata on *Europe's BIOMAR Collection for Ireland* (BIOMAR - obis.biomar), which we find by typing 'obis biomar' into the free text search box on the GCMD Home Page. Next, we find metadata on *Canada's Pacific Ocean Shelf Tracking* (POST - obis.post) project metadata starting from the GCMD home page by using the 'Google' spatial search tool to zoom into the general area of Vancouver Island and then typing 'OBIS' and "salmon" into free text search boxes. The ACON 'Get Data' link for the POST collection is also shown with particular attention to ACON's dynamic web links feature which gives global distribution data from OBIS and fact sheets from a variety of sources including the Integrated Taxonomic Information System (ITIS) and FishBase.

The GCMD Portals Collaboration Page is then used to bring up the OBIS Master Directory Portal, which is in turn used to display the list of OBIS Regional Nodes (Fig. 34) from which we select the OBIS Canada *'Three Oceans of Biodiversity'* portal page. In all, there currently are 12 data collections listed on the OBIS Canada page, each with a 'Get Data' link to the OBIS Data Access Portal (Table 3). As shown earlier in the demo, these collections can also all be accessed from the GCMD Home Page by keywords, collection names and/or by map/date search. The final element of the demonstration was to show GCMD's DocBuilder tools and accompanying templates which together greatly facilitate the creation and maintenance of metadata.

Table 3. Data collections currently available from OBIS Canada.

- Atlantic Reference Centre (OBIS Canada) [OBIS.ARC] -This is the Atlantic Reference Centre museum database for Canadian Atlantic marine organisms. Specimens represent invertebrates from sponges to tunicates, and fishes. The ichthyoplankton ...
- Electronic Atlas of Ichthyoplankton on the Scotian Shelf of North America (OBIS Canada) [OBIS.AtlasIchthyoplankton] - Location and time of spawning, and abundance and distribution of eggs and larvae of 107 taxa of fish and invertebrates on the Scotian Shelf of North America. Derived from 197 scientific ...
- Canadian Museum of Nature - Fish Collection (OBIS Canada) [OBIS.CMN_FishCollection] - This digital database contains all fish records held at the Canadian Museum of Nature and collected from Canada and the United States as well as from associated marine water masses ...
- ECNASAP - East Coast North America Strategic Assessment (OBIS Canada) [OBIS.groundfish_atlas] - Fishery-independent groundfish data for the east coast of North America from Cape Hatteras to the US/Canadian border and for Bay of Fundy through the Scotian Shelf. Time period ...
- Eastern Canada Benthic Macro Fauna (OBIS Canada) [OBIS.ECanBenthicMacrofaun] - Measurements of biomass and productivity of seabed macrobenthic and megabenthic organisms, from studies in eastern North
- America from New England to the Canadian Arctic dating from ...
- Gwaii Haanas Invertebrates (OBIS Canada) [OBIS.Gwaii_Inv] - The database covers the Haida Gwaii archipelago, including the contiguous waters of Dixon Entrance, Hecate Strait, Queen Charlotte Sound and westward into the Northeast Pacific ...
- Gwaii Haanas Marine Plants (OBIS Canada) [OBIS.Gwaii_MarPlants] - The database covers the Haida Gwaii archipelago on the West Coast of Canada, including all species of the Haida Gwaii region from any published source, accessible collection and ...
- Marine Invertebrate Diversity Initiative (OBIS Canada) [OBIS.MIDI] - The goal of Marine Invertebrate Diversity Initiative (MIDI) is to provide information about marine invertebrates (animals without backbones). We hope to engage scientists, educators ...
- Nova Scotia Museum of Natural History - Marine Birds, Mammals, and Fishes (OBIS Canada) [OBIS.NSMNH] - This is the Nova Scotia Museum of Natural History database for marine organisms, including birds, mammals, and fishes. It contains mostly Nova Scotia material but there is also ...
- Pacific Ocean Shelf Tracking - POST (OBIS Canada) [OBIS.POST] - The Pacific Ocean Shelf Tracking Project (POST) was created to monitor the movement of marine animals through an array of listening stations set along the west coast of North America. ...
- Resolute Passage Copepod Distribution (OBIS Canada) [OBIS.Copepod_distrib] - This dataset includes data collected from the ice station set up in Resolute Passage, 74 degrees 40'N and 94 degrees 54'W between the years 1983 to 1989.
- Maritimes Regional Cetacean Sightings (OBIS Canada) [OBIS.Marwhale] - This is the Fisheries and Oceans Canada Maritimes Region database for sightings records of cetaceans, other large pelagic animals and marine mammal survey information. The bulk ...

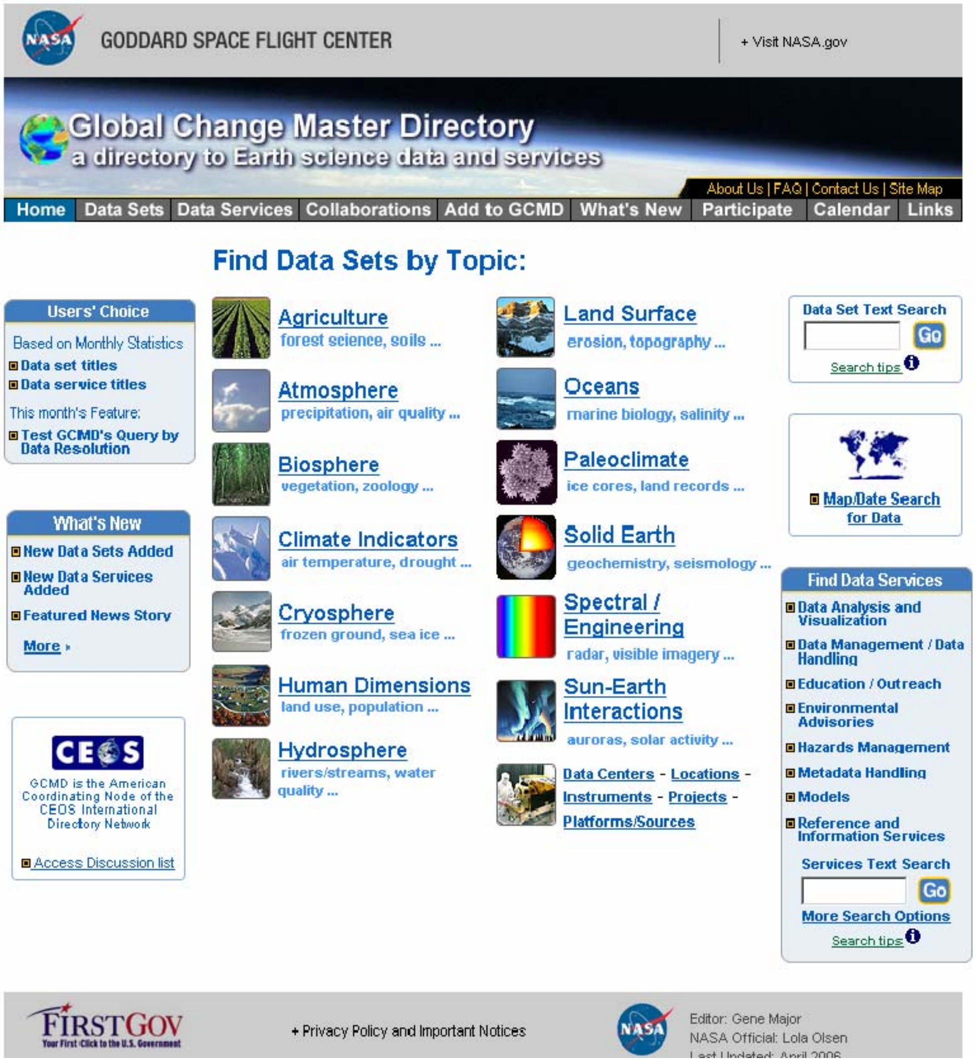


Figure 33. Global Change Master Directory home page.

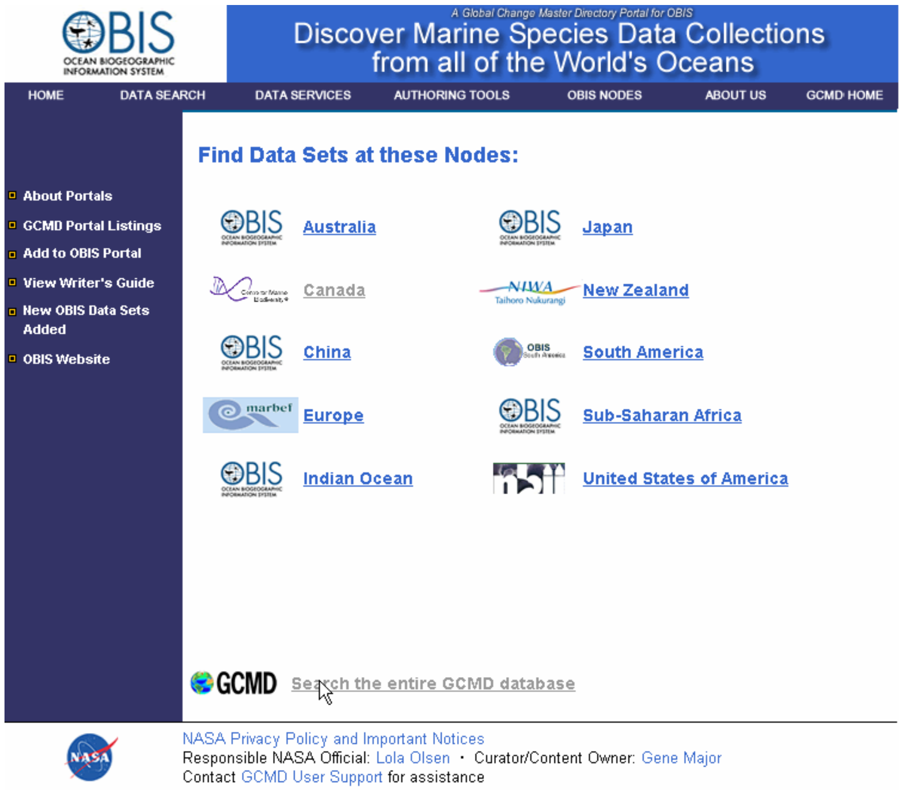


Figure 34. OBIS Master Directory 'OBIS NODES' page.

The second paper on data access challenges, also presented by Bob Branton, was entitled "Using standards to achieve data interoperability" (R. Branton, L. Bajona, S. Bond, J. Black, and T. McIntyre).

Researchers generally expect that broad scale ecological research, such as definition of Ecologically and Biologically Sensitive areas (EBSAs) and routine publishing of Ecosystem and Habitat Status Reports (ESRs and HSRs), would be greatly facilitated if all of the available information on distribution and abundance of organisms, oceanographic data, and information on habitat and bottom types were to be gathered into, or made accessible through, a single source. Is this truly a realistic expectation? Even though the Department of Fisheries and Oceans (DFO)'s scientific data are considered a public resource, and subject to full and open access within two years of being acquired, what about the expectations of privacy in the collection and sharing of data as well as the ever growing trend for more data security?

Despite these concerns, Canada's Centre for Marine Biodiversity (CMB : www.marinebiodiversity.ca/) believes that a single point of access for scientific data is a realistic expectation and to date, together with the Bedford Institute of Oceanography (BIO: www.bio.gc.ca/welcome-e.html) and the Gulf of Maine Ocean Data Partnership (GoMODP: gcmd.nasa.gov/portals/gomodp/), has published 18 Canadian scientific data collections onto the Internet.

Under these arrangements, end-users agree to acknowledge the use of contributor's data, just as they would a publication. As well, end-users are encouraged to recognize the limitations of the data they are using and provide the portal managers with a full citation for any publications resulting from data obtained from the portal.

The technical term for this capacity to consistently and reliably use data from different and remote systems is called "interoperability" and results from community-wide acceptance of data standards. A key component of interoperability is *metadata* (e.g., information about the data) *standards* for *discovery*, *authority* and *access*. The day to day end-user contact with these standards is usually given by way of interconnected *portals* or gateways. In many cases, *discovery portals* also provide links to *access portals* and *access portals* also provide links to *authority portals.*

Discovery portals like the Global Change Master Directory (GCMD: gcmd.nasa.gov) manage information provided by original data providers and allow end-users to search that information for data collections particular to their needs. GCMD is currently providing discovery metadata on over 16,000 data collections.

Authority portals (Fig. 35) like the Integrated Taxonomic Information System (ITIS: www.itis.usda.gov/) allow for names (species, locations, etc.) to be unambiguously defined by providing the original source or authority for a given name. ITIS for example would tell you that the accepted scientific name for barndoor skate is *Dipturus laevis* and not *Raja laevis*. ITIS currently contains information on over 400,000 biological names and should be used wherever possible when dealing with scientific names. MEDS at Ottawa has recently taken on downloading and maintaining an Oracle copy of this database.

Access portals like the Ocean Biogeographic Information System (OBIS: www.iobis.org) provide the actual means for getting data to the end-user. With public system such as OBIS, end-users are given access to standardized quality controlled results from a wide variety project database(s). OBIS currently provides access to over 9,000,000 location records on 60,000 species from 92 sources worldwide.

In addition to using *metadata standards* based *portal* systems, the CMB approach makes use of *quasi standard* data products such as spreadsheet-ready *text files* and geographic information system (GIS) ready *shapefiles* (ESRI - www.esri.com/library/whitepapers/pdfs/shapefile.pdf). *Text files* give points with columns of associated values, whereas *shapefiles* give points, as well as complex line and area features. In the case of the GCMD and OBIS *portals*, users are given the opportunity to use interactive mapping tools such as DFO's ACON (A Contouring Program- www.iobis.org/OBISTEST/HowToDocs/How_to_use_ACON.pdf) to preview the data, find the desired subset (e.g., species, area, time), and then download the data to a personal computer in the desired form. From there, scientists or technicians load the data into their preferred analytical software. Two useful and freely available analysis systems are the R software environment for statistics and graphics (www.r-project.org/) and the DIVA geographical information system (www.diva-gis.org/). The basic R system, although extremely powerful in its own right, can be greatly enhanced with many packages such as the R-Commander user interface (socserv.mcmaster.ca/jfox/Misc/Rcmdr/) and the R Lattice graphics (web.csb.ias.edu/library/lattice/html/Lattice.html). The DIVA GIS, although looking very much like the commercial ARC GIS suite, is tailor-made specifically to analyze biological distribution data and is very easy to use.

A discovery metadata and data warehousing facility (Fig. 33), such as being developed for OBIS Canada at BIO, is intended to provide for controlled flow of standardized product level data on marine species from various project databases onto the internet.

Under such a scheme, individual projects would continue to operate as is, while discovery metadata, species lists, and OBIS standard products would be submitted to a central data warehouse for time stamping and long term non-volatile retention. Temporal, spatial, and taxonomic resolution of the OBIS product data would very much depend on the nature and quality of the underlying data and require considerable cooperation from the originating data owner. Discovery metadata and species lists for all projects would be expected to appear on discovery portals, whereas only pre-selected OBIS products would appear on access portals. The underlying data would not be accessible beyond the operational system nor would it be contained in the data warehouse. Public access to, and use of, OBIS product data not on the access portals and underlying would require individual limited agreements between the data owner and the end-user.

In conclusion, not working with open and reusable systems, such as these will result in ever escalating operating costs, duplication of effort, and individual frustration. Furthermore, it is only by routine publishing of standards based biological data and metadata that individual scientists will be able to effectively operate joint project agreements and participate in large scale international projects.

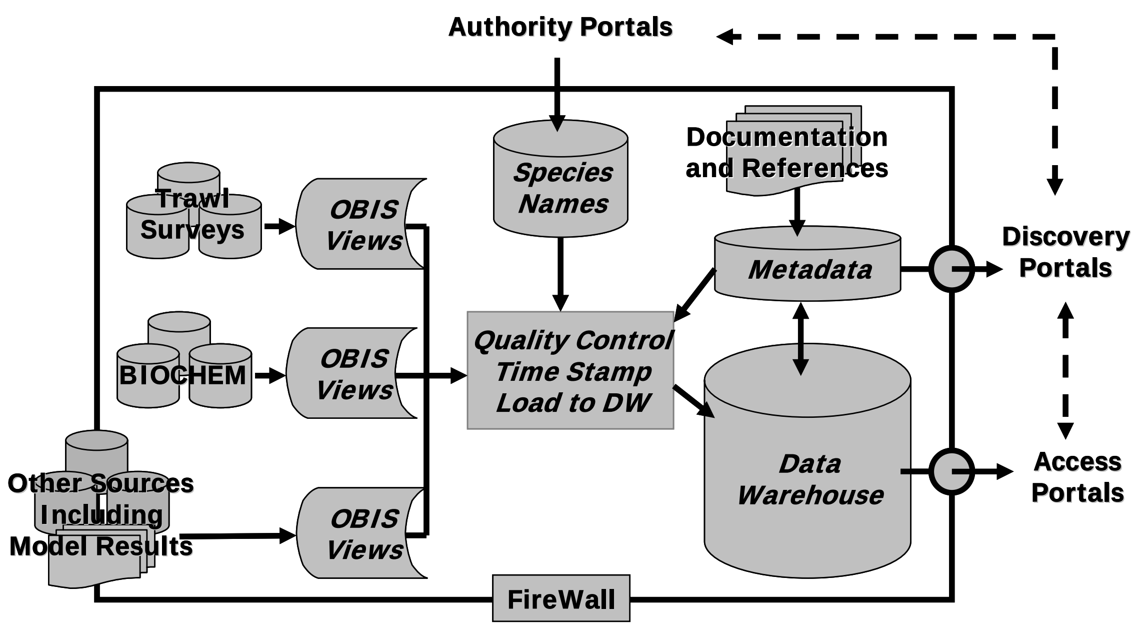


Figure 35. OBIS Canada Concept Diagram

Further information can be found in the following websites:

CMB Report of Workshop on Open Standards Access to Biological Data, BIO Nov. 27, 2003. (www.marinebiodiversity.ca/en/standards/standards.html)

DFO, 2003. State of the eastern Scotian Shelf Ecosystem. DFO Can. Sci. Advis. Sec. Ecosystem Status Rep. 2003/04. www.dfo-mpo.gc.ca/csas/Csas/status/2003/ESR2003_004_e.pdf

DFO, 2004. Identification of Ecologically and Biologically Significant Areas. DFO Can. Sci. Advis. Sec. Ecosystem Status Rep. 2004/006. (www.dfo-mpo.gc.ca/csas/Csas/status/2004/ESR2004_006_e.pdf)

DFO, 2004. Habitat Status Report on Ecosystem Objectives. DFO Can. Sci. Advis. Sec. Habitat Status Report 2004/001. (www.dfo-mpo.gc.ca/csas/Csas/status/2004/HSR2004_001_e.pdf)

4.2 Physical Oceanographic Changes in the Gulf of St. Lawrence

As an indication of the type of oceanographic data analyses that will be carried out over the coming years in support of the FOC multi-year workplan, Joel Chassé and Brian Petrie presented a paper entitled "A multi-variate, physical environmental characterization of the southern Gulf of St. Lawrence from past to present: Preliminary results". The summary is as follows.

The results of an on-going analysis of atmospheric and oceanic physical variables in the southern Gulf of St. Lawrence (SGL) were presented. Time series of selected variables (air temperature, cloud cover, relative humidity, wind, runoff, SST, water level, bottom T, stratification, volume and areas of waters within specified temperature intervals, ice, etc.) were constructed. Anomalies were calculated by subtracting the 1971-2000 averages from the yearly values. Z-normalized anomalies were then obtained by dividing the anomalies by their standard deviations during the baseline period. Plotting the anomalies themselves revealed interesting patterns, e.g., the cold period of the early 1990s and the continuous increasing trend in SST since then. An Empirical Orthogonal Function (EOF, also known as principal component analysis) analysis was performed of a set of 72 Z-normalized anomaly time series. The results show that the first principal component (first mode) accounts for 18% and the second 15% of the overall variance. The first mode mostly shows inter-annual variations around the mean; anomalous years like 1993 (cold) and 1999 (warm) stand out. The second mode shows less inter-annual variability with an increasing trend from the 1970s to the current period. The 72 variables were then sorted as a function of the amplitude of the first mode. The ordering shows that atmospheric variables (like temperature and cloud cover) have the greatest amplitudes followed by stratification, ice properties, and ocean temperatures. A mosaic color-coded plot of the yearly Z-anomalies, sorted by the amplitudes of the first EOF mode, reveals mostly noise reflecting the inter-annual variability with no clear pattern. The next step will be to group some well correlated parameters together and include other ones in an attempt to better characterize the physical environment of the SGL. A few examples were also given on how to use an existing numerical model of the Gulf of St. Lawrence to provide indices like transport and heat fluxes for periods when no data are available.

4.3 Habitat Mapping

Due to availability of multi-beam mapping and side-scan sonar images at the same spatial resolution, in combination with oceanographic models which provide fine scale estimates of bottom circulation and turbulence, there are opportunities for enhanced spatial resolution of the results of the multi-species trawl survey data. Two presentations were provided as examples of the potential use of high resolution habitat mapping in delivering the FOC workplan.

Vlad Kostylew provided a summary of his work with Charles Hannah and other collaborators at BIO, on predicting spatial patterns in benthic community types on the Scotian Shelf. The information is available in CSAS Science Advisory Report 2005/071.

Jerry Black and Steve Smith presented a paper entitled "The application of habitat mapping to fisheries conservation: An example based on scallops".

The availability of Vessel Monitoring System (VMS) positional information and bottom type derived from the SFA 29 multi-beam survey permitted the comparison of commercial catch rates from a new perspective. Commercial catch rate data are often used to monitor changes in abundance, with the assumption that changes in catch rate are proportional to the population abundance. While there are many factors that may mask the efficacy of catch rate as an indicator, the general presumptions are that no change in observed catch rate is indicative of a sustainable fishery, while an increase/decrease in catch rate may indicate that removals are less than/greater than growth + recruitment production (Figs. 36 and 37).

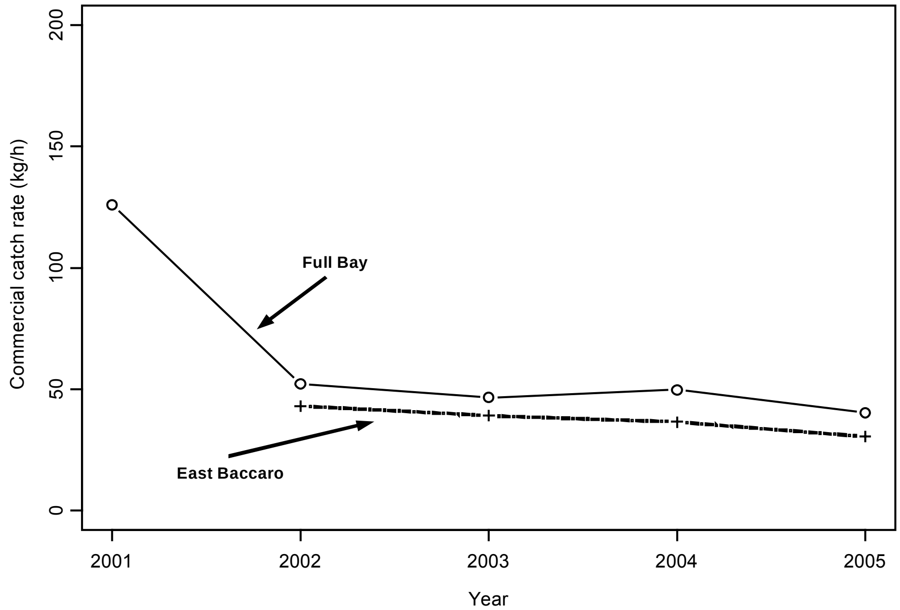


Figure 36. SFA 29 catch rates by fleet.

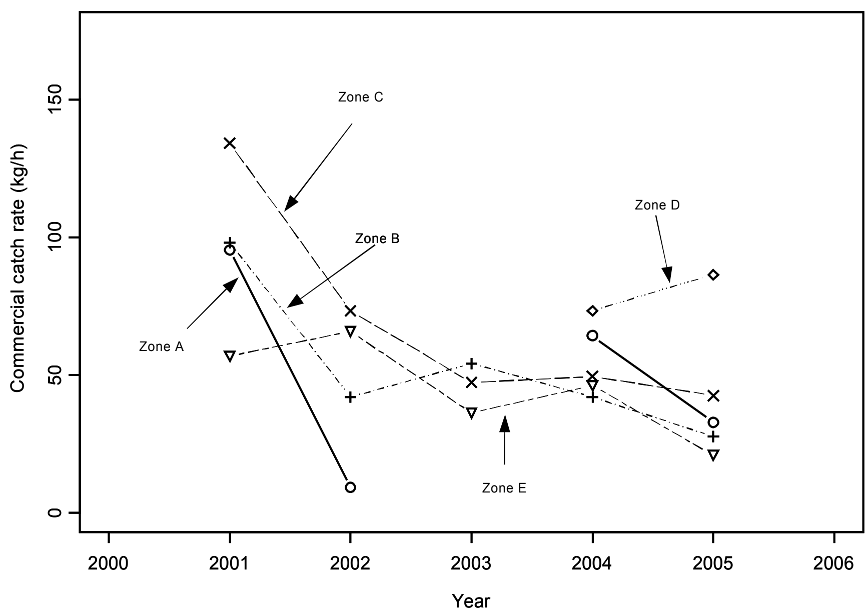


Figure 37. SFA 29 Full Bay Fleet catch rate by zones.

A significant error in using catch rates for scallop fisheries is the ability of the fleet to maintain catch rates by targeting new fishing grounds. To detect evidence of changes in the spatial distribution of fleet activity, the fishing log book data and VMS positional information were compared.

The VMS data provide hourly positional information for each vessel without an indication of vessel activity (Fig. 38). The vessel speed is available from some vessel instrumentation, or sometimes may be inferred with additional error from successive observations. Low speed observations (less than 4 knots) were used as indicators of where fishing activity may have occurred.

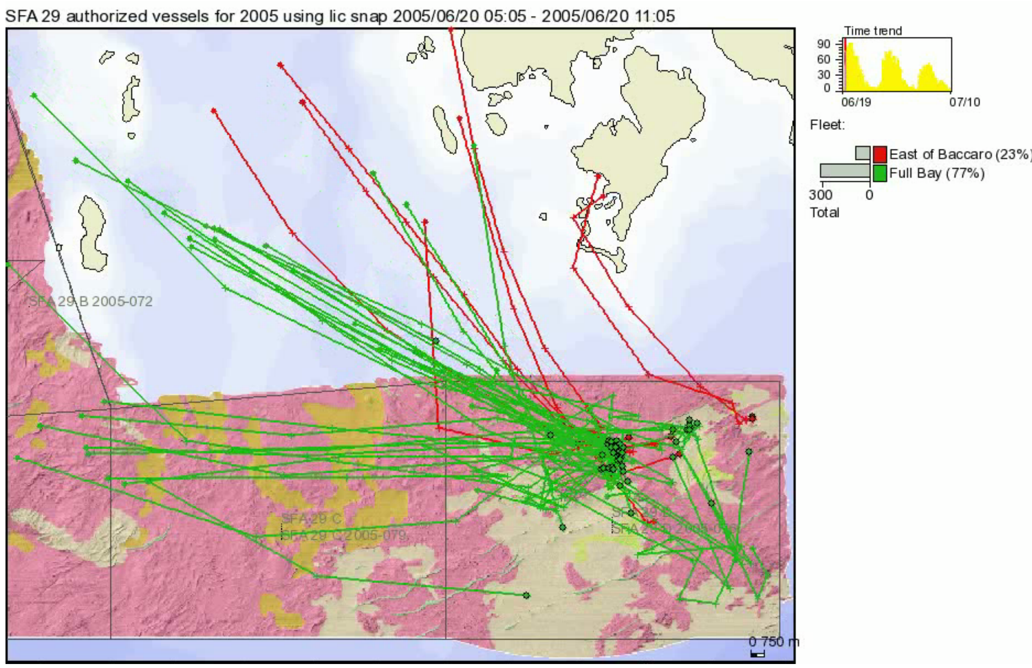


Figure 38. SFA 29 Fleet activity for a six hour time period from VMS positional information.

The distribution of VMS positions and log book data were compared using the bottom type classification to partition the data.

	Bedrock granitic	Glacial landforms till	Glacial till	Sand thick	Sand thin	Sand wedge	Till Silt
# VMS < 4 knots	5281	43	2604	25	1836	8	225
% VMS	52.69	0.43	25.98	0.25	18.32	0.08	2.25
% from Logs	59.1	0.42	18.93	2.94	16.18	0	2.42
% Bottom Type	66.7	0.65	7.07	0.64	10.38	0.19	14.37

The VMS and log book data both indicated significant fishing activity in the be Bedrock granitic, Glacial till and Thin sand bottom types, and preferential fishing activity occurred in the Glacial till and Thin Sand bottom types, exceeding that expected by the available area (Figs. 39 and 40).

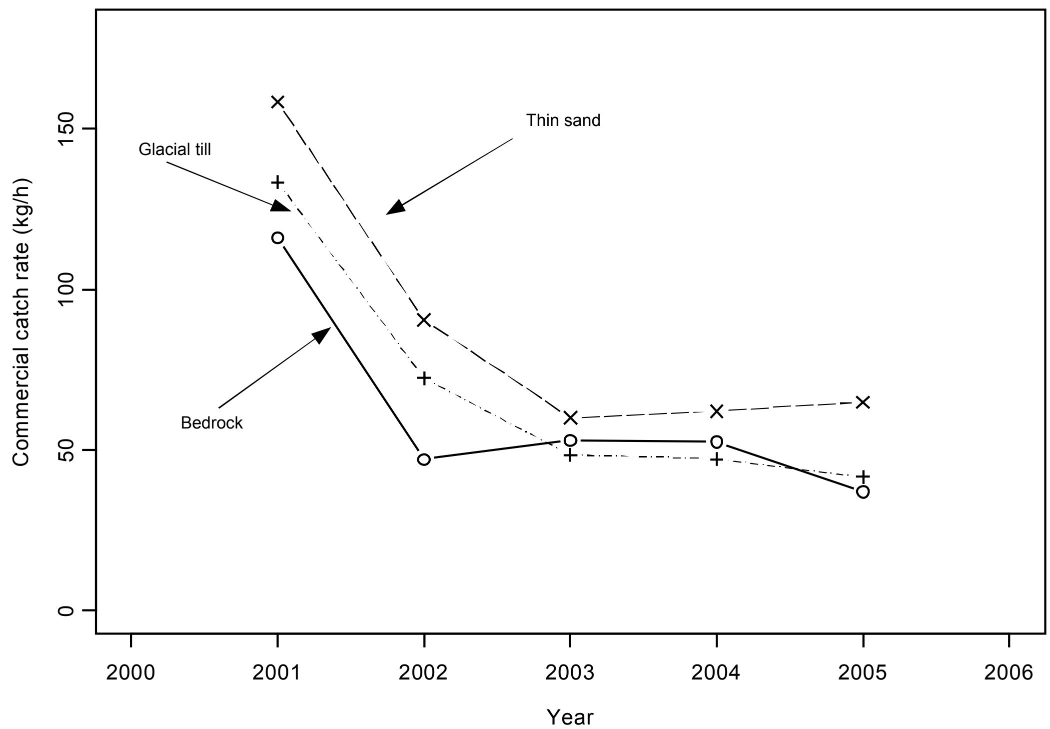


Figure 39. SFA 29 Full Bay Fleet catch rate 2001-05.

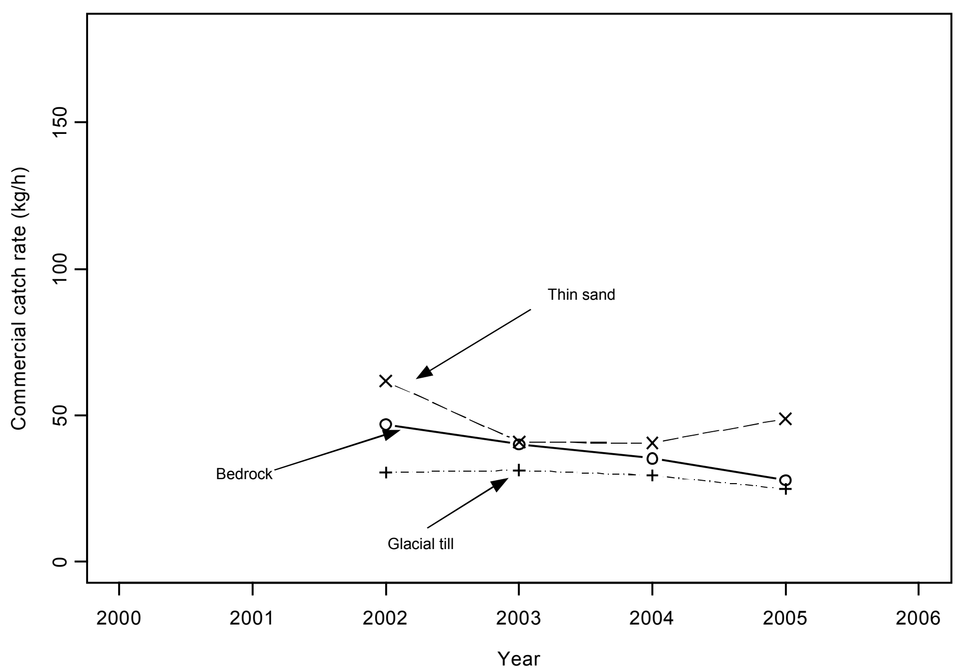


Figure 40. SFA 29 East of Bacarro catch rate 2001-05.

Comparison of log book catch rate and VMS positional data for 2003-05 indicated that in some areas, area fished changed on a yearly basis (ignoring areas where management restrictions affected fishing distribution) (Figs. 41 and 42). This was hypothesized as suggesting the "hyper-stability" of catch rates, and indicated that catch rates should be used with caution when used as an abundance index.

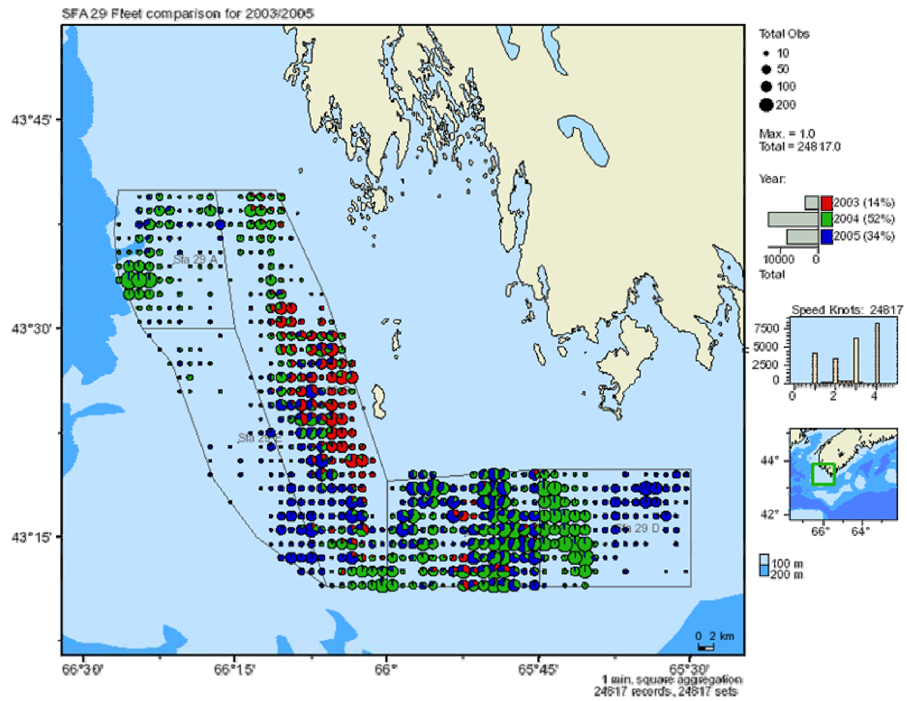


Figure 41. SFA 29 Log book summary for 2004-05.

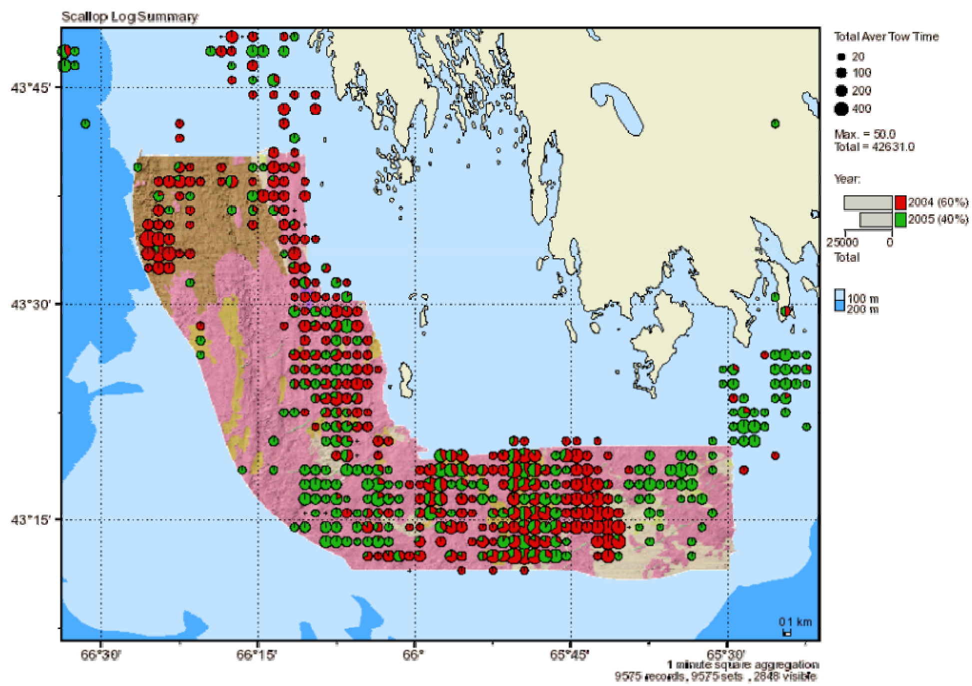


Figure 42. SFA 29 VMS summary for 2004-05.

5.0 GENERAL DISCUSSION

5.1 Summary of Multi-species Trawl Survey

Analyses

On the morning of March 31, 2006, there was a joint meeting of FOC and ASDC to present a summary of the work presented during the first two days, and a short discussion of next steps. Ken Frank presented the summary of the diverse regional syntheses of the multi-species trawl survey data sets.

For the Newfoundland and Labrador shelf seas, the overall biomass estimates have declined since the 1980s, in both the commercial and non-commercial species. In some areas, the non-commercial species show declines a few years prior to the commercial species suggesting that environmental factors are important influences in community level temporal changes. There has been limited or no recovery of commercially-important groundfish since the 1992 moratorium on directed fishing. The smaller sized demersal fish species do not show as great a change. Also, some of these smaller sized species showed an increasing trend in the 1980s, followed by a decline (e.g., alligator fish, Arctic cod). Average size of the fish captured in the trawl surveys has been declining. Small pelagic species (such as capelin and Arctic cod) do not appear to be increasing, as might be expected from a depletion of large commercial predators. The standard diversity indices of the spatially aggregated data appear to be somewhat static. However, when the data are spatially disaggregated some shifting patterns in diversity (low to high and vice versa) are evident. Various indices of community level response to environmental change and fishing pressure were explored, with the so-called ABC plot showing the most promise.

For the Quebec Region (i.e., northern Gulf of St. Lawrence), the analyses were carried out on the summer survey using the *Needler* with the UR1 81/114 trawl (1990 to 2003, and 2005). There have been decreases in the demersal fish biomass over the 16-year period due predominantly to declines in the abundance of cod and redfish. Three to five species account for about 80% of the total biomass in this geographic area. Greenland halibut and shrimp have been increasing in biomass, as have seals and cetaceans. These observations are consistent with the CDEENA results (which were based predominantly in stock assessment data, rather than the trawl surveys).

For the Gulf Region (i.e., the southern Gulf of the St. Lawrence), there has been a comprehensive analyses of the overall trawl survey database (1971 to 2005), which is near completion and involves collaborative work with statisticians at the Université de Paris. The decadal scale results (36 years) indicate steady change in the composition of the fish and macro-invertebrate bottom community. Climate factors, seals, and fishing influence the changes in species composition. The relative importance of these three factors are difficult to tease apart. The present fish community is characterized by smaller sized, cold-water species, which generally spawn in the winter months, not impacted by commercial fishing. In sum, there has been the evolution from warmer water, larger sized fish species that were subject to commercial fishing practices (directed species and by-catch/discard species) to smaller sized cold-water species. When the survey estimates of abundance are corrected for their catchability by the trawl (i.e., q corrected) there is little or no trend in overall aggregate fish and invertebrate biomass, although the distribution of biomass amongst functional groups and body size has changed considerably. Biomass estimates of several macro-invertebrate species have increased from 1985 to present. It is important to note that the southern Gulf survey has systematically quantified both commercial and non-commercial invertebrates. This is not the case for the other surveys.

The oceanographic data analysis for the southern Gulf was also summarized (the temporal trends of 72 atmospheric and oceanographic variables). Significant changes in the ocean temperature indices have been observed; with the trend during the past 15 years to warmer values, decreasing volume of bottom water with temperatures below 1ºC, decreasing area of temperature from -1º to 3ºC (the so-called snow crab index), and increasing temperature of the so-called snow crab core area. There has also been a general trend from less vertically stratified conditions from the late 1980s to the present (although significant inter-annual variability is to be noted).

For the Maritimes Region, the analyses were conducted in three geographic areas (eastern Scotian Shelf, western Scotian Shelf, and Bay of Fundy, and Georges Bank). On the eastern Scotian Shelf, it had already been demonstrated in an Ecosystem Status Report of 2003, that the biomass of large demersal species had steadily declined over three decades, with a lack of compensation in the other demersal fish species. There has been, however, a major increase in the biomass of small pelagic species and macro-invertebrates. The overall observed changes in this ecosystem have been interpreted as a “trophic cascade”, in response to the decline of large fish, due to both fishing, and increasing natural mortality, due to grey seal predation.

For the western Scotian Shelf, the estimates of biomass of the larger sized demersal species has been somewhat steady over three decades, although there have been major changes in relative abundance (e.g., cod, haddock down and dogfish up). The temporal dynamics are very different from those observed on the eastern Scotian Shelf in spite of relatively similar trends in fishing pressure. The ecosystem appears to be more driven by “bottom-up” processes with recent increase in dissolved nutrients (N.P.). There are many similarities between trends on the western Scotian Shelf and those observed on Georges Bank, including the increase in elasmobranch species. Only a preliminary look at the relatively short DFO regional February survey on Georges Bank was undertaken. The NOAA experts were unable to attend (their surveys, spring and autumn, are from the early 1960s to the present, with common protocols throughout the time period).

5.2 Issues and Next Steps

Comparisons amongst the regional analyses of the multi-species trawl surveys are hindered by a number of factors:

- changes in gear type over time within regions;
- differences between regions in gear types;
- incomplete species identification on some surveys (both fish and macro-invertebrates);
- differences in species coding amongst regions;
- different objectives amongst regions for the trawl surveys;
- a drift over time (and/or interannual variability) in the protocols used for the surveys based on shifts in regional priorities for sampling, etc.; and
- difficult access to the data sets in two regions (Quebec and Newfoundland and Labrador).

Given the above constraints, it was concluded that it is premature to develop a zonal consolidation of the survey database as was done for ECNASAP (1974 to 1994). In retrospect, it was very timely to conduct the analyses during this timeframe, as several changes to gears occurred in 1996, and subsequent years (e.g., introduction of Campelan trawl in place of Engel trawl).

Several next steps and recommendations were made:

- A zonal review of the objectives of the regional trawl surveys is required, followed by the standardization (within surveys at least) of protocols (action needed by ASDC).
- Training is required amongst regions to ensure minimal requirements are met (e.g., species identification).
- Need for an outline for the regional Ecosystem Status Reports, including indices from the single species stock assessments.
- Identification of analyses required of AZMP in support of the comparative ecosystem analyses.

6.0 REFERENCES

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ANNEX 1

Terms of Reference

Fisheries Oceanography Committee

It is the responsibility of the Fisheries Oceanography Committee to contribute to the scientific basis for the advice on fisheries issues influenced by meteorological, oceanographic, and biological processes and interactions by:

- providing a scientific forum for the discussion of the application and integration of environmental information and ecosystems knowledge to the analyses of the distribution and production patterns in commercially and/or ecologically important marine and Diadromous species;
- reviewing pertinent scientific data and coordinating the necessary analyses to evaluate the role of environmental factors and ecosystem processes on migration, spawning time, stock definition, recruitment variability and trends, growth characteristics, and spawning stock abundance of living marine resources;
- providing a scientific forum for the integration of results and knowledge from different disciplines (e.g., ecosystem modeling, fisheries science and biological and physical oceanography) across regions pf the Northwest Atlantic to achieve a more complete understanding of changes in productivity, ecosystem structure and availability of living marine resources to the commercial fisheries and the research surveys;
- reviewing the research requirements for fisheries oceanography and the Ecosystem Approach to Fisheries and recommending initiation of such programs to the Science Directors, as may be required; and
- maintaining a written record of the proceedings of the Committee, documenting the conclusions of the Committee and their scientific basic, and making the conclusions of the Committee available to management and the public.

ANNEX 2

Fisheries Oceanography Committee, 29-31 March 2006,
Hayes Boardroom – 1st Floor Fish Laboratory
Bedford Institute of Oceanography
Dartmouth, Nova Scotia

Day 1 -- 29 March -- Hayes Boardroom

0900 Introduction: FOC's strategic plan and other matters. Mike Sinclair and Ken Frank

0930 Changes in the fish community of the NAFO Divisions 2J3KLN0 in the period 1981-2004: Searching for signals and trends from the Newfoundland Region multi-species trawl survey. Mariano Koen-Alonso, Fran Mowbray, and George Lilly

1015 Health Break

1030 Specifications and considerations for using Newfoundland Region bottom-trawl survey data fish biodiversity measures. Fran Mowbray

1100 Overview of compositions, abundance, and biomass of fish and invertebrates in the northern Gulf of St. Lawrence. Claude Savenkoff, Patrick Ouellet, and Jacques Gagné

Note: Boardroom change to the Gully Boardroom, 6th Floor Polaris

1315 Ecosystem change in the southern Gulf of the St. Lawrence 1971-2005. Hugues Benoît and Doug Swain

1400 Changes in community structure on the eastern (Div. 4VW), western (Div. 4X) Scotian Shelf during the past forty years. Nancy Shackell and Ken Frank

1500 Health Break

1530 An ecosystem status report for the western Scotian Shelf (Div. 4X), Nancy Shackell, Ken Frank, Brian Petrie, Jae Choi

1630 General Discussion

1700 End of Day 1

1900 Reception for FOC participants at the home of Mike Sinclair (details to be provided at the meeting)

Day 2 -- March 30 -- Hayes Boardroom

0900	A historical perspective of the East Coast of North America Strategic Assessment Project. Bob O'Boyle
0930	Using Standards to Achieve Data Interoperability; OBISMD. Bob Branton
1000	Health Break
1030	A multi-variate, physical environmental characterization of the southern Gulf of St. Lawrence from past to present. Joel Chassé/Brian Petrie, Ken Frank
1100	The AZMP scorecard: compilation of regional/zonal indices of oceans climate and lower trophic dynamics. Glen Harrison, Brian Petrie, Ken Frank
1200	Lunch Break
1300	Model based approach to benthic habitat mapping, Vlad Kostalev
1330	The application of habitat mapping of fisheries conservation: an example based on scallops. Jerry Black and Steve Smith
1400	A GCMD Portal for the Ocean Biodiversity Information System. Bob Branton
1430	Health Break
1500	Development of Workshop report/presentation to Atlantic Science Directors
1700	End of Day 2

Day 3 -- March 31 -- Hayes Boardroom

0830	Presentation to Atlantic Science Directors of major findings/conclusions developed by FOC during day 1 and including work plan integration with AZMP. Mike Sinclair and Ken Frank
1015	Health Break
1045	FOC work plan discussion – the next steps.
1200	Adjourn

ANNEX 3

Fisheries Oceanography Committee, 29-31 March 2006,
Hayes Boardroom – 1st Floor Fish Laboratory
Bedford Institute of Oceanography
Dartmouth, Nova Scotia

Attendance

NFLD (NWAFC)	Mariano Keon-Alonso Fran Mowbray Dave Kulka
QUEBEC (IML)	Patrick Ouellet Claude Savenkoff Jacques Gagné
Gulf (GFC)	Hugues Benoît Joel Chassé
Maritimes (BIO & SABS)	Nancy Shackell Brian Petrie Jae Choi Glen Harrison Alida Bundy Bob O'Boyle Bob Branton Vlad Kostylev Jerry Black Steve Smith Mike Sinclair