Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS)

Second Session
Montpellier, France
22-24 March l999

GOOS Report No. 74

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SUMMARY REPORT

1. INTRODUCTION

The meeting was opened at 0900 on 22 March, 1999 by Warren Wooster and Dagoberto Arcos, Co-Chairs of the Panel, who thanked panel members and observers (Annex II) for attending. Dr. Wooster also thanked the Institut de recherche pour le développement (IRD) in Montpellier for hosting the meeting. Dr. Jean-Michel Stretta, Chef de Section Halieutiques, IRD Montpellier, welcomed the meeting participants on behalf of his institute.

2. ADMINISTRATIVE ARRANGEMENTS

The provisional agenda was discussed and adopted (Annex I). Mike Laurs agreed to serve as rapporteur. Ned Cyr discussed logistical arrangements with the panel, and thanked the Food and Agriculture Organization of the United Nations (FAO) for their contribution to the meeting.

3. SOME VIEWS OF CO-CHAIRMAN WARREN WOOSTER

[*This text was provided to the panel prior to the Montpellier meeting to stimulate discussion on the panel's direction and strategy.*]

The panel must consider how to proceed from where it is to the development of a strategic, and eventually an implementation, plan. The problems in achieving a firm design for the LMR component of an operating system include the heterogeneity of present observing systems for biological elements, and the lack of agreement on which observations would benefit potential users. Although it is now generally accepted that variability in the physical and biological environment has an important role in determining the abundance and availability of living marine resources, there are no generally accepted models whereby observations of the relevant physical and biological variables can be used in forecasting such abundance and availability.

The development of such models, which will be made possible by research programmes such as GLOBEC, is a prerequisite for the success of an LMR monitoring system that is to generate products desired by users. With no present observing system on which to build and no agreed linkage between measurable variables and desired products, the optimal route to the desired outcome remains obscure.

At its first meeting, the panel identified in generic form the ecosystem components and conditions for which information is required, and it now must further specify the measurements of these components and conditions that should be incorporated in an operating system. It must also consider how such data can be applied to desired end products. For example, one might propose a scheme for monitoring phytoplankton abundance and primary production, but there is as yet no agreed way to use such data to predict abundance of some fish stock of commercial importance. On the other hand, such information could be useful in determining changes in the condition (health) of an ecosystem.

The present system of observation, data storage, analysis, promulgation of findings, and utilization of relevant biological information by appropriate national and regional agencies is weak or non-existent. Progress toward an operational LMR-GOOS system will require analysis of available data on monitoring of lower trophic levels to learn what they tell about ecosystem change, and analysis of available fishery data and observations of marine mammals and seabirds to learn what they tell about changes in the upper trophic level of ecosystems.

There are few, if any, regional or larger-scale centers for analysis of biological observations from present, and later from improved, monitoring systems and for training and education in their use. Such centers could be responsible for developing products for distribution to users, and their existence and operation could constitute a demand function that should trigger enhancement of the observational network. From a capacity-building point of view, important skills are those required to transform biological data, together with outputs from the system of physical observations, into now-casts and forecasts of biological variables of concern to users, including those involved in the harvest of living marine resources. These skills are not widely held even in the technically-advanced countries of the northern hemisphere, and the heart of capacity building for LMR-GOOS might be regional analytical centers whose staff and other scientists from the region could learn together how to make useful products from the incoming data.

4. STATUS OF GOOS ACTIVITIES

Ned Cyr reported on recent GOOS activities and how they relate to the LMR panel. He reviewed the main objectives of GOOS, and the four-module structure of the design phase. He also discussed the five phases of GOOS implementation, noting that LMR-GOOS is in the design and planning phase, and is beginning to move to the second phase of operational demonstrations and pilot projects. In this regard, the GOOS regional pilot efforts being implemented globally, and the projects which comprise the GOOS Initial Observing System (IOS) were presented. LMR panelists were encouraged to consider projects which could comprise an LMR contribution toward the IOS. Finally, the panel was informed about the Joint G3OS Data and Information Management Panel (JDIMP). JDIMP is charged with developing an overall data management plan for G3OS, including GOOS, and LMR-GOOS should consider what its data management needs are, and how the panel can interact with JDIMP to ensure that they are considered in the plan.

5. RELEVANT ACTIVITIES OF OTHER ORGANIZATIONS

As recognized during the first panel meeting, successful design and implementation of LMR-GOOS is dependent on the contributions of many related organizations and activities. To keep the panel abreast of relevant activities, panelists and invited guests provided brief reports from their organizations.

5.1 INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (IOC OF UNESCO

Ned Cyr introduced IOC programmes and activities relevant to LMR-GOOS. Among the most relevant are the developing Large Marine Ecosystem (LME) monitoring and assessment projects which are co-sponsored by the GEF, IOC, UNIDO, UNDP, IUCN and other governmental, intergovernmental and non-governmental agencies. The projects comprise five modules - productivity, fish and fisheries, pollution, socioeconomics and governance - which are designed to provide integrated information on ecosystem status and trends. A GEF-funded LME monitoring and assessment project has been implemented in the Gulf of Guinea since 1996, and might be considered as a pilot LMR-GOOS project. The GEF is also funding project planning for the Benguela Current Ecosystem (South Africa, Angola, Namibia) and the Yellow Sea LME (Republic of Korea, People=s Republic of China, Democratic People=s Republic of Korea).

5.2 NORTH PACIFIC MARINE SCIENCE ORGANIZATION (PICES

A major programme of PICES, its GLOBEC programme on Climate Change and Carrying Capacity (CCCC), includes a Monitoring Task Team which will focus on monitoring needs of the research programme and whose work is intended to contribute to LMR-GOOS. It seems likely that one or more pilot/demonstration projects for LMR-GOOS will be developed. During its Eighth Annual Meeting, in Vladivostok on 15 October 1999, PICES will convene a conference on the Nature and Impacts of North Pacific Climate Regime Shifts which will give particular attention to analysis of the 1976-77 event as a contribution to the LMR-GOOS effort in retrospective experiments (see Section 7, this report). A related symposium on important time scales in climate variability, ABeyond El Niño: a Conference on Pacific Climate Variability and Marine Ecosystem Impacts, from the Tropics to the Arctic,@ will be held in La Jolla, California in March 2000.

5.3 CENSUS OF THE FISHES

In December 1996 the Board of Trustees of the Alfred P. Sloan Foundation endorsed two years of feasibility studies for a Census of the Fishes. The studies were to explore if the Foundation might catalyze a major new international observational programme to assess and explain the diversity, abundance, and distribution of marine life. Observational strategies would not be restricted to fish, and the project might more properly be termed a Census of Marine Life. The feasibility studies sought expert views on the scientific and social value and motivations of a Census, its technical feasibility at reasonable cost, and the extent of support for the programme by the stakeholder communities. A series of workshops were held in 1997-98 to examine various aspects of the questions what did live in the oceans, what does live in the oceans?, and what will live in the oceans. In December 1998, the Foundation decided to proceed with the programme, with the expectation of making grants during 1999 to further its development.

It was suggested that in its initial phase, the census could serve as a demonstration project in a selected region to describe and explain the distribution of abundance and diversity of marine life, especially of the upper trophic levels. The use of new technology will improve the quality of the background description. Products of the census will include improved knowledge of biogeography and of biodiversity. Such demonstrations might be tried, for example, in the Gulf of Maine or the northeast Pacific.

5.4 INTERNATIONAL COUNCIL ON THE EXPLORATION OF THE SEAS (ICES)

The year 1999 is the centenary of the first planning meeting held in Stockholm that led to the formation of ICES in 1902. To a large degree the goals of ICES in 1902 included the goals of LMR-GOOS. As a result, ICES has been actively involved in monitoring activities within the North Atlantic for the past century. During the past several years the Science Committees have been re-structured in order to improve the role of ICES in the leadership of research and monitoring. In addition, the organization is in the midst of formulating and implementing a strategic plan. The Consultative Committee, the two advisory committees and each of the Science Committees have been requested to define priorities in relation to the goals of the plan.

The activities of most relevance to LMR-GOOS are managed by the Oceanography, Resource Management, Marine Habitat, Living Resources, Baltic and the two advisory Committees. For each of the Committees there are a number of working groups, study groups and coordination groups. Many of these are dealing with monitoring issues.

There is an enormous investment presently in place in the North Atlantic for monitoring of living marine resources, and for the interpretation of observed trends. The challenge is to identify gaps or deficiencies in the three steps of the monitoring programme: (i) the observations being collected, (ii) the generation of data products in a timely manner; and (iii) the ecological interpretation of the data products (synthesis and forecasting).

The activities of particular relevance to LMR-GOOS are the attempts by ICES to integrate the fisheries and environmental advisory functions. The Working Group on the Ecosystem Effects of Fishing has been addressing this need. The final term of reference of the 1999 meeting is:

Begin consideration of the development of integrated management objectives for an ecosystem approach to management, integrating fisheries and environmental aspects.

This activity and parallel activities in several countries (Australia, United States and Canada, for example) are of immediate interest to LMR-GOOS. The overarching ecosystem objectives for evolving integrated ocean management can be used to evaluate the degree to which the monitoring strategy is adequate. The data products from LMR-GOOS should generate performance measures of relevance to the ecosystem objectives of the management of ocean uses. A second key activity is the coordination of the GLOBEC programme in the North Atlantic. LMR-GOOS is recommending that pilot monitoring projects be co-located with geographic areas of intense GLOBEC research. In this way the efficiency of the monitoring strategies can be more readily evaluated. A third key activity is the data management function of ICES. LMR-GOOS requires the management of diverse categories of oceanographic, ecological and fisheries data. ICES has a wealth of experience in this function of monitoring programmes.

5.5 ICES/SCOR SYMPOSIUM ON THE ECOSYSTEM EFFECTS OF FISHING

The ICES/SCOR Symposium on the Ecosystem Effects of Fishing was held in Montpellier, France from March 15 - 19, 1999. The aims of the symposium were: (i) to provide a synthesis of impacts of fishing on the full range of marine ecosystems, from the intertidal zone to the deep ocean; (ii) review methods for measuring the impacts on ecosystems; and (iii) provide management options for limiting such impacts.

An approach proposed in several countries has been to define ecosystem features of fairly large ocean management areas that need to be conserved. Then conservation objectives for management plans for diverse ocean uses (fisheries, marine transportation, oil and gas, etc.) need to be consistent with the conservation of the ecosystem features. A number of such Aecosystem objectives@ were identified during the symposium, including maintenance of biodiversity and habitat productivity. The next step is to make the achievement of such broadly stated objectives operational by the definition of performance measures and reference points/decision rules.

The expansion of ocean management to explicitly incorporate ecosystem objectives has implications for monitoring of living marine resources. New needs include measures of biodiversity of benthic communities, abundance of non-commercial forage species, genetic diversity, biomass by trophic levels, and predator/prey linkages. It was concluded at the LMR-GOOS meeting, which followed the ICES/SCOR Symposium, to use the ecosystem objectives defined during the symposium conclusions by Keith Sainsbury to evaluate the efficiency of the monitoring programme outlined in Annex V.1 and V.3. Would such a monitoring programme generate performance measures relative to specific ecosystem objectives?

5.6 FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)

Andy Bakun reported on FAO's participation in the GOOS LMR Module development. GOOS is the major United Nations ocean initiative of the 1990s, having been established as one of the principal outcomes of the 1992 UNCED Conference in Rio de Janiero. FAO, being the UN Agency with primary responsibility for marine fisheries issues, wishes an important role in GOOS activities directly related to its mission. Thus, while FAO is not a sponsoring agency of the GOOS system as a whole (as are IOC, WMO, UNEP, and ICSU), FAO has provided funding support to GOOS LMR Module development since its inception in 1993. More recently, FAO's logo has appeared on the cover of the report of the first GOOS LMR Panel meeting last year, indicating its status as a formal sponsor of the Panel.

FAO considers it important that the United Nations speak with a coordinated voice on marine fishery status and trends issues. Thus FAO would wish to be collaboratively involved in all aspects of development and operation of the GOOS LMR module. FAO offers its own considerable efforts in monitoring global status and trends of fisheries and fishery resources as potential contributions to the GOOS information system.

While FAO's potential contributions to GOOS are largely incorporated in the LMR module, many of the inputs to FAO's work on its own mission that are expected to be derived from GOOS (i.e., status of critical habitats and nursery grounds such as large estuaries, sea grass beds, mangrove areas, coral reefs, etc.) are being developed within the GOOS Coastal Module. FAO currently does not support, nor have direct input into, this GOOS module. In the coming reorientation of GOOS module "taxonomy" in April, it is expected that the current situation may be altered in some manner or degree.

5.7 SIR ALISTER HARDY FOUNDATION FOR OCEAN SCIENCE (SAHFOS

The Continuous Plankton Recorder survey has monitored the plankton in the North Sea and North Atlantic with a consistent methodology since 1948. The survey has provided information on large scale plankton distributions, seasonal, interannual and decadal variability and more recently the effects of climate change and an ecosystem regime shift. All these aspects are relevant to LMR-GOOS. However, whilst the sampling device and analytical protocols have produced an internally consistent data set there are limitations to these data which reduce its wider applicability; the CPR samples at a constant, near surface depth of about 7m which may not be fully representative of the mixed layer plankton communities, the water flow through the device is unquantified so that absolute abundances of organisms are unknown and the size of the filtering mesh, at 270μ, prevents the quantitative recording of smaller organisms.

The Sir Alister Hardy foundation for Ocean Science has recently concentrated on reducing these limitations through a number of initiatives. A new device has been developed in collaboration with commercial partners, the W.S. Oceans Systems Ltd. 'U-Tow', which has the ability to undulate throughout the water column and to carry a suite of instruments which will record the physical and chemical environment, in addition to the plankton sampling mechanism. Furthermore, WS Oceans 'Aquamonitor', a water sampler that collects and preserves microplankton has been developed to be carried within the U-Tow. Recent trials have shown the U-Tow to be capable of undulating to depths of 60m and to be successfully towed at speeds of 12knots from research vessels. It is hoped that ship-of-opportunity deployments will soon follow. Electromagnetic flowmeters have also been fitted to some of the existing CPRs to record the actual water flow through the machine. The data collected will be used to produce a relationship between the number and type of organisms on the mesh and the volume of water sampled. This relationship will then be applied to the CPR archive to calculate absolute abundances. Through improving the existing database and developing new technology, the CPR survey will continue to play an important role in ocean scale monitoring.

5.8 GLOBAL OCEAN ECOSYSTEM DYNAMICS (GLOBEC)

The IGBP/SCOR/IOC international GLOBEC programme has four main components which are described in detail in the GLOBEC Implementation Plan, which will shortly be published as IGBP Report No. 47. These include four research Foci, each with Activities and Tasks, four cross-cutting Framework Activities, and four Regional Programmes, and finally an Integrating Activity. These are the elements that have been planned by, and will be implemented under the auspices of, the GLOBEC Scientific Steering Committee. National GLOBEC programmes will select those aspects of this international framework which are relevant to meeting national objectives, or they may develop new directions as needed to meet specific national needs.

The four Foci define the overall practical research approaches, and each has potential for linkage with GOOS.

Focus 1: Retrospective analyses and time series studies
Focus 2: Process studies
Focus 3: Predictive and modeling capabilities
Focus 4: Feedback from Changes in Marine Ecosystem Structure

For each Focus, major Activities have been identified and described. The Activities have been broken down into a series of initial Tasks, but the lists of Tasks are not intended to be definitive; they are indications of the types of research projects which would lead to progress in each area of GLOBEC research. No doubt, many national GLOBEC programmes will add to the list of suggested Tasks.

The Implementation Plan also describes the Framework Activities, which are "cross-cutting" efforts requiring international co-ordination. These will be developed through the direct leadership of the international GLOBEC SSC and the International Project Office (IPO). They include:

Sampling and models: protocols and inter-comparisons
Data management
Scientific networking
Capacity building

For example, data and methods from the whole array of GLOBEC research projects should be coherent and consistent. This can only be achieved if there is international agreement on the methods and standards to be applied in making field and laboratory observations. Similarly, international workshops will be required to evaluate and compare various GLOBEC-related models. All national participants will benefit from these Framework Activities, to the extent that they all contribute actively to them. Again there is good scope for productive interaction with GOOS.

In collaboration with GOOS and other relevant programmes, the results of GLOBEC investigations need to be distilled to identify the crucial variables and locations to study and develop long time series analyses of climate variability and marine ecosystem responses. Recommendations should be made for a co-ordinated network of sampling activities to assess ecosystem structure and changes.

GLOBEC can contribute to the design of GOOS by providing information on critical parameters to be measured and on time and space scales that are best suited for predictive capabilities in such a system. GLOBEC is also concerned with continuing development of technology suitable for continuous sampling of biological and chemical parameters in the ocean, and these should also be of interest to GOOS, especially its modules on Living Marine Resources and the Health of the Ocean.

The GOOS-LMR can benefit from GLOBEC research, especially in the areas of observational networks and modeling. In turn, development of the GOOS-LMR, HOTO, and Coastal modules should be valuable for GLOBEC in that particular opportunities for collaborative sampling should arise as GOOS evolves. In addition, capacity building through GOOS could benefit GLOBEC activities.

The design and implementation of GOOS will depend in large part on the results and analyses from GLOBEC. Linkages between GLOBEC and GOOS need to be established early, both to develop a history of information flow and to evaluate potential GOOS protocols, locations, and sampling designs. Such interaction is strongly supported by GLOBEC, and it's oversight should be conducted by the International Project Office, in consultation with the GLOBEC SSC.

6. SURVEYS OF EXISTING OBSERVING PROGRAMMES

6.1 FAO META-ASSESSMENT OF FISH DATA

The following request was directed to FAO from the First Session (Paris, 23-25 March 1998) of the GOOS Living Marine Resources Panel:

> *"A number of national and regional bodies collect and analyze fishery statistics and make fishery assessments. An aggregation of these analyses would be invaluable in assessing population changes in the upper trophic levels of marine ecosystems. The panel therefore requests FAO, the global centre for fishery statistics, to identify on a global scale the existing fishery analyses that could contribute to the desired meta assessment and advise on how it could best be organized and carried out."*

A reply from FAO was prepared and distributed to Panel members before the meeting. FAO's opinion is that in spite of great advances in ocean data and information systems, one of the primary sources of readily-available and interpretable information on the long-term, large-scale biological "health" of marine ecosystems remains, now as in the past, the fisheries. To cite only one of a number of examples, the recent collapse of much of the biological community structure in the Black Sea was progressively signaled by successive changes over the past decade and a half in the nature, composition, and productivity of the Black Sea fisheries. Because of the economic incentive, fisheries offer a sampling system for the upper trophic levels of the ocean system which provides temporal and spatial coverage that is non-duplicable by any other feasible means. Thus, data on fish landings, fish stock sizes, and annual reproductive success clearly offer a resource of information for GOOS-LMR.

Of these three data types, only fish landings are regularly reported by FAO's membership. These data can be validly considered to be indicators of the stress on marine ecosystems exerted by fishing activity. They are also obviously related to resource availability, but because economics and human behavior is involved, appropriate interpretation is non-trivial. However, experience has shown that while interpretation of short-term trends is not simple, interpretation of longer-term trends may often be easier and more reliable.

6.1.1. Estimates of resource population size and reproductive success

Data on resource population size and reproductive success are not routinely reported to FAO by member governments. However, many member governments as well as other bodies, organizations and institutions do of course produce such estimates. These range from high-precision fishery-independent survey estimates produced annually or even more frequently, to very rough estimates produced once, or at most, sporadically. FAO currently makes no attempt at a systematic compilation of these.

Many, and in many cases the best, of these data are routinely made available on various Internet web sites. A good example is the U.S. NOAA-NMFS "Our Living Oceans Annual Report" (http://www.nmfs.gov/olo.html). Note that the accuracy, validity, and objectivity of any estimates published on the Internet, must necessarily be solely the responsibility of the publishing entity. FAO currently assumes no responsibility (except, of course, for data published on its own Fisheries Dept. Home Page: http://www.fao.org/WAICENT/FAOINFO/FISHERY/FISHERY.HTM).

6.1.2. FAO Review of the State of World Fishery Resources

For a number of years, the Marine Resources Service of FAO has produced a biennial global review of the state of marine fisheries resources. The latest edition will be published later in 1999. This review is essentially the collective analyses and opinions of a small group of experienced FAO Marine Resources Service staff officers have been assigned responsibilities for following resource issues in various regions of the world's oceans. As such, it has been a widely cited, visible, and evidently useful document.

6.1.3. FIGIS

The FAO Fisheries Global Information System (FIGIS) is a project launched in 1998 which targets the integration of information in fisheries and aquaculture, to provide support to FAO's role in analyzing global fisheries issues and reporting on resources status and trends. The system will integrate such diverse information domains as biology, technology, trade and fish utilization, fisheries policy and management, etc. FIGIS will also provide external users with global access to fisheries and aquaculture information through the Internet, and is designed to facilitate the exchange of information among concerned parties.

The efficiency of the information system will rely heavily on the further development of equitable and realistic partnerships between countries and their regional institutions (organizations or arrangements) and FAO. Surveys will shortly be undertaken at regional and national level to assess more precisely the relevant needs, etc.

FIGIS will replace, incorporate, or provide links to various current FAO information systems and organs (e.g., Review of the State of World Fishery Resources, Yearbook of Fishery Statistics, FISHSTAT, POPDYN, etc.).

An ACFR (FAO's Advisory Committee on Fisheries Research) Working Party on Fisheries Status and Trends Reporting is scheduled to meet in Rome from 30 November to 3 December, 1999. This meeting has invited participation from the various FAO regional bodies, from several important NGOs (e.g., IUCN), from ICES, PICES, and also from IOC/GOOS.

6.1.4. Sustainability indicators

Currently FAO is actively involved in the development and implementation of sustainability indicators to support a sustainable reference system for capture fisheries. A major recent milestone in this effort was the FAO-Australian Technical Consultation on Indicators of Sustainable Development in Marine Capture Fisheries, which was held in Sydney, Australia, 18-22 January, 1999. The system being developed is intended to provide the main elements and standards of an objective monitoring of fisheries sustainability, to provide the basis for performance assessment of fishery policies and management schemes by fishing nations, and to assist in standardizing the reporting on state of resources and fisheries at global, regional and national levels. To underpin the system, a suite of criteria, indicators, reference points, verifiers, etc., will be selected, implemented, and monitored.

The aforementioned items under headings 6.1.1, 6.1.2, and 6.1.3 are the actions that FAO is currently undertaking with respect to following and reporting fisheries resource trends. It is clear therefore that these are the actions that FAO believes offer the best tradeoffs of feasibility, practicality, and utility.

FAO intends that the outputs be available to GOOS and that the development, implementation, and operation of these items be considered as an FAO contribution to GOOS. Further, FAO wishes to collaborate with GOOS in developing and implementing additional capabilities, products and actions, and to continue to participate fully as a partner in GOOS, particularly with respect to monitoring and analysis of fishery resources status and trends for which FAO historically has the mandate and the highest level of competence within the UN system.

6.2 IOC SURVEY OF OBSERVING PROGRAMMES

In response to requests by the LMR-GOOS and CGOOS panels, the IOC circulated a letter (Annex VII) to all member states requesting an inventory of national marine observing programmes. The purpose of the letter is to determine where observing programmes exist and what data are collected so that the panels can design modules to effectively provide for critical missing information. In addition to circulating the request, the IOC will conduct a search for observing programmes which may be conducted by international organizations (i.e., the ICES International Bottom Trawl Survey) and hence not be included under national contributions to GOOS.

7. DETECTING PATTERNS OF ECOSYSTEM CHANGE - RETROSPECTIVE EXPERIMENTS

At the first meeting of the panel it was recognized that the concepts of monitoring, analysis, and prediction could be tested in several well-sampled regions where significant ecosystem changes such as regime shifts had been observed. In such regions, one could ask to what extent ecosystem changes could have been predicted from observed variables, how that predictability could have been improved with more effective monitoring, and to what extent predictability was affected by inadequate monitoring, analysis, or understanding. Several retrospective experiments were proposed by panel members.

Drs. Zhang and Sugimoto reported on a joint Korea-Japan research project focusing on the planktonic community and small pelagic fish in the East Sea/Japan Sea and East China Sea, in which biomass changes and shifts in community structures depending on climatic and oceanic environmental changes will be retrospectively analyzed using historical data. In addition, developments of monitoring systems and of prediction systems by numerical modeling will be considered. The project is proposed to extend from September 2000 through March 2003.

Dr. Lluch reported on a retrospective analysis of the southern part of the California Current region to see if the observed ecosystem changes could have been predicted using data resulting from the California Cooperative Oceanic Fisheries Investigations (CalCOFI). While average zooplankton volumes in selected areas did reveal the regime change of the mid-1970s, changes in sampling strategy with data gaps at the time of the regime shift limited the analysis. It is planned for the investigation to continue with emphasis on selected Biological Action Centers. Details are set forth in Annex IV.1.

Dr. Sinclair reported on a retrospective experiment on the eastern Scotia Shelf, where the monitoring programme was considered adequate to describe aspects of ecosystem and fishing changes, although not sufficient to interpret the reasons for these changes. However, analysis of monitoring data was not adequate with respect to the needs of the decision makers for fisheries management. Moreover, inadequate knowledge of marine ecosystem structure and function set limits on the degree to which the monitoring programme could provide data products that are sufficient for decision makers on ocean use issues. Details are set forth in Annex IV.2.

Dr. von Bodungen reported on eutrophication in the Baltic Sea. Since 1979 the Baltic Sea Monitoring Programme (BMP) of the HELCOM has been in operation. The BMP comprises hydrographical, hydrochemical and biological measurements to identify and quantify the effects of anthropogenic discharges/activities including regulatory steps, in the context of natural variations in the Baltic Sea.

The BMP was well able to record changes and variability in biota and chemistry. However, the synthesis of the data did not allow the observed patterns to be ascribed unequivocally to climate forcing and man`s activity, respectively. Real time descriptions or predictability are insufficient.

A main problem with the BMP was undersampling as well as the lack of measurements to analyze the important sinks, such as denitrification and burial fluxes in the early phases of the programme. Techniques for continuous recording of critical variables with high spatial/temporal resolution may be superior to discrete measurements at selected station.

The BMP showed that the most critical gaps in knowledge are at present:

- adequate determination of the largest scales needed to record most of the variance of the ecological properties of interest;
- description and quantification of the propagation of change from local to basin scales and *vice versa*;
- knowledge and identification of key processes and species that can be used as early indicators of direction and magnitude of change interactions between species composition/diversity and matter fluxes.

An observation programme for the Baltic probably cannot yet be designed in a way to solve all these problems properly. Supporting research programmes on critical processes and scales are still needed to supplement the observation programme. This is done in the Baltic Sea in order to parameterize these processes and to find proxies which are easy to monitor and are suitable to indicate at least the direction of possible changes in magnitude of these processes. Because of the state and development of the monitoring in the Baltic Sea a retrospective experiment of the sort proposed GOOS-LMR is an ongoing process.

Dr. Wooster reported that at its Eighth Annual Meeting, in Vladivostok, PICES was convening a symposium to examine the nature and impacts of North Pacific climate regime shifts, which will pay particular attention to a detailed analysis of events just preceding and impacts resulting from the 1976-77 event. The symposium will also consider the physical mechanisms behind regime shifts and on observational evidence for other such events in this century.

The retrospective experiments are in the planning or early implementation stage. Continuing review should determine if these experiments are achieving the desired end of helping to identify the desired indicators of ecosystem change and the analysis necessary for hind-, now, and fore-casting. Some of the experiments now underway may not prove appropriate, and additional experiments (e.g., Chile and Gulf of Alaska) should also be considered.

8. POTENTIAL REGIONAL OBSERVING SYSTEMS AND MONITORING PRODUCTS

The global diversity of marine ecosystems precludes the ability to develop a ›one-size-fits all‹ observing programme for living marine resources. Regional approaches offer promise because the spatial scale is small enough for a homogeneous observing system to be effective. The panel was requested to bring to the meeting examples of existing regional observations which might represent a comprehensive and effective monitoring and assessment programme. After reviewing the existing observations, the panel was also asked to develop:

(i) a generic regional observing system, using the various regional examples as guides, which could serve as a template for the development of more comprehensive observing systems on a regional basis; and

(ii) a list of the useful products that could be derived from such a regional observing system.

Several excellent examples of existing regional observing systems were presented from Chile, the Scotian Shelf, the Black Sea, the Gulf of Guinea and the Northwest Pacific. The Chilean example (Annex V.2) was most comprehensive, containing information on commercial fish, physical and chemical oceanography and atmospheric forcing. In addition, each of these observations is linked to a parameter in one of several models, including stock assessments. Each of the model outputs is identified as a specific ›product‹ from the observing system which can be used by oceanographers, ecologists, fisheries scientists and resource managers. Finally, for each observation and model, specific capacity building needs were identified.

The end-to-end approach used in the Chilean observing system typifies the ideal GOOS approach. Each observation is linked to a specific product which is needed by an end-user. Similar tables for other regions will be developed for the next meeting of the panel.

The panel developed a generic table of regional observations (Annex V.1) using input from all of the regional tables. In doing so, the panel chose the minimum observations which could define a comprehensive ecosystem observing programme. These included observations of exploited fish species (both from fishery-dependent and independent surveys), top predators, phytoplankton, zooplankton, hydrography and atmospheric forcing. For each of these, the specific observation is generic, e.g. catch by area or species, or abundance, with the understanding that each region must develop its own specific observations and methodologies. This table will be refined further at the next panel meeting by considering how the generic observations can be parameterized and linked to specific products through models. The products will be defined in relation to performance measures for a suite of ecosystem objectives of ocean use management plans. These measures were discussed in general terms at the ICES/SCOR Symposium on the Ecosystem Effects of Fishing (see section 5.5). It is expected to become a central tool to provide general guidance as each region of the world develops its own contributions to GOOS.

The panel also developed a table of generic regional monitoring products (Annex V.3). The table identifies commonly monitored parameters related to e.g., population level, fishing activity and community structure, and then identifies useful indices related to these and ultimately how the indices can be utilized operationally. Such a table is useful as a tool to determine which monitored parameters can actually contribute to operational products, a primary objective of GOOS.

9 SUMMARY OF LACUNAE

The discussion of issues and formulation of monitoring methods and synthesis products was necessarily incomplete at the first meeting, and members agreed to submit short papers on lacunae they perceived. Some of the suggestions were considered under items 5 and 6 of the agenda. Others are summarized here.

Dr. Richardson emphasized the importance of reporting on size distribution, especially of phytoplankton. The size composition is important in determining which grazers benefit from the energy made available to the food web by phytoplankton. Thus there is a need to develop routine methodologies for determining size distribution. Appropriate methods may include measures of chlorophyll *a* from fluorescence measurements, determination of community composition through direct cell counting, and separation and identification of natural populations using flow cytometric techniques.

Dr. Arcos emphasized the importance of intercalibration of methods and instruments so that data from diverse sources can be effectively pooled for analysis.

Dr. Zhang noted the urgency of acquiring understanding of the physiological, behavioral, and ecological linkages with environmental factors which influence the distribution and abundance of fishes in the ocean ecosystems. He noted the value of identifying the monitoring outputs required for applying ECOPATH and other appropriate models.

Dr. Pope considered the needs to specify modeling and data base products and existing regional capacity to carry out the LMR-GOOS programme. He proposed that panel members be polled to ascertain the requirements for their regions, including specification of monitoring inputs, model types, and estimate outputs. An example of this approach is given in Annex V.2.

10. PILOT AND DEMONSTRATION PROJECTS

The panel recognized that there are ongoing monitoring, assessment and research efforts which are consistent with the LMR-GOOS approach, and which could be designated as LMR-GOOS pilot projects or contributions to the GOOS Initial Observing System (IOS). Two programmes were considered and adopted for the IOS. Several pilot projects were also proposed by panel members. These pilot project proposals will be developed further by panel members for consideration at the next meeting.

10.1 GOOS IOS PROJECTS

The GOOS IOS consists of ongoing observing systems, nominated by the GOOS design modules, which are consistent with the developing GOOS approach for monitoring, assessment and prediction, and which could be designated as GOOS components even before the design phase is complete. The panel considered two programmes for the IOS, the Sir Alistair Hardy Foundation's Continuous Plankton Recorder (CPR) Survey, and the ICES International Bottom Trawl Survey (IBTS). Other projects, such as the California Cooperative Oceanic Fisheries Investigations (CalCOFI) and the Southern ocean monitoring in connection with the Convention for the Conservation of Antarctic Living Marine resources (CCAMLR) will be considered at the next meeting. Other possibilities may become apparent when IOC has completed its compilation of significant monitoring and assessment programmes.

The CPR Survey has been in operation since 1931, and has maintained one of the longest time series in existence in marine science (see section 5.7, this report). Surveys are conducted on regular transects using ships of opportunity in the North Sea, the North Atlantic and from 2000 the Pacific. In addition to quantitatively collecting zooplankton and providing indices of phytoplankton biomass through "greenness indices," modern CPRs are instrumented with sensors to collect data on salinity, temperature and chlorophyll (as fluorescence). Additional sensors could be developed to measure oxygen and nutrients. While historically CPRs are towed at a constant ~10m depth, recent design advances have produced an undulating CPR which oscillates between the surface and up to 100m depth during a tow, providing two-dimensional profiles of plankton and their environment. The CPR survey comprises a cost-effective method to provide information on changes in the physics, nutrient chemistry, and lower trophic levels of marine ecosystems, particularly in open-ocean areas where research vessel costs are prohibitive. The panel determined that the CPR survey should be adopted as a programme of the IOS.

The ICES IBTS have been conducted quarterly in a coordinated way by various North Sea countries. The surveys produce data on a range of commercial fish species, including herring, sprat, mackerel, cod, haddock, whiting, saithe and Norwegian pout), along with concomitant physical and chemical oceanographic data (temperature, salinity, nutrients). The surveys have been conducted since 1970, providing the basis for long time series. Information from the surveys is used to provide abundance indices for ICES fish stock assessments, and support research through the provision of regional maps of bottom characteristics such as salinity and temperature. Data are managed through a readily accessible database maintained by ICES. Given the comprehensive nature of these surveys, the long time series, and the international cooperation involved, the panel concluded that the IBTS are consistent with the principles of LMR-GOOS, and should be included in the IOS.

10.2 PILOT PROJECTS

The panel considered two sets of potential pilot projects: 1. the ongoing and developing LME monitoring and assessment projects; and 2. projects to compare data produced by ongoing ocean observing systems with fine-scale data from GLOBEC regional projects. These potential pilot projects will be developed and presented for consideration at the Panel=s next meeting.

LME monitoring and assessment projects are operational or under development in several LMEs. These projects are based on a five-module strategy to produce observations on fish and fisheries, productivity (primary and secondary), contaminants, socioeconomic conditions, and ocean governance. An LME project has been operational in the Gulf of Guinea since 1995, and projects are under development in the Yellow Sea, Benguela Current and Baltic Sea. All are supported through the Global Environment Facility (GEF) and the World Bank. The panel considered nominating the Gulf of Guinea project as an LMR-GOOS pilot project because it is the most advanced of these efforts. It was decided that the LME monitoring and assessment approach should be evaluated as a whole to determine if it produces information consistent with the LMR-GOOS approach. If so, the panel might consider nominating the suite of LME projects as a pilot. This evaluation will be conducted intersessionally and considered at the panel=s next meeting.

10.3 PROPOSED GLOBEC-ASSOCIATED PILOT PROJECTS

The intensive sampling being conducted within diverse GLOBEC initiatives provides opportunities for evaluating monitoring strategies for GOOS. The Georges Bank component of US GLOBEC and the Scotian Shelf component of Canada GLOBEC provide examples that illustrate the potential benefits. Both Canada and the United States have already established shelf seas oceans monitoring programmes that contain most of the components identified in the LMR-GOOS template for shelf seas monitoring. The respective GLOBEC programmes on Georges Bank and the Scotian Shelf involve intensive seasonal sampling of plankton abundance over several years, with particular emphasis on zooplankton population dynamics. The longer term monitoring strategies for both countries include the use of Continuous Plankton Recorder (CPR) transects, complemented by relatively sparse (in both space and time) net sampling from research vessel surveys. CPR has well described limitations with respect to resolution of vertical zooplankton structure, but provides excellent broad-scale descriptions of plankton distributions at a modest cost. The vertical net sampling included in the present monitoring programmes should help evaluate further the efficacy of CPR as the key measure of trends in zooplankton abundance and community structure. The intensive GLOBEC sampling will allow evaluation of the degree to which the zooplankton monitoring strategy being proposed by LMR-GOOS picks up the inter-annual variability.

In addition GLOBEC aims to enhance understanding of the role of variability in circulation and mixing on marine ecosystem structure and function. To the degree that explanatory power is generated by GLOBEC, the pilot LMR-GOOS/GLOBEC initiatives will generate increased understanding of monitoring requirements necessary for both interpretation of ecosystem change, and possibly forecasting of impacts of climate variability on living marine resources. The LMR-GOOS monitoring strategy needs to be adaptive, and pilot projects with GLOBEC should contribute in this respect.

In the PICES region, work was described in the northwest Pacific that could constitute an LMR-GOOS pilot project as could a northeast Pacific plan being developed for use of the CPR.

11. CAPACITY BUILDING

Capacity building is a challenge for most elements of the GOOS initiative. Significant disparity exists between the capacities of scientists in developed and developing countries, precluding design of a single approach to this issue. In the same way that a generic set of observations on LMR and their environment will not be valid globally, neither will a single capacity building plan. Kwame Koranteng highlighted this issue clearly with an example from West Africa. Coastal pelagic fisheries are extremely important to the region between Mauritania and Equatorial Guinea, yet the countries of the region lack not only a research vessel to conduct assessments, but in some cases even the basic institutions to support fisheries research and management. Therefore any set of observations recommended for West Africa would probably exclude ship-based assessments.

LMR-GOOS planning must take into account how far responsibility for capacity building extends. Ambitious science-based monitoring and assessment projects in the developing world often prove unsustainable because the most basic infrastructure on which the projects rely - electricity grids, transportation, salary for scientists - are not reliable. To propose the development of a sophisticated observing programme in areas lacking basic infrastructure would be unwise. However, it should be questioned whether LMR-GOOS has the responsibility, or the capability to ensure this basic infrastructure before proceeding with the design of an observing system. This issue should be addressed before any final recommendations are made regarding capacity building.

After discussing these issues, the panel determined that:

(i) a regional or sub-regional approach to capacity building should be used. The establishment of Aregional LMR-GOOS training and analysis centers@ could facilitate this approach by ensuring that capacity building plans are developed according to specific regional needs and circumstances;

(ii) capacity building should not be conducted just so countries can contribute to LMR-GOOS. Instead, LMR-GOOS should be used to help develop capacity so that countries, regions or sub-regions can carry out observations that are of use to them;

(iii) to ensure consistency with other GOOS design panels, final decision on an LMR-GOOS approach to capacity building should be postponed until the GOOS Capacity Building Panel has produced some general guidance on this issue.

12. DATA ANALYSIS AND MANAGEMENT

The panel discussed the need to have a comprehensive plan for the management of data coming from all the GOOS modules. The FAO is developing a new data management system called Fisheries Global Information System (FIGIS) in cooperation with the Fisheries Agency of Japan (see 6.1.3 in this report). Similarly, physical oceanographic data are managed by coordinated data systems. However, for ecosystem components such as phytoplankton, zooplankton and nutrients, few mechanisms exist at a regional or global level to manage data. Some data networks may exist for seabirds and marine mammals, but these are probably not linked to physical oceanographic or fisheries data sets. It is not clear whether metadata are available for all these data sets.

Another challenge to LMR data management is the difficulty getting reliable fisheries-dependent data from many countries. Such data, when available, often cannot be desegregated to a degree such that spatial patterns of LMR abundance can be determined. If fisheries-dependent data could be reported on smaller spatial scales, and by species, it would be more useful in the analysis of fish population and ecosystem trends. Toward that end, on 30 November-3 December 1999 in Rome, Italy, there will be a meeting of the FAO Working Party on Status and Trends of Fisheries, *ad hoc* working party of the FAO Advisory Committee on Fisheries Research. The meeting will deal with the improvement of the international effort to improve the transparency and availability of data on the state of world fishery resources. As such, its outcome will be relevant to LMR-GOOS, and the IOC has been invited to represent the GOOS at that meeting.

Several actions were recommended to further the development of an LMR-GOOS data management approach:

(i) the G3OS Joint Data and Information Management Panel is supposed to develop an overall framework for GOOS data management. The panel should have this framework for discussion at its next meeting, and perhaps a J-DIMP representative could be invited to attend;

(ii) ICLARM represents a good source of fisheries and ecosystem data through their set of CD-ROM available databases, e.g., TrawlBase, FishBase, ReefBase. The utility of these for LMR-GOOS should be explored;

(iii) CGOOS= data management approach should be investigated to ensure coordination between the panels.

13. DATE AND VENUE OF NEXT

The next meeting of the panel will be held at the Fisheries Research Institute, Talcahuano, Chile, in December 1999.

ANNEX I

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ANNEX II
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ANNEX III

LIST OF DOCUMENTS

1. Notes on lacunae (submitted separately by D. Arcos, C.I. Zhang, J. Pope and K. Richardson)

2. Table of Possible Regional Monitoring Products from Chile (D. Arcos)

3. Table of Possible Regional Monitoring Products from: 1. East Sea/Sea of Japan; 2. Yellow Sea and East China Sea; and 3. Kuroshio Current (C.I. Zhang and T. Sugimoto)

4. Table of Possible Regional Monitoring Products from the Western Gulf of Guinea (K. Koranteng)

5. Table of Possible Regional Monitoring Products from the Black Sea (T. Shiganova)

6. Table of Possible Regional Monitoring Products from the northwest Atlantic (M. Sinclair)

7. Development of a Fisheries Global Information System (FIGIS), FAO and Japan Fisheries Agency, 1998.

8. A multifaceted approach to fishery status and trends reporting. FAO - Meeting of FAO and non-FAO Regional Fishery Bodies or Arrangements, Feb. 1999.

Coral reef activities undertaken by IOC-UNESCO. Report from the International Coral Reef Initiative Coordination and Planning Committee meeting, Paris, Feb. 1999.

10. Interdisciplinary ocean science is evolving. J. McCarthy, A. Robinson and B. Rothschild. Harvard University, Jan. 1998.

The Census of the Fishes: Initial Thoughts. J. Ausubel

12. A ›fish= component for GOOS. (A brief prepared by FAO for the LMR-GOOS meeting.

13. Retrospective Experiment: Eastern Scotian Shelf. M. Sinclair

14. Retrospective analysis of the California Current. D. Lluch-Belda and M. Laurs

15. Monitoring in the Baltic Sea and retrospective studies. B. von Bodungen

16. Proposal for a joint research project under the Korea-Japan Basic Science promotion Programme. C.I. Zhang and T. Sugimoto

17. Retrospective experiment of the Black Sea and Sea of Azov. T. Shiganova

ANNEX IV

RETROSPECTIVE EXPERIMENTS

IV.1 Retrospective analysis of the California Current Region

Daniel Lluch-Belda and Mike Laurs

ABSTRACT

A retrospective analysis of the California Current Region (CC) was conducted to evaluate if data collected using the California Cooperative Oceanic Fisheries Investigations (CalCOFI) monitoring strategy can be used to forecast changes in the CC.

Information used in the analysis included physical environmental data obtained from COADS and other databases on sea surface temperature (SST), sea level height (SLH), upwelling, ENSO indices and others; and biological data on sardine and anchovy abundance indices, macro zooplankton displacement volumes and information for certain species that have shown particularly strong changes in abundance and distribution. The strategy for the analysis has been to examine the variation in the CC from two different and complementary standpoints: a) variation in the physical environmental on temporal scales of *high frequency (interyear), ENSO, decadal, and long term unidirectional change* and b) apparent variations in indices of living populations.

Average inter-year variations can be estimated from existing data and their distribution has been found to be close to normal. ENSOs are quasi cyclic with a frequency of less than 10 years. Interdecadal fluctuations have been mostly interpreted through their affects on fisheries; there are firm evidences showing that even in the absence of harvesting, population abundance has changed in the time scale of decades. However, there are still only faint indications of the mechanisms through which environmental change acts on population abundance. Although there must be longer than decadal cyclic changes, they have not been unveiled to a workable level; even long-term proxi series of abundance show interdecadal fluctuations as the dominating signal. Thus only very general questions may be addressed when discussing long-term, unidirectional changes and their effects on fisheries.

INTRODUCTION

There are 29 reported ENSO or La Niña events during the past Century. However, taking in account both physical and biological indices, there have been only five major events occurring in 1941, 1957, 1972, 1982 and 1997.

In order to determine decadal-scale variation, a number of validation procedures were undertaken to form a proxi series to extend over the full period of the recent Century, including: a) coherence; b) comparison to another long term physical data series and c) contrasting anecdotal references and biological indices. The general pattern that emerges from the physical evidence is: a) the century started with a near-average temperature level and then rapid cooling until about 1910; b) this was followed by gradual warming until the 1940s; c) then there was gradual, slow cooling until the 1970s, and d) this was followed by warming which has continued through the present.

The time and area coverages of the CalCOFI programme have decreased significantly since its inception. Sampling frequency was basically monthly during the first decade, but then evolved into quarterly, with some important gaps. The geographic range has also changed considerably, being restricted mostly to 30-35°N after the 1970s. There is an excellent coverage of the cooling period that occurred during the 1950s through early 1970s, but, unfortunately both the regime shift and the warming that has occurred in the post-1970s lack parallel data in the CalCOFI data series. However, adequate sampling densities can be found in coastal sectors that allow the data to be stratified into Biological Action Centers (BACs). Four BACs were chosen and analyzed as indices of abundance for biological populations.

Average zooplankton volumes in the BACs reveal the regime change of the mid-1970s, discounting the effects of short-term, intense periods. While there is a clear and consistently diminishing trend in the number of species of planktonic fish larvae in all areas, the southernmost one reveals most clearly the expected effect of cooling on species diversity. One should expect that the number of species increased again after the mid-1970s. Sardine and anchovy eggs have been identified for the full CalCOFI database. Because of their short lives, high mortality rates and rapid population growth these populations provide relatively good indices of the impacts of environmental change on biological populations Yearly averages of eggs and larvae for each BAC show lower population sizes of sardine at the northern BACs during the late cooling and early warming period (1960s-1970s), while anchovy populations are more abundant. However, there is considerable patchiness and noise in the data and there is work to be done to extract more useful information, e.g., process and include data from collections that exist to partially fill the gaps in the southern BACs after the late 1970s. What is clear at this point is that these data seem promising for monitoring purposes.

There are a number of data sets for scale abundance of sardine and anchovy from oceanic sediment cores extracted from a few sites. For the Santa Barbara Basin, the series extends for back approximately 2,000 years and for the Soledad Basin and the Guaymas Basin for 250 years. The Santa Barbara series shows 60-year average cycles in the abundance of both species, while anchovies also show a 100-year cycle. The 60-yr cycle for sardine scales abundance has been the basis for some forecasting approaches. There seems to be a consensus belief that a new regime shift could happen in the very near future. Sardine abundance fluctuations have been shown to empirically correlate with some environmental variables at the decadal time scale.

Global air temperature anomalies at the geologic scale have been reconstructed through various indices. In very rough terms, they coincide quite well with sardine scale abundance, with high abundance trends dominating during warm periods and low abundance during cool periods. Also, there is a proxy of SST anomalies in the coastal area, reconstructed from tree-ring data since 1670 and up to 1920.

Since 1750, both the SST and sardine scale abundance series exhibit good agreement with some discrepancies: showing turning points during 1790, 1850, 1875, 1899, 1912, 1942 and 1970. There appear to have been three major regime shifts during the recent Century: 1910; 1940 and 1976. Of these, only the 1970 is within the time limits of the CalCOFI programme.

Data suggest that sardine population abundance tends to be predominantly higher during prolonged warm periods in the scale of hundreds of years and that they grow simultaneously with decadal trends of warming and collapse during the opposite. The extreme events in the sardine population series do not show apparent relationships with regime shifts because higher frequency variability is far more intense. The relationships only become evident when examining the inverse *sustained trend*. The number of fish larvae species appears to be a more promising index to be evaluated.

There seem to be mostly two ways of approaching the problem of forecasting change: either to know what drives variability (and can thus predict what will happen if that is regular) or to find something that occurs before the change and trust in empirical correlations. So far, very few candidates seem apt for this last approach.

Sardine population abundance, combined with past cycles is as yet the most utilized index of change. In other words, if the detected cycle of about 60 years holds, it could mean that a new shift is coming soon. However, while 60 years is the mean, cycles have not been regular and show ample variations. Also, sardine populations have never been very abundant for long and the identification of "high" is difficult because peak abundance magnitudes have fluctuated considerably.

It seems promising to further pursue the retrospective analysis with a) more empirical correlations and b) hypothesis testing regarding the ultimate origin and the transference mechanisms of change. For example, multivariate analysis may be useful to explore the possible parallel behavior of atmospheric and biological indices. Filling the gaps in important data series would be critical. For example unprocessed plankton collections may provide sufficient information to fill in the BACs data series. Organisms debris in varved sediments are also fundamental to obtain a long time-series of data. Fortunately a number of cores have been obtained from the BAC areas and are being processed. Hypothesis testing for ultimate driving forces and physical connections is yet at a very preliminary stage. From the very limited results so far obtained, however, ocean currents seem to be determinant and worthwhile examining.

IV.2 An Evaluation of The Monitoring Activities on The Eastern Scotian Shelf from 1987 to 1994

Mike Sinclair

TABLE OF CONTENTS

1. INTRODUCTION

The Living Marine Resources Panel of the Global Oceans Observing System (LMR-GOOS) held its first session on 23-25 March, 1998 (Anon 1998). The intent of LMR-GOOS is A*to provide observational services and forecasts to those concerned with the harvest, conservation and scientific investigation of living marine resources of the deep ocean and shelf seas.*@ From this perspective, the Panel developed a template for a monitoring programme that should detect patterns of ecosystem change. To help evaluate the utility of such monitoring programmes for decision making on ocean use issues (including both the choice of data to be collected on a routine basis, as well as the institutional structures required for data interpretation), it was recommended that several well-monitored shelf seas that have been characterized by Aregime shifts@ be evaluated in a retrospective sense. These evaluations were termed Aretrospective experiments.@ The components and questions of the evaluations are:

Summary of what parameters were monitored:
identification of critical gaps;
summary of what syntheses were carried out;
evaluation of the adequacy of the ecosystem analyses carried out.

Could ecosystem change have been described in near real-time (or predicted) from the data collected in the monitoring programme?

Could near real-time descriptions (or predictability) have been improved if additional variables had been monitored?

If near real-time descriptions (or predictability) were inadequate, was this due to:
inadequate monitoring,
inadequate analysis, or
inadequate theoretical understanding?

Although the northwest Atlantic demersal stocks were initially identified as the study area, due to time constraints and the geographical complexity of the shelf seas in this area, it was decided to limit the evaluation to the eastern Scotian Shelf off Nova Scotia (4VsW in Figure 1). Also, the fisheries focus is on a single management unit for Atlantic cod (4VsW cod). This evaluation of a more limited area and a single fish stock, however, should reflect in general terms the strengths and weaknesses of ecosystem monitoring for fisheries management in the Northwest Atlantic.

Although the mechanism of the influence of the North Atlantic Oscillation (NAO) on shelf seas oceanographic conditions off Nova Scotia is still under considerable debate, it is well recognized that this ocean/atmospheric system has strong decadal scale variability (Figure 2). The ANAO anomaly@ has been strongly positive from the mid-1980s to the mid-1990s (Figure 2, see also, Hurrell 1995). During the same time period, a major ecosystem change has occurred on the eastern Scotian Shelf (e.g., Frank *et al.* 1996 and Sinclair *et al.* 1997). Thus this area fits the Aregime shift@ criteria for the retrospective experiment. In addition to the oceanographic changes, a fish predator (the Grey seal) has been increasing in abundance at an exponential rate since the 1970s (Mohn and Bowen 1996).

The analysis has been limited to the 1987 to 1994 time period. During these years the 4VsW cod stock declined from moderate levels to the lowest on record (Figure 3). Recruitment (i.e., the strength of year-classes) has been very weak since 1983 (Figure 4). A moratorium on directed commercial fishing of this stock was put in place in September 1993. Thus the 1987 to 1994 time period brackets the decision-making period during which the stock collapsed and the fishery was closed.

2. THE ECOSYSTEM MONITORING PROGRAMME

An inventory of past monitoring activities for Atlantic Canada, including those extant during the 1987 to 1994 time period, is provided as Annexes III and IV of Therriault *et al.* (1998). The activities for the Scotian Shelf are extracted in Table 1. In summary, there had been comprehensive annual and seasonal monitoring of the following variables for about two decades:

fishing effort by gear type and location;
landings by species and location;
Grey seal abundance;
groundfish abundance by species and area during July (annual trawl survey);
size and age composition of landings for several commercially important species;
air pressure;
air temperatures;
geostrophic wind;
freshwater inflow;
ocean features (eddies, Gulf Stream and shelf-slope boundary positions);
ice/iceberg distribution;
monthly SST from ships of opportunity;
Halifax SST;
monthly T-S series for Emerald Basin;
sea level;
ship-of-opportunity CTD (from all major research cruises, including the annual groundfish trawl surveys).

The list indicates that the monitoring activities focused on fishing, Grey seals, groundfish, and ocean/atmosphere physical parameters. Shelf scale special purpose research studies that provide data on some temporal trends for biological oceanographic parameters for the time period of interest have been carried out on ichthyoplankton and zooplankton. Also, the time series from line E of the Continuous Plankton Recorder (CPR) programme provides seasonal and decadal data on a phytoplankton colour index and plankton species abundances. However, the series is discontinuous, with critical gaps for the time period of our interest.

3. EVALUATION OF THE DATA ANALYSIS ACTIVITIES

In 1977, following extension of jurisdiction to 200 miles, the Department of Fisheries and Oceans (DFO) established enhanced institutional structures to provide scientific advice in support of fisheries and habitat management. The Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) provided peer reviewed scientific advice for the Atlantic Zone as a whole from 1977 to 1992. DFO regional committees replaced this function in 1993. Several categories of documents are available for the retrospective experiment. Research documents were prepared by individual scientists (or teams), which included the information that had been presented to the respective subcommittees for peer review, as well as any additional work done at the meeting. The advisory documents and stock status reports represent the advice prepared, either by the steering committee of CAFSAC or by the review subcommittee itself (in the case of the subsequent regional review committee process). In addition, there are subcommittee reports (for CAFSAC) and proceedings (regional review process). In this analysis, only the relevant research documents and advisory documents/stock status reports are reviewed.

There were four subcommittees of CAFSAC that reviewed data from monitoring activities of relevance to the management of 4VsW cod. These are the:

Groundfish Subcommittee;
Marine Mammals Subcommittee;
Marine Environment and Ecosystems Subcommittee (disbanded in 1992);
Fisheries Oceanography Subcommittee (initiated in 1992).

In addition, the Northwest Atlantic Fisheries Organization (NAFO) published annual overviews of the environmental conditions in the NAFO area, which includes 4VsW. Subsequent to the demise of CAFSAC, the fisheries oceanography reviews were continued within a DFO zonal committee (FOC), in addition to the NAFO overviews. The regional review process initiated in 1993 included subcommittees and working groups for review of technical issues for the full range of ocean issues.

From the above summary of the institutional structures for the provision of scientific advice, two points are of interest for this retrospective experiment. First, following the traditions of the International Council for the Exploration of the Seas (ICES) and the International Commission for Northwest Atlantic Fisheries (ICNAF), the Department of Fisheries and Oceans has established mechanisms for the ongoing peer review of fisheries and ocean monitoring activities. Second, until 1992 the CAFSAC committee structure did not, however, facilitate annual reviews of oceanographic and ecosystem data on spatial scales relevant to specific fisheries. In the following sections I review the environmental and ecosystem syntheses, the cod stock assessment documents, and the actual scientific advice that was provided to the decision-makers.

3.1 SUMMARY OF ENVIRONMENTAL AND ECOSYSTEM OVERVIEWS

In the 1987 environmental overview for NAFO by Drinkwater and Trites (1988) most of the emphasis was on broad temporal and spatial scales. The focus of the ocean temperature data was on the surface layer. Subsurface temperature changes were limited to hydrographic monitoring sites, none of which were on the northeastern Scotian Shelf. The 1988 to 1990 environmental overviews (Trites and Drinkwater 1989; Drinkwater and Trites 1990; and Drinkwater and Trites 1991) provided a similar format. The data products were useful to describe atmospheric, surface oceanographic, and sea ice trends, but they were not very good at describing changes in cod habitat, particularly for the Scotian Shelf which is characterized by complex bottom topography. As a result, the cooling of the eastern Scotian Shelf beginning in the mid-1980s was not identified by 1991.

In 1992, the environmental overviews captured more of the detail required for 4VsW cod (Drinkwater 1992a, b; Drinkwater *et al.* 1992). However, the use of Emerald Basin as a major index again masked the degree to which cod habitat in 4VsW had cooled. Drinkwater (1993) provided more detail on the Scotian Shelf in the 1992 overview of environmental conditions. The Emerald Basin monitoring station indicated that deep-water temperature conditions were above normal for most of the 1970s and 1980s, up to 1992. In summary, the environmental data products developed for the overviews were sufficient to describe the changing conditions beginning in the mid-1980s on the Grand Banks and the Labrador Shelf, but they were not sufficient to characterize cod habitat changes in 4VsW in near real-time.

In 1994, considerably more detail was provided on the bottom water environmental trends for the eastern Scotian Shelf (Drinkwater 1994; Petrie *et al.* 1994). The analysis showed that the temperatures declined during the late-1980s and early-1990s, but that in 1992 and 1993 conditions were returning towards long-term means. For several years a large part of the bottom had been cooler than 2°C during the July groundfish survey, with some stations below 0°C. The CPR data up until 1992 was summarized by Sameoto (Anon 1994). No general conclusions could be derived on decadal scale trends in plankton production. Frank *et al.* (1994b) described excursions of capelin, Greenland halibut and Checker eelpout (a cold-water species) onto the eastern Scotian Shelf beginning in the late-1980s. The analysis provided by Ken Drinkwater and Brian Petrie of declines in bottom temperature in 4Vn, 4Vs and 4W since the mid-1980s was much clearer than had been shown in the environmental overviews. The changes in distribution of cold-water species described by the trawl surveys were a clearer demonstration of bottom temperature changes than the temperature analyses themselves. However, these data were not described until 1994.

The analyses of environmental and ecosystem data presented in 1995 (Drinkwater *et al.* 1995a, b; Page *et al.* 1995) followed the pattern of 1994. Maps of trends in bottom temperature had become a routine feature of the overviews. However, stock specific indices of habitat had not been developed. In recent years stock specific indices are being produced for cod, snow crab and salmon.

In summary, the environmental and ecosystem overviews did not describe the major changes that were occurring on the eastern Scotian Shelf beginning in the late-1980s and continuing, until 1993, the year the cod fishery was closed.

From discussion with Ken Drinkwater a number of points are important to consider with respect to the delay in describing the cod habitat changes in this area:

Prior to 1992 it was difficult to access the overall temperature/salinity data set.

The purpose of the NAFO environmental reviews was to provide the large-scale picture, not to describe smaller areas in detail.

Prior to 1992 there was insufficient funds available for analysis of environmental data in support of stock assessment.

The accepted understanding of oceanographic conditions on the eastern Scotian Shelf implied that the Emerald Basin Station should have representative of 4VW as a whole. In the early 1990s, with the availability of a structural database, Petrie and Drinkwater (1993) showed there was similar low-frequency variability throughout the shelf from the Laurentian Channel to the Middle Atlantic Bight (surface to bottom). On the basis of this analysis it was felt that Emerald Basin would be a representative index of what was happening on the Scotian Shelf. Most of the data in the Petrie and Drinkwater paper was pre-1988. It did not include enough of the post mid-1980s data to identify the cold conditions on the eastern Scotian Shelf being significantly different from those observed in Emerald Basin.

At the 1993 FOC Meeting Page *et al*. (1993) noted low temperatures on the eastern Scotian Shelf, as part of the groundfish trawl survey environmental data. This led in 1994 to a new understanding of spatial complexity in bottom temperature changes.

The new understanding of spatial complexity in oceanographic conditions on the Scotian Shelf has led to improved data products for the environmental overviews. In general, CAFSAC did not show an interest in oceanographic information until 1992 at the earliest.

3.2 SUMMARY OF 4VSW COD STOCK ASSESSMENTS

Fanning *et al.* (1988) reviewed the monitoring data up until 1987, giving projections for the 1989 fishing year. The following points relevant to the Aregime shift@ are made:

- the extremely weak 1983, 1984 year-classes were identified;
- declining trends in weight-at-age for cod were described;
- changes in the geographical patterns of cod distribution were described.

Fanning and MacEachern (1989) reviewed the monitoring data up until 1988, giving projections for the 1990 fishing year:

- the weak 1983, 1984 year-classes re-affirmed, as well as first indication of weak 1985 year-classes;
- declining trends in weight-at-age were described;
- spawning stock biomass declines described, based on both commercial catch rates and research vessel surveys;
- geographical changes in cod distribution described;
- a fundamental flaw in the assessment model (the so-called retrospective problem) was identified. This Aproblem@ results in overestimation of stock biomass in the most recent years of the assessment model.

Fanning and MacEachern (1990) reviewed the monitoring data up until 1989, giving projections for the 1991 fishing year:

- weight-at-age trends not described;
- recruitment Acollapse@ since 1983 described;
- retrospective problem again highlighted, but not corrected for;
- spawning stock biomass projected to increase in 1991 with a total allowable catch (TAC) of 35,200 t (three-year stable TACs were being proposed).

Fanning and MacEachern (1991) reviewed the monitoring data up until 1990, giving projections for the 1992 fishing year:

- Weight-at-age trends not described;
- Changes in geographical distribution of cod were described in some detail. Overwintering cod from the southern Gulf of St. Lawrence were observed to have migrated further to the west on the Scotian Shelf (within the 4VsW management unit).

The 1986 and 1987 year-classes were described as being very strong.

Due to the strong retrospective problem the assessment model was rejected. Even with the retrospective problem, the model indicated spawning stock biomass declines and a 1990 fishing mortality of about 0.5 (which would be an underestimate). The target F under the management plan was about 0.2.

- A TAC of 35,200 t (under the three-year constant catch approach to management) was stated to not be detrimental to the stock.

Mohn and MacEachern (1992) reviewed the monitoring data up until 1991, giving projections for the 1993 fishing year:

- geographical changes in cod distribution and in the fishery described;
- declining trends in weight-at-age described;
- declining spawning stock biomass described with most recent year at historical low for the time series;
- retrospective problem in the assessment model corrected for, using innovative statistical techniques;
- Year-cass strengths for 1986 and 1987 estimated to be very strong;
- AYellow flag@ warning on precarious state of the stock was provided.

Mohn and MacEachern (1993) reviewed the monitoring data up until 1992, giving projections for the 1994 fishing year:

- recruitment collapse in 1983 discussed, with the 1986/87 year-classes now evaluated to be weak;
- a problem of reduced survivorship at older ages is identified;
- spawning stock biomass again described as being at lowest level in historical time series with very few fish at older ages;
- the retrospective problem is again identified and the implications discussed;
- ARed flag@ warning on precarious state of the stock was provided;
- in addition to overfishing, a number of hypotheses contributing to stock collapse are briefly discussed. These include reduction in cod production due to ecosystem change and increases in Grey seal predation on juvenile cod;
- the merits of closing the fishery within the 1993 year are discussed.

Mohn and MacEachern (1994) reviewed the monitoring data up until 1993, giving projections for the 1995 fishing year:

- ecosystem change and the impact of exponential growth in Grey seal population on cod survivorship are included in the analytical assessment;

- reduced survivorship at older ages again identified;
- odd stock/recruitment relationship described (i.e., the weak year-classes in 1983 to 1988 occurred when the spawning stock biomass was at moderate levels);
- it was recommended that the fishery should remain closed;
- retrospective problem again discussed, but the underlying causes not identified.

Fanning *et al.* (1995) reviewed the monitoring data up until 1994, providing projections for the 1996 fishing year:

- the role of environmental conditions on cod growth and condition factor was analyzed;
- the reduction in area and time of spawning was described;
- the impact of Grey seal trends in abundance on juvenile cod survivorship was incorporated into the assessment model;
- the role of environmental variability on recruitment was analyzed;
- changes in species composition in the 4VsW area were described (yellowtail-cod correlation changed over time; capelin, a cold-water species, had increased in abundance since late-1980s);
- temperature conditions since 1986 were described as having been cool;
- the long-term prognosis was that stock rebuilding would take many years, and that there should be no directed fishery.

In summary, the stock assessments described major changes in cod population biology in the 1988 and subsequent assessments. However, the rate of decline of the stock and the increase in fishing mortality were underestimated. The links of cod population biology to ecosystem change were not made until 1993.

3.3 SUMMARY OF ADVISORY DOCUMENTS

The CAFSAC Steering Committee (until 1992), and the regional steering committee (1993 to 1995), provided the scientific advice (until 1992) or summaries of the stock status with implications of different harvesting options (1993 to 1995). These steering committees had access to the output of all of the subcommittees, and thus were in a position to synthesize the overall analyses of the monitoring activities. Through the 1988 to 1993 time period, the groundfish advice was given in relation to a decision rule (or Aharvest control law@) in the management plan.

Rule 8, Point 1

If the stock assessment provides evidence of levels of spawning stock biomass likely to endanger recruitment, fishing effort in the coming year will be reduced to allow immediate growth in spawning stock biomass.

Point 2

Where the $F_{0.1}$ catch level for the next year differs 10% or 10,000 t from the current year=s TAC, the following formula would apply:

50% rule (i.e., move to a fishing mortality half way between current year and $F_{0.1}$);
for larger reductions B twice $F_{0.1}$ rule (i.e., move to a fishing mortality twice $F_{0.1}$).

During 1988, the Marine Environment and Ecosystem Subcommittee (MEES) did not address any issues of relevance to groundfish stock status and the NAFO environmental overview was not considered (Anon 1988a). The advice was cautionary and indicated poor growth and weak incoming recruitment (Anon 1988b).

In 1989, MEES did not have a meeting and the NAFO environmental overview was not considered during preparation of the advice on groundfish stocks (Anon 1989a). The decline in stock status was again identified, as well as weak recruitment (Anon 1989b). There was no mention of other negative indicators, such as declining weight-at-age and the retrospective problem.

In 1990, there was considerable discussion on the role of bottom temperature and cod abundance on cod growth in the northwest Atlantic as a whole (Anon 1990a). Although the work was not completed, it was concluded that environmental conditions explained little if any of the variation in cod growth. The NAFO environmental overview was not considered. For 4VsW cod, the declines in stock status and weak recruitment were again identified, with fishing mortality noted as being above the target (Anon 1990b). No ecosystem change issues or uncertainty in the assessment due to the retrospective problem were mentioned in the advice. Three-year TACs were introduced at this time (i.e., for fishing years 1991, 1992 and 1993). It was stated that a TAC of 35,200 t for 4VsW cod would not be detrimental to the resource. With hindsight, the introduction of multi-year TACs based on historical landings could not have happened at a worse time. The 4VsW cod stock was declining at a faster rate than indicated by the assessment, environmental conditions were poor for cod growth, and ecosystem change was occurring. The retrospective problem in the assessment generated considerable uncertainty, which was not captured in the advice (Anon 1990b).

In 1991, the CAFSAC Steering Committee discussed how rule 8(1) should be triggered (i.e., when should the Ared flag@ be raised indicating that spawning stock biomass is at critically low levels, such that immediate measures should be taken to rebuild the stock) (Anon 1991a). No conclusions were made, and no further work requested. The retrospective problems in the groundfish analytical assessments were highlighted in the summary of the groundfish advice. MEES did not assess environmental change, and the NAFO environmental overview was not considered by the Steering Committee. The Marine Mammals Subcommittee did address the seal/cod issue, but there were no conclusions on Grey seal impacts on 4VsW cod. The actual 1991 advice for 4VsW cod was minimalist in the extreme (Anon 1991b). Due to the severe retrospective problem, the quantitative model was not used, and little of the qualitative information was described. A TAC of 35,200 t for 1992 was stated to be Aunlikely to be detrimental to the resource.@

In 1992, the Fisheries Oceanography and Habitat Subcommittees replaced MEES (Anon 1992a). This was done because it was recognized by the Steering Committee in 1990/91 that more focus was required on the near real-time analysis of the oceanographic monitoring data in relation to specific fisheries issues. The NAFO environmental overview was considered very useful for the big picture, but not sufficient for advice on specific management units. Most of the focus of the 1992 FOC meeting was on Northern cod (2J3KL). The analyses showed declining temperatures off Newfoundland and Labrador since the mid-1980s, with shifts of cod into deeper waters and associated ecosystem change. FOC instituted the Aannual review of the state of the ocean,@ to begin in 1993.

A joint meeting of The Groundfish and the Pelagics Subcommittees in 1992 reviewed long-term changes in bottom temperature on the Scotian Shelf (Anon 1992a). The analysis had been reviewed by the FOC. From the Groundfish Subcommittee, there were warnings that spawning stock biomass for several stocks were at dangerously low levels. The retrospective patterns in the assessments, along with the observations that TACs in recent years were not being caught, indicated that the low stock estimates might be overly optimistic. The Marine Mammals Subcommittee described the exponential increases of Grey seals on the Scotian Shelf (13% annual increase over two decades), with annual fish consumption for the total population between 76,000 t and 270,000 t (a three-fold range) (Anon 1992a).

In spite of the broadbased information on ecosystem change reviewed by the Steering Committee, the 1992 advice for 4VsW cod was limited in scope (Anon 1992b). It noted that the spawning stock biomass was the lowest seen since the mid-1970s, and that spawning areas were more restricted compared to studies in the early-1980s. Harvesting at twice $F_{0.1}$ was considered too high, and that exploitation rate should decline immediately to $F_{0.1}$ in 1993 (11,000 t). No information was provided on environment, seals, and weight-at-age declines. However, the retrospective problem was accounted for in the advice. Also, the mixing problem of southern Gulf of St. Lawrence cod in the eastern part of the management unit during winter was identified. It was recommended that this area of stock mixture be closed during the first quarter.

In 1993, a regional review process provided the scientific advice for 4VsW cod (Anon 1993). A summary of the environmental conditions preceded the summaries of stock status for each groundfish management unit. The 1992 environmental conditions were described in a long-term context. The status of the 4VsW cod resource was considered precarious and there were concerns about its long-term viability if fishing mortality was not reduced. The summary indicated poor environmental conditions, recruitment collapse, and inferred that increasing seal predation was an important contributing factor.

In 1994, the format for the scientific advice continued to evolve with more detailed inclusion of information on ecosystem and environmental trends (Anon 1994; O=Boyle and Zwanenburg 1994). In addition, descriptions of trends in fishing activities and in the management system were included in the advice. Overviews of ocean climate, of the ecosystem, and of Amanagement and issues in the fishery@ preceded stock status summaries for the individual management units. Trends in ocean colour and zooplankton abundance from the CPR programme were described, but the gaps in the time series limited interpretation. Trends in fish community diversity were provided, but interpretations of the changes were not provided due in part to constraints in ecological explanatory power of such indices. In the groundfish overview of the Scotian Shelf, the eastern and western parts were contrasted in fish production/ocean climate terms. The 4VW eastern part was concluded to be more Afragile@ and thus more susceptible to overfishing.

For the 4VsW cod stock, the odd stock/recruitment history was analyzed (i.e., sharp drop in 1983 onwards), with loss of spring spawning component noted (Anon 1994). An influx of capelin, a cold-water species, into the Scotian Shelf beginning in 1988 was also indicated. The marine mammal overview summarized the degree to which Grey seal predation on 4VsW cod had increased from 1970 to 1993. The ocean climate overview was still limited for this management unit. The major climate index for the eastern Scotian Shelf was Emerald Basin, which is not representative of cod habitat. Data, however, was provided on a cooling trend on Misaine Bank which showed a different pattern that observed in Emerald Bank. There is still a need for stock specific environmental indices. In sum, the stock status of 4VsW cod was interpreted within an ecosystem change context, but there was limited explanatory power on the degree to which natural mortality had changed over the 1985 to 1993 time period.

The 1995 stock status report continued the direction of 1994 (Anon 1995). It included detailed summaries of all aspects of the monitoring data:

<u>State of the Ocean</u>:
- mean conditions;
- time trends;
- conditions in 1994.

<u>State of the Ecosystem</u>:
- plankton trends;
- finfish community trends;
- groundfish overview;
- pelagic overview;
- invertebrate overview.

<u>State of the Fishery</u>:
- fishing capacity trends and economic performance;
- effort trends;
- groundfish regulatory activities in 1994;
- gear impacts;
- management considerations.

The 4VsW cod stock status summary included trends in weight-at-age, fish condition, and losses in areas of spawning (Anon 1995). Ecosystem considerations included Grey seal predation on juvenile cod, temperature influence on recruitment variability, changes in fish species associations, shifts in distribution of cold-water species into the 4VsW area. It was stated that the short-term prospects for this stock remain dismal, with spawning stock biomass at critically low levels.

In summary, there was a shift in 1993 in the degree to which the ecosystem and fisheries monitoring data was integrated within the advisory documents. Until 1992, essentially no information on ecosystem change was included in the advice, even though the stock assessments did provide indicators of major changes.

4. ADEQUACY OF THE MONITORING PROGRAMME

4.1 WHAT DO WE KNOW IN 1999

Evaluation of the adequacy of the extant monitoring activities in the 1987 to 1994 period depends to a certain degree on our present understanding (in 1999) of what ecosystem changes have occurred. Zwanenburg and Fanning (submitted) and Zwanenburg *et al.* (pers. com.) have analyzed in some detail the influence of bottom temperature changes on cod distribution in 4VsW. Cod in this area avoid temperatures less than 2°C, and during the 1987 to 1994 period there was a large part of the area at such levels. Campana *et al.* (1995) conclude that declines in bottom water temperature since about 1985 are at least partly responsible for the reduced growth rates of cod on the eastern Scotian Shelf. Frank *et al.* (1996) describe the excursion of three cold-water species into the eastern Scotian Shelf beginning in the late-1980s in response to the colder environmental conditions. O=Boyle *et al.* (pers. com) have analyzed the overall groundfish trawl survey data set and conclude that there was a shift in the spatial distribution of the fish communities on the eastern Scotian Shelf during the cooling period. Sinclair (unpublished manuscript) has shown that natural mortality for all of the cod stocks to the north and east of Halifax, Nova Scotia (including 4VsW cod) have increased substantially in the late-1980s (from an annual mortality of about 20% to over 40%). There is controversy concerning the contribution of increasing Grey seal predation on the trend in natural mortality for 4VsW cod, and to the recruitment collapse beginning in 1983 (Mohn and Bowen 1996; Mohn *et al.* 1998). Mohn (1999) has concluded that trends in natural mortality and discarding generate retrospective problems of the type observed in the 4VsW cod assessment from 1989 to 1995 (i.e., overestimation of abundance for the most recent years of each assessment). Information on discarding (Fanning, pers. com.) implies that the temporal patterns in this fishing practice are not consistent with the retrospective problems of the assessment (i.e., discarding was decreasing over time during the 1988 to 1995 period, rather than increasing). Thus, undetected changes in natural mortality may have been a major cause of the inaccuracies in the stock assessments during the collapse. Frank *et al.* (1994a) have described the changes in season and location of 4VsW cod spawning (spring spawning disappeared in the mid-1980s). Younger *et al.* (1996) document observations from fishermen that there has been a reduction in the geographic extent of spawning during the same time period. The relative contribution of overfishing and ecosystem change to the recruitment collapse in the mid-1980s has not been resolved (Sinclair *et al.* 1997). The very weak year-classes in the mid-1980s occurred when the spawning stock biomass was relatively high (Figures 3 and 4).

In sum, with the benefit of hindsight, there is a general consensus that fishing mortality exceeded both $F_{0.1}$ and F_{MAX} throughout the 1980s. However, due to uncertainty about changes in natural mortality in the late-1980s, it is difficult to determine the rate of increase in fishing mortality during the 1988 to 1992 period prior to the closure. Thus, even though there is no question that Agrowth overfishing@ occurred, the degree and trajectory is uncertain. There is less consensus on the causes of recruitment collapse beginning in the mid-1980s. Overfishing may have been responsible for the loss of some spawning components. Seal predation on juvenile cod may have contributed to the weak year-classes observed since 1983. The cold bottom temperatures beginning in the mid-1980s may have contributed to poor egg production. Even with the benefit of hindsight, there is not a consensus on whether Arecruitment overfishing@ occurred. Sinclair *et al.* (1997) suggest that even if $F_{0.1}$ management had been implemented for 4VsW cod, given the weak recruitment since 1983, the stock would have collapsed. It is within the above context of present limited explanatory power of these complex fishing and ecosystem changes that we need to evaluate the adequacy of the monitoring programme. Much of the monitoring had been put in place to aid the decision-making process for the conservation of fisheries. The following sections will address the degree to which the programme meets this specific ocean management need.

4.2 WAS THE MONITORING PROGRAMME ADEQUATE?

The short answer is a qualified yes. The routine data collected on the fishery and during the annual trawl surveys were adequate to describe trends in fishing effort by area and gear type, changes in size and age composition of the landings, trends in cod abundance and geographic distribution, and trends in fish community distributions. The Grey seal surveys provide excellent estimates of absolute abundance of an important fish predator. The environmental data (temperature, salinity, sea ice, atmospheric conditions, sea level, etc.) provide sufficient data to describe in near real-time the changing state of the ocean off Atlantic Canada.

There were, however, some gaps in the oceans monitoring programme that have been evaluated in some detail by Therriault *et al.* (1998). These include indices of trends in plankton production. The gaps in the fisheries monitoring activities were evaluated by Angel *et al.* (1994). It is perhaps useful to separate out two functions of the monitoring programme B descriptions of ecosystem change and understanding of what is causing the changes. The requirements of the former are much less stringent than the latter. The DFO/DOE core monitoring activities of the 1977 to 1994 period are adequate to describe aspects of ecosystem and fishing changes (fishing industry, seals, fish communities, state of the ocean/atmosphere physics). The programme on its own is not sufficient to interpret the reasons for changes in fishing patterns and in the ecosystem. It should have been sufficient to support the decision-making process in support of achievement of the conservation objectives of fisheries management.

There is a significant caveat. A major complication in near real-time description of cod abundance changes and fishing mortality trends during the 1987 to 1994 period was the change that occurred in natural mortality (M). Without a fishery since 1993, it has been possible to estimate this population parameter from the trawl survey data. Up until 1997, it was assumed in the stock assessments for all of the cod stocks that M is about 20% annually for ages that are fished. This assumption is now known to be incorrect, and a trend in M generates overestimates in abundance and underestimates in fishing mortality in the most recent years of the assessment. It is hard to imagine any monitoring programme that could have allowed trends in M to have been described in near real-time. Thus, there are limits to what a monitoring programme can capture. The direction of the trend is attainable, but the rate in some cases is not.

For broader objectives of a monitoring programme, including evaluation of marine Aecosystem health@ and understanding the causes of ecosystem change, additional variables (beyond those outlined in Table 1) are required. Therriault *et al.* (1998) describe a more comprehensive multi-purpose ocean monitoring programme which was implemented on a trial basis in 1999. Long-term funding has not yet been secured. The elements are summarized in Table 2.

4.3 WAS THE ANALYSIS OF THE MONITORING DATA ADEQUATE?

With respect to the needs of the decision-makers for fisheries management, the short answer is no. The reasons for the inadequate analyses are both institutional and scientific. Until the early 1990s the scientific advice on fisheries, as shown for 4VsW cod in this paper, was based on a very restricted subset of the data from the extant monitoring programme (of both the fisheries and ecosystem components). Essentially the only data analyzed for the advice was the geographic and temporal patterns in landings, aggregate CPUE, the size composition of the landings of the target species, and trawl survey data on target species. A considerable amount of available data, both from the fishery (including the management system itself) and the DFO science monitoring activities, were not analyzed in conjunction with the assessment. Part of the deficiency was the lack of a subcommittee that had as part of its remit the generation of data products on the state of the ecosystem. The formation of the Fisheries Oceanography Subcommittee of CAFSAC in 1992 partially corrected for this gap.

The science analysis limitations were that some of the data that were available were not analyzed at all until after the collapse, or the data products were of limited utility for 4VsW cod. These include:

- bottom temperature for cod habitat (compare Figure 5 and 6);
- changes in fish community structure (not evaluated until 1994, but changes occurred beginning in late-1980s);
- fishing effort (days-at-sea by fleet sector) trends were not described until 1994;
- rule 8.1 was not made operational (i.e., at what spawning stock biomass [SSB] level is there concern about recruitment), and thus the assessment did not compare estimates of SSB to a critical threshold;
- stock production and natural rate of increase (r) were not evaluated.

4.4 WAS THEORETICAL UNDERSTANDING A CONSTRAINT TO INTERPRETATION OF DATA PRODUCTS?

The answer to this question is an unqualified yes. During the period of stock decline (1987 to 1992) the scientific consensus was that cod as a species, in contrast to herring for example, is resilient to high levels of exploitation. North Sea cod recruitment had been moderately strong during several decades of high exploitation. As a result, the danger signals that were described in the 1988 to 1991 assessments were downplayed in the scientific advice. There was a false sense of security generated by the science consensus of cod resilience, which in hindsight is known to be incorrect for some cod stocks. Even with the benefit of hindsight, there is considerable uncertainty in the causes of the recruitment collapse that started in 1983. The causes of the reduction in growth rate and poor fish condition are also not well understood. These observed trends in cod population characteristics are no doubt responses to a combination of overfishing and ecosystem change. There are limits in explanatory power within ecology, even for well-monitored systems such as the eastern Scotian Shelf.

From an oceanographic perspective, the relative role of the NAO, and other oceanographic processes, in cooling of bottom water of 4VsW is not well understood. The foraging behavior of Grey seals on the changing fish species abundances within their distributional range for feeding is also poorly understood.

In summary, a combination of false rules of thumb (e.g. resilience of cod to heavy fishing), and limits to knowledge of marine ecosystem structure and function, set limits on the degree to which the monitoring programme can provide data products that are sufficient for decision-makers on ocean use issues. Given such theoretical constraints, it is of interest to evaluate the degree to which a precautionary approach was taken during the period of cod declines.

2. IMPLICATIONS OF MONITORING LIMITATIONS ON THE PRECAUTIONARY APPROACH

The UN Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, as well as the FAO Code of Conduct for Responsible Fishing, have adopted the precautionary approach for fisheries management. In the case of Canada, subsequent legislation - the 1997 Oceans Act - has incorporated this approach in national law. There is a linkage between the adequacy of oceans monitoring and the application of the precautionary approach (PA). Article 6 of the above UN agreement states, for example, that:

> *AStates shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures.@*

Annex II of the agreement provides guidelines for the application of precautionary reference points for fisheries management decisions. Subsequent work by ICES and NAFO has considered two categories of reference points. The first category involves estimates of spawning stock biomass (B) and fishing mortality (F) in relation to critical thresholds and targets. Recent history has indicated that, even with state-of-the-art assessment methodology and sophisticated monitoring activities, there is considerable uncertainty around estimates of most recent year B and F values. Also it is difficult to capture the level of uncertainty in a quantitative manner. The second category involves a series of indicators, some of them qualitative, that in aggregate provide an evaluation of the state of the stock and the management system (Caddy 1998). The indicators include size composition, area of distribution, recruitment trends, weight-at-age or weight-at-length, condition, and oceanographic conditions, as well as fishery and management indices. Some of these indicators can be measured relatively easily and with precision (e.g. size composition and area of distribution).

It is of interest to apply the two categories of PA guidelines to the 4VsW cod assessments during the period of stock decline. From the summary in section 3.2, some general conclusions can be reached relative to their performance. In the 1988 to 1992 stock assessments, the danger signals based on indicators were described as the stock abundance was declining (e.g. age structure, area of distribution, weak recruitment, changes in geographic area of distribution, weight-at-age declines). The estimates of B and F in these assessments may not have triggered precautionary limit reference points. It was not until the 1992 assessment that the precaution was stated in both the assessment and the advice. A more detailed analysis is warranted using the ICES and NAFO precautionary reference points, as well as the Caddy Atraffic light@ approach of system-wide multiple indicators. My impression is that the latter approach would have been more effective in the 4VsW cod case history.

The above focus on the link between monitoring data products and the degree of uncertainty in stock status of exploited species suggests that LMR-GOOS should include an analysis of the role of monitoring in the application of the precautionary approach. In situations of limited monitoring, ocean uses would need to be more limited.

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Table 1.
Inventory of Past and Current Monitoring Activities on the Scotian Shelf
(from Annex III of Therriault *et al.* 1998)

Maritimes Region

Inventory of Climate Indices Files

These files are maintained in an archive and are updated regularly.

Air Pressure Time Series: NAOINDEX 1895-1995; OPTEST covers air pressure for approx. 20-90N, 5E-90N.
Annual Air Temperatures: 13 data series primarily from northern Europe starting as early as 1816.
Monthly Air Temperatures: 83 time series covering the Arctic, east coast of Canada and the U.S., some European, some inland Canada starting as early as 1757.
Geostrophic Wind (6 h): 25 time series for the AES standard east coast sites 1946-1991.
Freshwater Inflow (monthly): 24 time series for NS, NB rivers plus a Hudson Bay index from as early as 1914.
Ocean Features: Eddies, Gulf Stream and shelf-slope boundary positions from as early as 1966 on monthly and chart frequency basis.
Ice/Icebergs: Ice area seaward of Cabot Strait (1970-1994), south of 55N (1963-1994)and number of bergs (1983-1994).
Monthly SST by Area: 24 time series for geographic areas (1971-1993).
Coastal/Lightship SST: 13 time series from Woods Hole to Grande Rivière beginning as early as 1906 (some have been discontinued).
Bay of Fundy SST: 41 time series for period 1980-1990.
Monthly T/S Series: 3 series for Emerald basin (1947-1995), Prince 5 (1924-1995) and Sta. 27 (1946-1995).
Zooplankton (Doug Sameoto): Years Covered - 1984-1995. Areas - Scotian Shelf and Gulf of Maine primarily, some from Arctic, northern Atlantic, eastern tropical Pacific. Tables include cruise, space, time information, counts, weights, species. The data in the database are from the Biological Oceanography Section almost exclusively.
Marine Fish Division (Bob Branton): SSIP database - includes fish larvae, zooplankton, nutrients on Scotian Shelf between 1977-82.
Fish Database - 1970-1996 abundance and distribution in Scotia-Fundy Region.
Observer Program Foreign and Domestic - 1977-present, catch, time, location.
Ports Landing Program - Decades, species, size and age of landed fish.

Other Time Series

Sea Level: Approximately 20 sea level gauges has made up the permanent tide gauge network of Eastern Canada, though the number has been decreasing over the past several years. Data have been collected since the late 1800s.
LTTMP (Long-Term Temperature Monitoring Program): Eleven coastal temperature sites are sampled with recording instruments year-round at from 1 to 3 depths. Programme began in 1978. Data are maintained in a regularly updated database.
Ice Forecast Cruise: Late fall-early winter hydrographic and lately oxygen and nutrient survey of the Gulf of St. Lawrence. Started in the early 1960s and ongoing. Temperature of the 200-300 m layer at Cabot Strait has been used as a climate index.
Hydrographic Sections: The Cabot Strait, Louisbourg, Halifax and Cape Sable Sections were sampled irregularly beginning in the early 1950s and continuing until the late 1970s. Of these, the Halifax Section has the largest number of occupations followed by the Cabot Strait Section. There has been a mini-revival in sampling the sections in the last few years.
Current Meter Data: While current meter moorings have not generally been occupied for long periods of time, the Cape Sable region had instruments in place from 1978-85 and 1995-96. In terms of current meter time series, this and the mooring off Hamilton Bank are the longest.

Pte. Lepreau Environmental Monitoring Programme: Ongoing since 1978, this monitoring project collected oceanographic data on a yearly basis to start but has dropped to one cruise every 5 years. A total of about 10 oceanographic cruises have been run. A wide suite of radioactive tracers are sampled in atmosphere, on land and in the ocean. Land programme is in co-operation with New Brunswick and provides some monthly series.

Bedford Basin Station: A multi-disciplinary time series spanning over 30 years, this data set is the result of various research programmes. Measurements of T-S, chlorophyll and nutrients are currently being collected on a weekly basis from a small boat.

Contaminants in Cod and Lobster: Chemistry has an extensive collection of contaminants in cod (livers and muscle tissue) from the southern Gulf of St. Lawrence stock. The data, which extend from 1976 to 1994, are sporadic in time and space. A similar series (1980-92) was collected annually for the Belledune area lobster.

- *Cores:* The contaminant record in a number of cores from various sites (e.g., Saguenay, Halifax Harbour) have been compiled and provide long time series.
- *NAQUADAT:* DOE has compiled an extensive database of contaminant concentrations in rivers.
- *Mussel Watch:* DOE with some involvement from DFO has monitored contaminants in mussels form very inshore waters. There is broad spatial coverage but the sampling sites (e.g. intertidal in the early years, lately subtidal) have changed.
- *Archived Data General:* Hydrographic observations and data collected by moored instruments (current meters, temperature recorders, ADCPs, pressure gauges) are maintained in an archive. Tools are available for data extraction, analysis (e. g. creation of time series, spatial series) and display. Data from drifting buoys are also archived. Nutrient (nitrate, nitrite, silicate, ammonium) and dissolved oxygen observations are maintained in a database that supports data extract to create temporal or spatial distributions.
- *Satellite SST:* For 1981-95 and continuing thereafter, 18 km monthly resolution satellite SST data are available. We have the raw tapes of daily passes from 1984-present.

Current Programmes (i.e., regular monitoring)

The hydrographic, chemical and moored instrument databases are being maintained and updated regularly. The climatological database is also revised regularly.

The groundfish surveys typically cover a broad area, sometimes acquire data during seasons when there is generally the least number of observations, and thus serve as an extremely important source of oceanographic as well as fisheries data.

The LTTMP, the Prince 5 monthly sampling, sea level sampling at Saint John, Yarmouth, Halifax, North Sydney, Charlottetown and Escouminac are being maintained.

Following the phytoplankton monitoring programme (1989-91), a long-term monitoring programme is being carried out at Indian Point (Mahone Bay) and Sambro in N.S. and at 4 sites in southern N.B. (Passamaquoddy Bay). There are no sites in the southern Gulf of St. Lawrence but at least one site is being considered. Sampling is carried out about 26 times per year for temperature, salinity, Dissolved oxygen, PAR, nutrients, chlorophyll, SPM and phytoplankton analyses. Thermographs are maintained and plankton tows carried out. All data are maintained in a database.

Fish Surveys:

Groundfish, Scotian Shelf GOM, July
Herring, Bay of Fundy GOM, November
Groundfish, Georges Bank, Feb-March
Groundfish, Eastern Scotian Shelf, March

Table 2. Possible Regional Monitoring Products LMR-GOOS

Region: NW Atlantic - Scotian Shelf, Gulf of Maine, Southern Gulf of Saint Lawrence

Serial ♯	Major Ecological Group or condition	Subgroups or Species Physical Obs.	Type of Information	Freq. in Time	Freq. in Space	Accuracy (no bias/ constant bias %)	Precision Give C.V.%	Avail able? Yes/ No	Linkage to other Obs.	Priority (Vital/ Hi/Med Low?)	Comments particularly on 11
♯1	Top predator	Fishing industry	Catch by area and species	Annual	Lat./Long Preferred NAFO Statistical areas as a minimum	Constant bias	<5%	Yes	All LMR-GOOS obs.	Vital	Critical information for fisheries management annual planning process
♯2	Top predator	Right Whale	Location/ abundance	Annual	Known range	No bias	10%?	Yes	Fisheries	Vital	Not actually a top predator, but here for convenience High priority while endangered/threaten ed
♯3	Top predator	Harbour porpoise	Location/ abundance	Every 5 years	Known range	Constant bias	20%?	Yes	Fisheries (Herring abundance)	High	High priority while endangered/threaten ed
♯4a	Top predator	Grey and Harbour Seal	Abundance	Every 3 years	Sable Is. areal survey	Constant bias	5%	Yes	Food habits	High	Aids in interpretation of slow Cod stock recovery
♯4b	Top predator	Grey and Harbour Seal	Scat collections	Same as above	Same as above	Constant bias	25%?	Yes	Seal abundance	Medium	Same as above
♯5	Finfish and forage species	Trawl surveys	Catch by tow , by area and age	Annual	30 min hauls one set/ 850 km2	Constant bias	30% (for fully recruited ages)	Yes	Fisheries landings, fishing effort, bottom temp.	Vital	Part of unique Abiodiversity@ survey from Cape Hatteras to Cape Chidley
♯6a	Plankton	Zoopl. (CPR)	Abundance and species	Monthly	Horiz. 10 nmi.	Constant bias	50%?	Yes	Phyto. Hydrogr.	Vital	Index of food supply for forage species

					(0-100m)						and commercial fish
Serial #	Major Ecological Group or condition	Subgroups or Species Physical Obs.	Type of Information	Freq. in Time	Freq. in Space	Accuracy (no bias/ constant bias %)	Precision Give C.V.%	Avail able? Yes/ No	Linkage to other Obs.	Priority (Vital/ Hi/Med Low?)	Comments particularly on 11
#6c	Plankton	Zoopl.	Column-integrated abundance and species	Bi-annual	Cross-Shelf sections Vert. net haul	No bias	50%?	Yes	Phyto., Hydrogr.	Medium	Index of food supply for forage species and commercial finfish AGround-truth@ for CPR
#6d	Plankton	Phyto. CPR	Abundance and species	Monthly	Horiz. 10 nmi. Vert. 10m	Constant bias	50%?	Yes	Hydrogr., Nutrients, ocean colour, zoopl.	Vital	Index of food supply for zoopl. And larval fish CPR Agreenness@ and cell counts
#6e	Plankton	Phyto	Biomass, abundance, species	Bi-monthly	Fixed Stn. Vert. multi-depth (0-100m)	No bias	50%?	Yes	Hydrogr., nutrients, ocean colour, zoopl.	Medium	Index of food supply for zoopl. and larval fish Chlorophyll and cell counts AGround-truth@ for CPR
#6f	Plankton	Phyto.	Biomass	Bi-annual	Cross-Shelf sections Vert. multi-depth (0-100m)	No bias	50%?	Yes	Hydrogr., nutrients, ocean colour, zoopl.	Medium	Index of food supply for zoopl. and larval fish AGround-truth@ for CPR
#6g	Plankton	Phyto.	Satellite-spectral (visible)	Bi-monthly composite	Zonal coverage (l km2) Surface	Constant bias	30%	Yes	Hydrogr., nutrients, zoopl.	Vital	Index of food supply for zoopl. and larval fish satellite-based ocean colour
#7a	Chemistry	Nutrients	Conc. (NO_3, PO_4, SiO_3)	Bi-monthly	Fixed Stn. Vert. multi-depth (0-bottom)	No bias	10%	Yes	Hydrogr., oxygen, phyto.	Medium	Index of areas of active mixing/high productivity Vital or High in C-GOOS, HOTO?

Serial ♯	Major Ecological Group or condition	Subgroups or Species Physical Obs.	Type of Information	Freq. in Time	Freq. in Space	Accuracy (no bias/ constant bias %)	Precision Give C.V.%	Avail able? Yes/ No	Linkage to other Obs.	Priority (Vital/ Hi/Med Low?)	Comments particularly on 11
♯7b	Chemistry	Nutrients	Conc. (NO3,PO4, SiO3)	Bi-annual	Cross-Shelf sections Vert. multi-depth (0-bottom)	No bias	10%	Yes	Hydrogr., oxygen, phyto.	Medium	Index of areas of active mixing/high productivity Vital or High in C-GOOS, HOTO?
♯7c	Chemistry	Oxygen	Conc.	Bi-monthly	Fixed Stn. Vert. multi-depth (0-bottom)	No bias	1%	Yes	Hydrogr., nutrients, phyto., fisheries	Medium	Index of areas of active mixing/high productivity Important factor in distribution of invert. and finfish Vital or High in C-GOOS, HOTO?
♯7d	Chemistry	Oxygen	Conc.	Bi-annual	Cross-Shelf sections Vert. multi-depth (0-bottom)	No bias	1%	Yes	Hydrogr., nutrients, phyto., fisheries	Medium	Index of areas of active mixing/high productivity Important factor in distribution of invert. and finfish Vital or High in C-GOOS, HOTO?
♯8a	Hydrogr.	Temp/Sal.	CTD profiles	Bi-monthly	Fixed Stn. Vert. (0-bottom)	No bias	<1%	Yes	Nutrients, phyto., fisheries	Medium	Index of circulation, areas of active mixing and high productivity Important factor in distribution of all trophic levels
♯8b	Hydrogr.	Temp/Sal.	CTD profiles	Bi-annual	Cross-Shelf sections Vert. (0-bottom)	No bias	<1%	Yes	Nutrients, phyto., fisheries	Medium	Index of circulation, areas of active mixing and high productivity Important factor in distribution of all

											trophic levels
Serial ♯	Major Ecological Group or condition	Subgroups or Species Physical Obs.	Type of Information	Freq. in Time	Freq. in Space	Accuracy (no bias/ constant bias %)	Precision Give C.V.%	Avail able? Yes/ No	Linkage to other Obs.	Priority (Vital/ Hi/Med Low?)	Comments particularly on 11
♯8c	Hydrogr.	Temp/Sal.	CTD profiles	Annual	Shelf-wide, summer trawl survey	No bias	<1%	Yes	Nutrients, phyto., fisheries		Index of circulation, areas of active mixing and high productivity Important factor in distribution of all trophic levels
♯8d	Hydrogr.	Temp.	Satellite-spectral (IR)	Bi-monthly	Constant bias	(~ 1degC)					Index of circulation, areas of active mixing and high productivity Important factor in distribution of all trophic levels

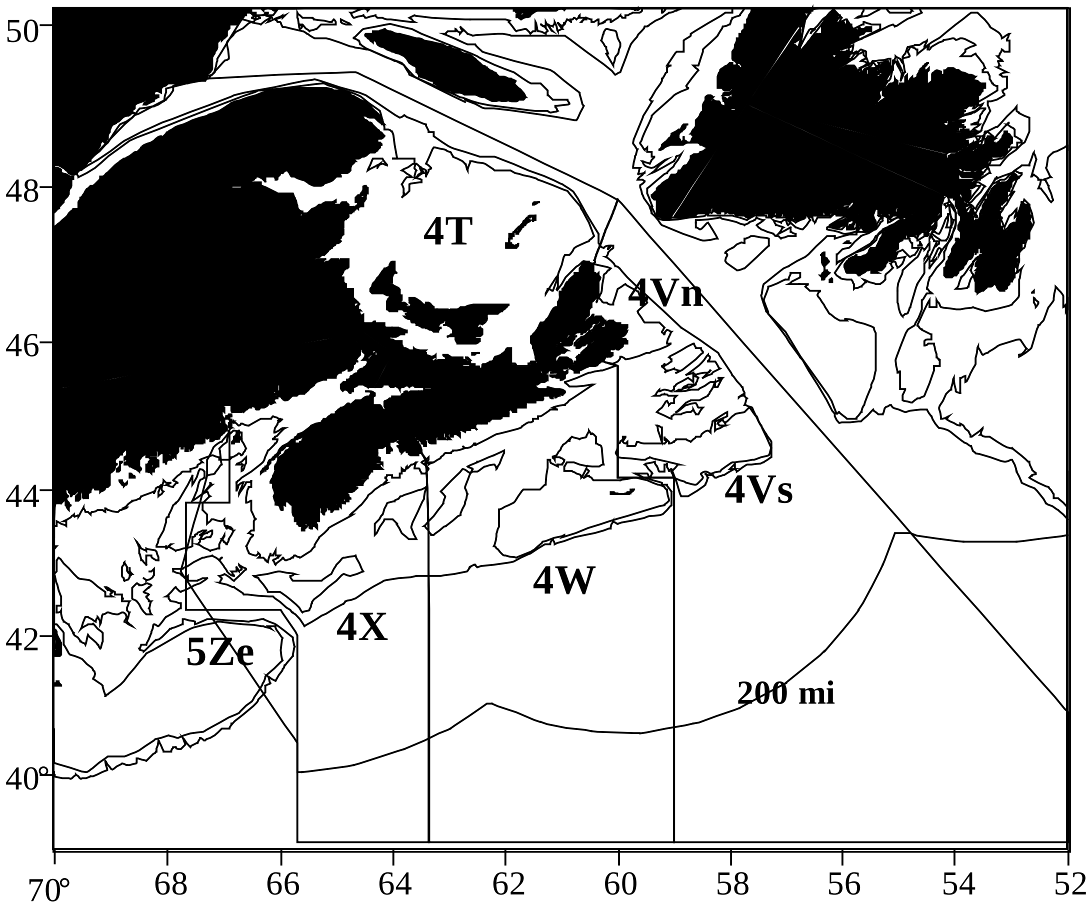

Figure 1. The DFO Scotia-Fundy area of Atlantic Canada includes NAFO statistical divisions 4VWX and 5Ze.

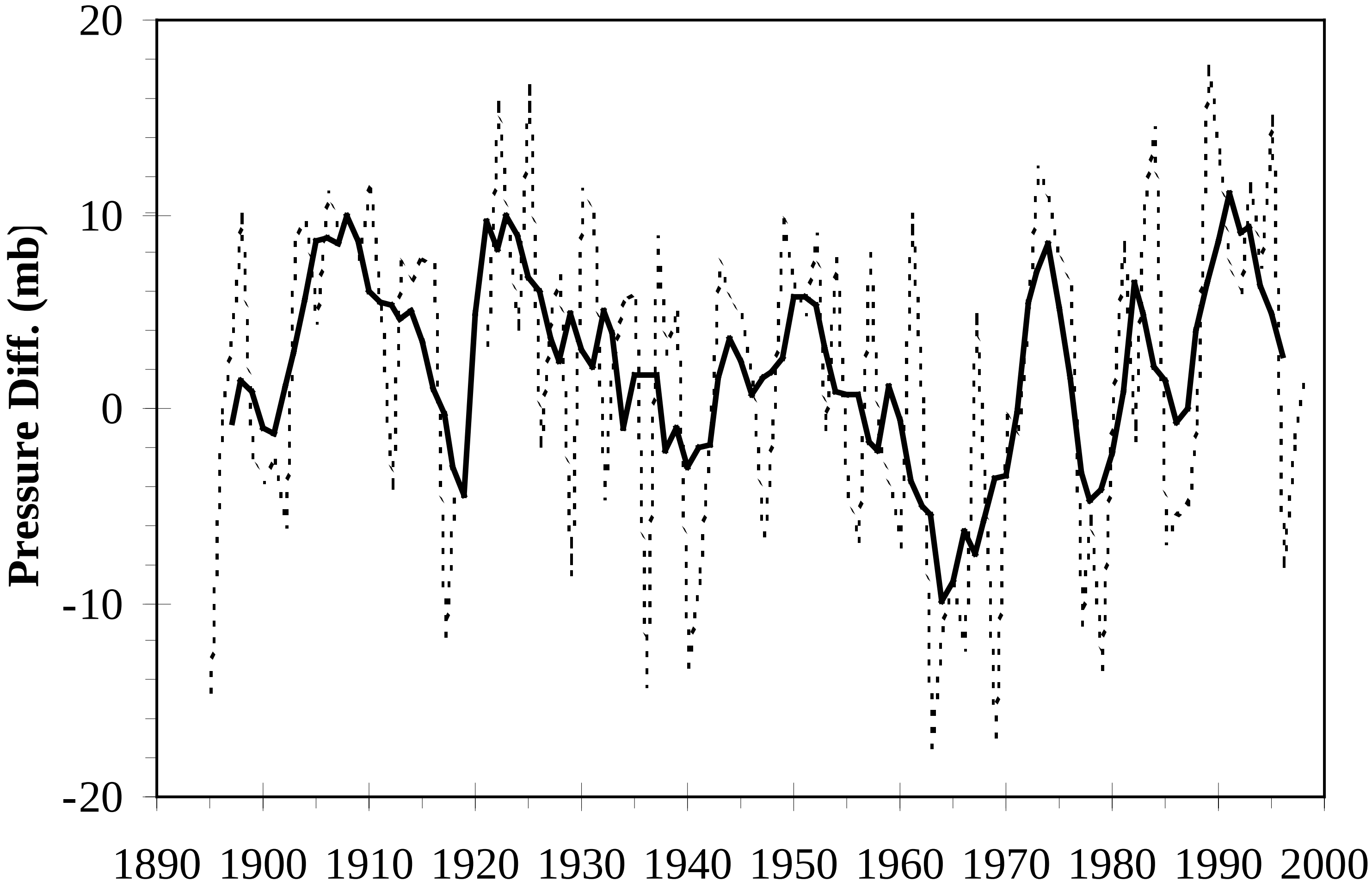

Figure 2. Anomalies of NAO Index

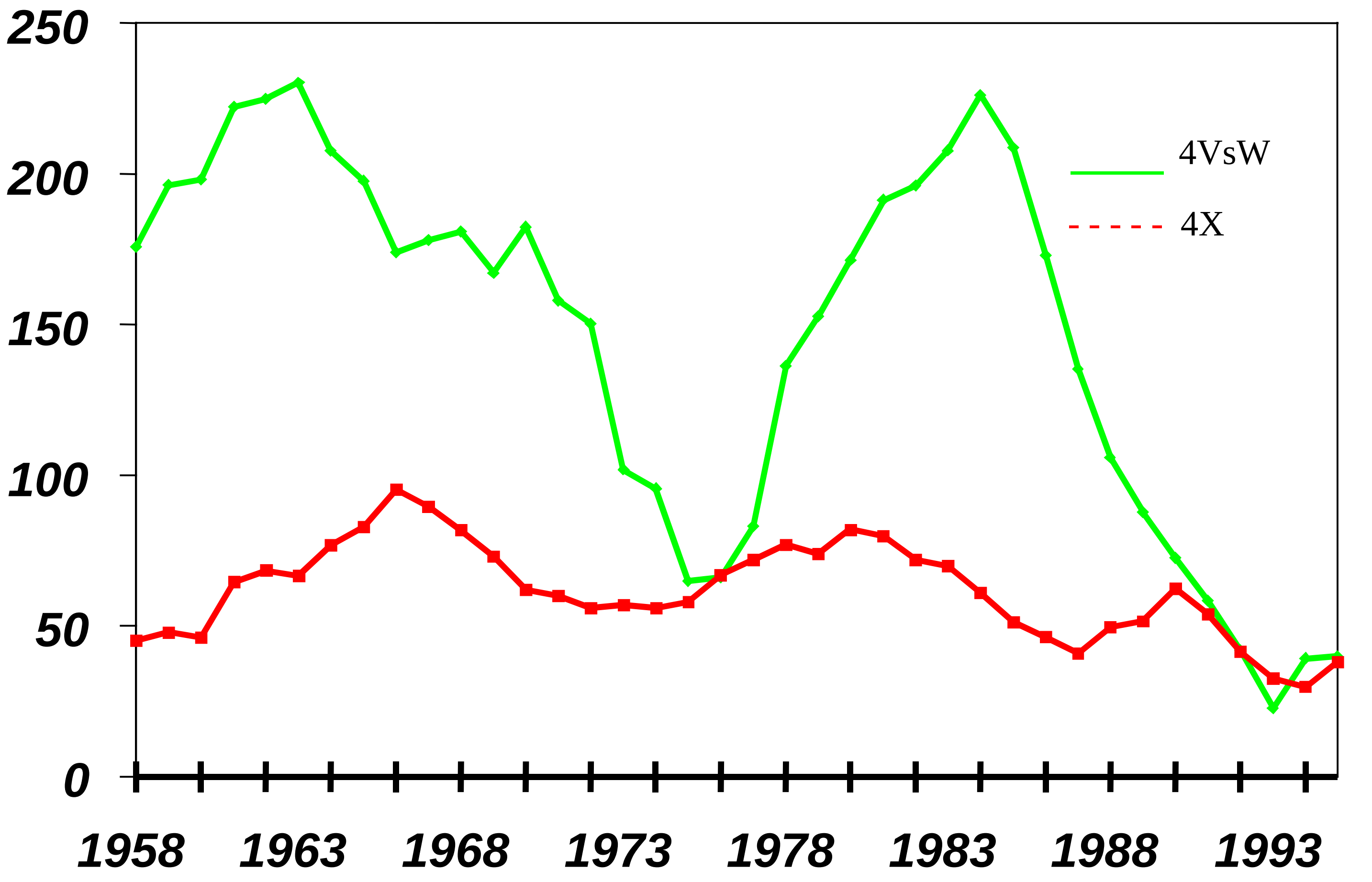

Figure 3. Trends in estimates of spawning stock biomass for 4VsW cod (age 4+) and 4X cod (age 3+) from 1958

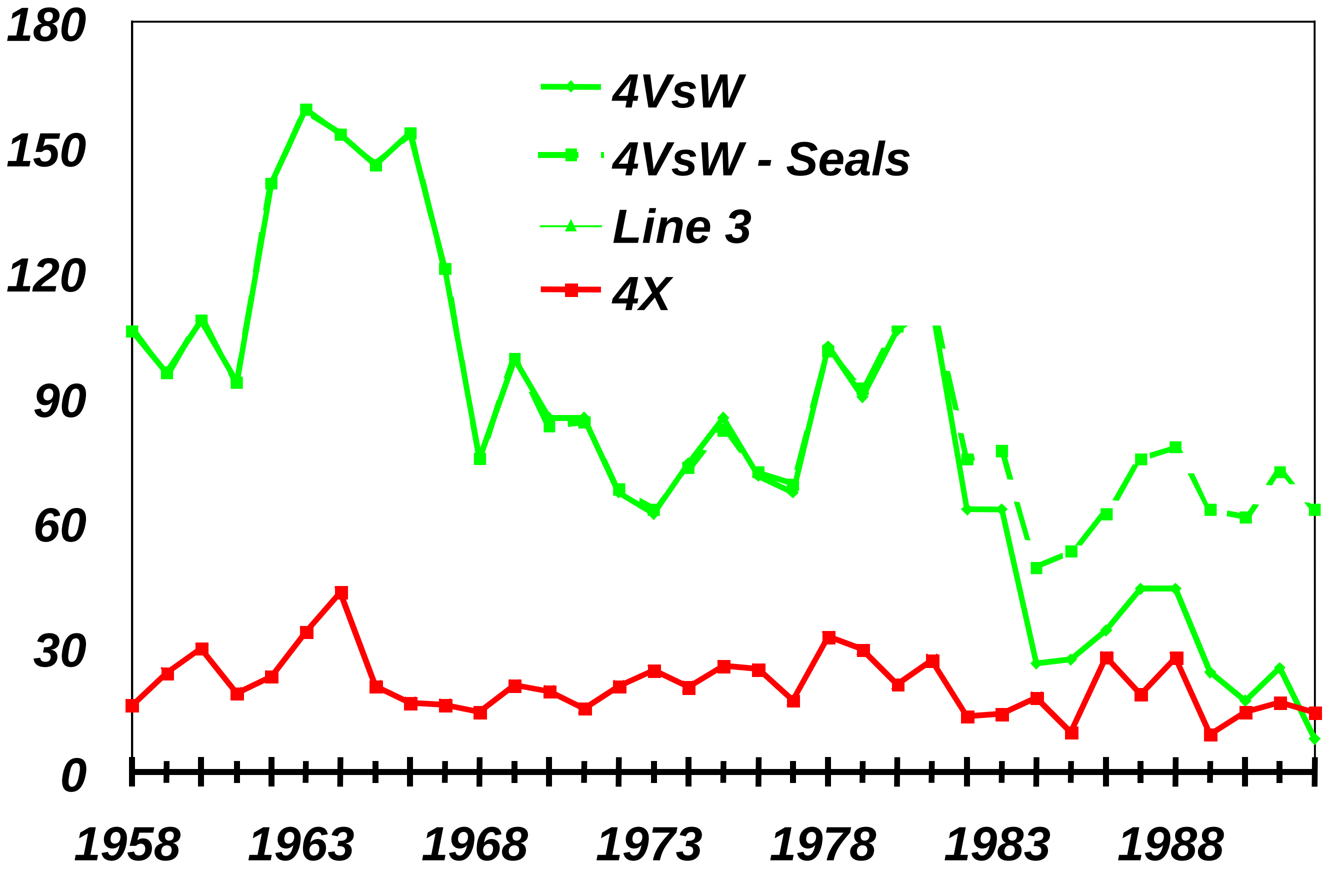

Figure 4. Trends in estimates of recruitment (abundance at age 1) for 4VsW cod and 4X cod

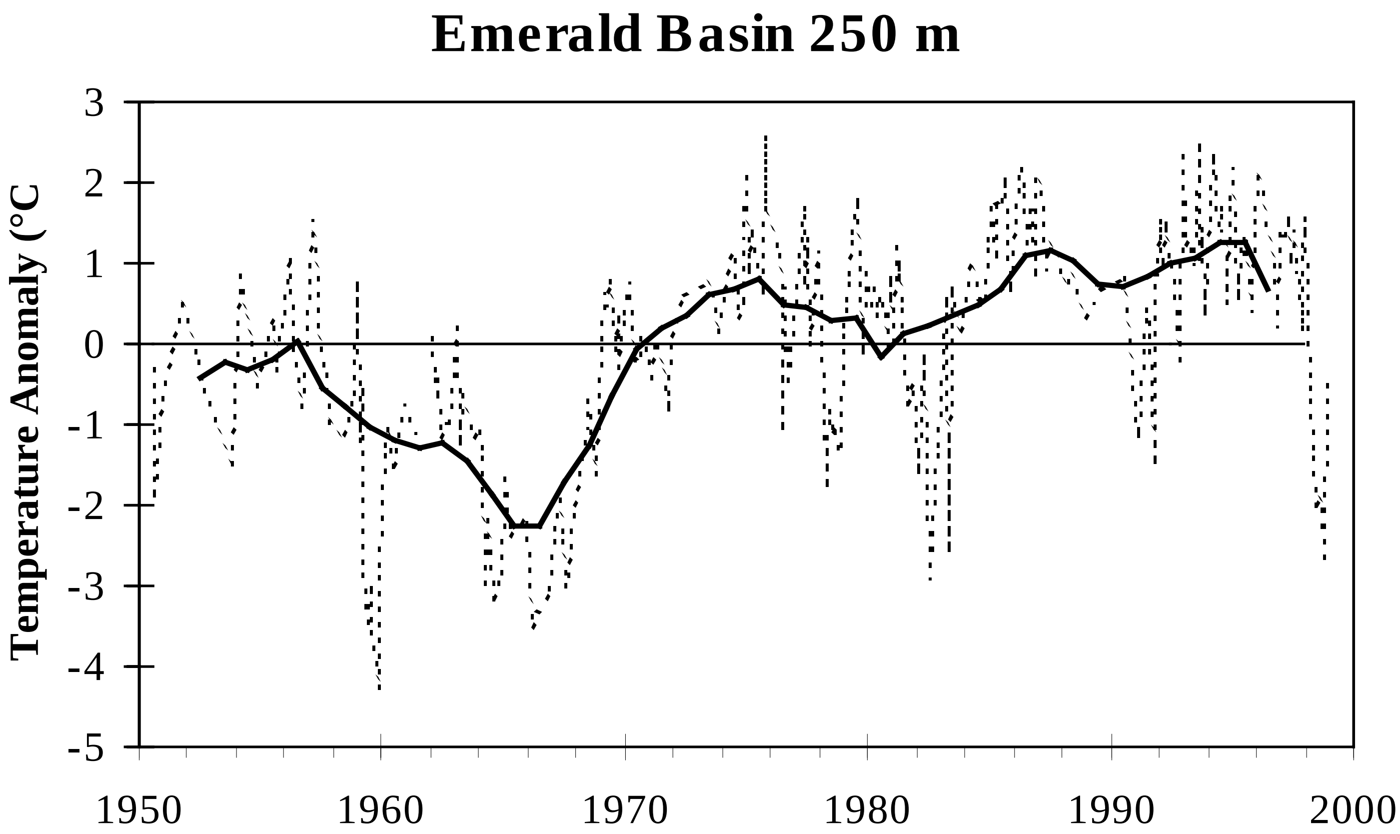

Figure 5. Temperature anomaly (ºC).

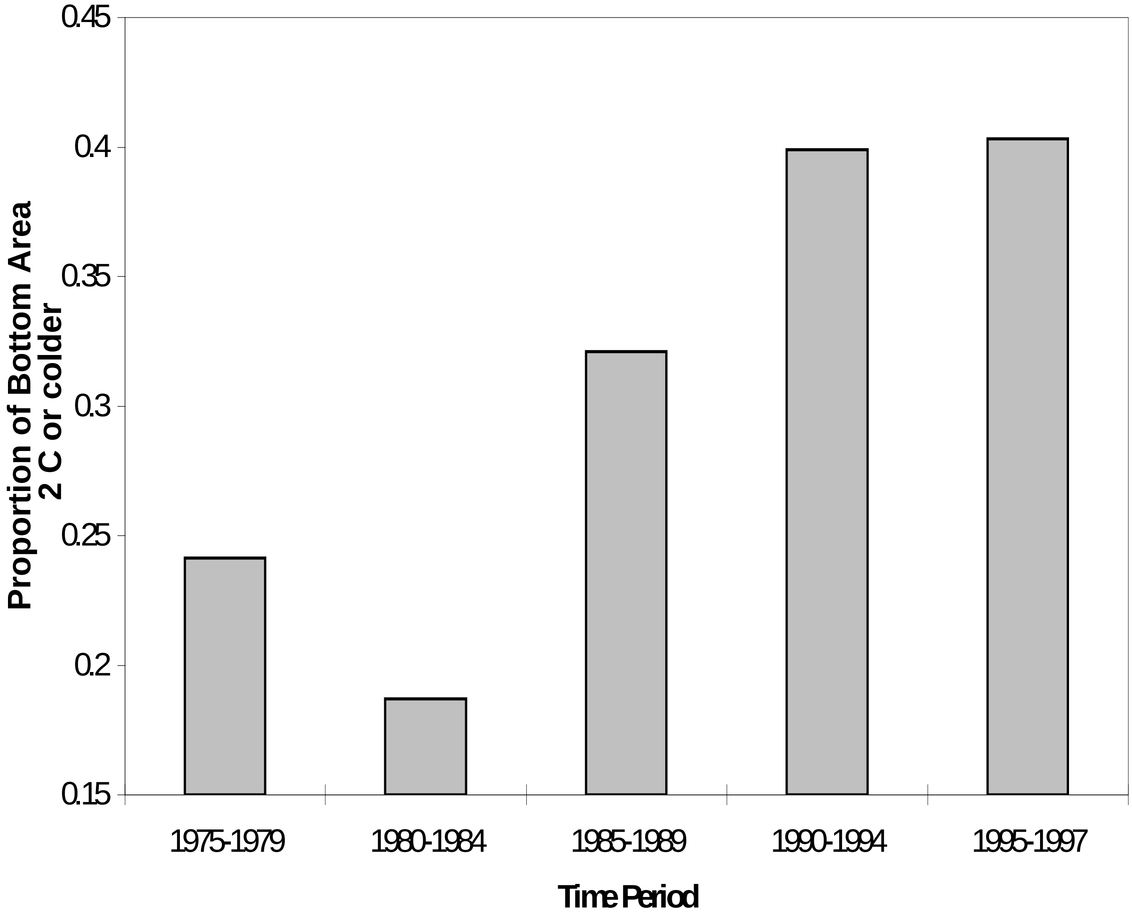

Figure 6. Proportion of 4VsW with bottom temperature less than 2ºC.

ANNEX V

TABLES OF PROPOSED MONITORING PRODUCTS

Annex V. 1 Table of possible regional observations.

1	2	3	4	5	6	7	8
Serial #.	**Major ecological group or condition**	**Subgroup or species or physical observations**	**Type of observations**	**Frequency in time**	**Frequency in space**	**Priority**	**Comment**
1a	Target Species of fishing	Fishing industry	catch by area and species	annual	lat/long preferred or FAO area	Vital	Critical information for fisheries management annual planning process.
1b	Target Species of fishing.	Fishing industry	Length frequency samples of landings by species and area.	seasonal	management unit or FAO area.	High	Without this information trends in exploitation rates cannot be estimated.
1c	Target Species of fishing.	Fishing industry	length/weight relationships for key species	seasonal	management unit or FAO area	High	Necessary for estimation of numbers at length that are removed by fishery.
1d	Target species of fishing.	Fishing industry	Effort	annual	lat/long preferred or FAO area	Vital	Critical information for fisheries management annual planning, changes in technology and behavior should be monitored.
2a	Top Predator	Whales, dolphins, porpoises, seals etc	abundance	3-5 years	population area	Vital if species is at risk, high if species is bay	Obligations under international conventions dealing with biodiversity.
2b	Top Predator	Whales, dolphins, porpoises, seals etc	food habits eg stomach contents, for key predators	3-5 years	By management areas for commercial	medium	Information necessary to estimate potential trends in natural mortality of target species.
2c	Top Predator	sharks	by-catch/abundance	annual	FAO area	Vital if species is at risk	Obligations under international conventions dealing with biodiversity.
2d	Top Predator	sea birds	abundance, fledging success and breeding success	pref annual but may be 3-5 years.	population area	high	Provides good indicators of ecosystem change.
3a	Commercially exploited finfish and forage species	surveys, e.g. trawl	catch by area and species	pref annual but may be 3-5 years	30 min hauls, one set/850 km2	high	Provides good indication of fish community trends, ecosystem change.
3b	Commercially exploited finfish and forage species	acoustic surveys	abundance by area and species	pref anual, but may be 3-5 years	FAO area, survey design dependent on target species.	high	Provides information for fisheries management planning process, and knowledge on ecosystem change.
3c	Commercially exploited finfish and forage species	fish eggs/larvae	abundance/by area and species	pref annual, but may be 3-5 years	by management areas for commercial fisheries	high	Provides information on abundance of commercially important pelagic species.
4a	Plankton	Continuous plankton transects (eg. CPR)	abundance and species	monthly	10 nautical miles	high	Provides estimates of plankton community trends at shelf and ocean basin scales.
4b	Plankton	zooplankton (net sampling)	column integrated species and abundance using plankton nets.	frequency should be determined by the hydrographic regime of the area	transects and fixed stations.	medium	Includes monitoring of coastal fixed stations and transects across continental shelves.
4c	Plankton	phytoplankton	column integrated species and abundance using discrete depth	frequency should be determined by the hydrographic regime of the area	transects and fixed stations	medium	Includes monitoring of coastal fixed stations and transects across continental shelves.
4d	Plankton	phytoplankton	satellite-spectral (visible)	bi-monthly coverage	zonal surface coverage (1 km2)	Vital	Provides estimates of phytoplankton biomass and production at shelf and ocean basin scales (longhurst areas).

1	2	3	4	5	6	7	8
Serial #.	**Major ecological group or condition**	**Subgroup or species or physical observations**	**Type of observations**	**Frequency in time**	**Frequency in space**	**Priority**	**Comment**
5	Benthos	noncommercial species	community structure, appropriate methodology	3-5 years	representative habitats (sandy, soft, rocky)	medium	Obligations under international conventions dealing with biodiversity require enhanced monitoring of benthos for wide range of habitats.
6	Chemistry	nutrients/oxygen	discrete depths and column integrated	frequency should be determined by the hydrographic regime of the area	transects and fixed stations	high	samples to be taken in conjunction with plankton monitoring
7a	Hydrography	tem/sal.	CTD profiles	frequency should be determined by the hydrographic regime of the area	transects and fixed stations	high	provides information on habitat change and contributes to estimates/circulation
7b	Hydrography	temp/sal.	CTD profiles	frequency should be determined by the hydrographic regime of the area	shelf wide, trawl survey	High	These data to be taken at select fish survey stations under 5a, b, c
7c	Hydrography	ocean pigments	satellite-spectral	bi-monthly coverage	zonal surface coverage	Vital	Provides estimates of sea surface temperature at shelf and ocean basin scales.
7d	Hydrography	ocean winds	satellite-spectral	bi-monthly coverage	zonal surface coverage	Vital	Provides estimates of sea surface temperature at shelf and ocean basin scales.
7e	Hydrography	sea height (altimetry)	satellite-spectral	bi-monthly coverage	zonal surface coverage	Vital	Provides estimates of sea surface temperature at shelf and ocean basin scales.
7f	Hydrography	temp.	satellite-spectral	bi-monthly coverage	zonal surface coverage	Vital	Provides estimates of sea surface temperature at shelf and ocean basin scales.
8a	Atmospheric forcing	wind fields	should be cross referenced with other GOOS	four synoptic samplings per day	gridded analysis input	high	Provides information to interprete changes in biological production.
8b	Atmospheric forcing	Upwelling indices	a. alongshore wind stress; b. offshore SST gradient	a. daily and bi-monthly; b. weekly and monthly	100-300km intervals along the coast	high	Provides information to interpret changes inbiological production.
8c	Composite indices	Pressure pattern indices (SOE, PNA, NAO, etc.	Selected permanent weather stations	monthly	ocean basin scale	high	Information to interpret changes in biological production
8d	Composite indices	coastal sea level	permanent coastal tide gauges	monthly	where avail. and feasible (at least one per LME)	high	Information to interpret changes in biological production

* Open ocean fish, benthic communities and sea mounts should be considered as a research question until appropriate technology exists for monitoring, but should be flagged.

TABLE V.2.1 Possible regional monitoring products for Southern-Central Chile.

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Serial #	**Major ecological group or condition**	**Subgroup or species or physical observations**	**Type of observations**	**Frequency in time**	**Frequency in space**	**Accuracy**	**Precision. CV (%)**	**Available? Yes/No**	**Linkage to other observations**	**Priority (vital/Hi/med/low)**	**Comment (particularly on 11)**
1	Small Pelagic Fish	Common Sardine &	Length-frequency data	Weekly	Random	no bias		Yes	Catch n°	Vital, while stocks are fully and heavily exploited	This data is used for growth, recruitment and abundance analysis
2	Small Pelagic Fish	Common Sardine & Anchovy	Length-weight relationships	Weekly	Random	no bias		Yes	Catch n°	Median value, high under El Niño conditions	This data is used for transforming weight units into number (e.g. catch biomass to nº)
3	Small Pelagic Fish	Common Sardine & Anchovy	Macroscopic reproductive indices	Weekly	Random	no bias		Yes	Egg and larvae	Median value, high under El Niño conditions	This data is used for monitoring reproductive changes in time
4	Small Pelagic Fish	Common Sardine & Anchovy	Eggs and larvae surveys	Annually	1 haul each 5nm (max:30 nm)	no bias		Yes	Reproductive indexes	Vital, related to environmental variability and stock size changes	Data base for mortality, growth and recruitment variability. Also for daily production method
5	Small Pelagic Fish	Common Sardine & Anchovy	Fishing effort	Daily	Latitude and longitude known	no bias		Yes	Catch biomass	Vital, while stocks are fully and heavily exploited	This data is used for routine abundance and biomass information
6	Small Pelagic Fish	Common Sardine & Anchovy	Standardized commercial catch rates	Monthly	Latitude and longitude known	no bias		Yes	Catch nº at age	Vital, while stocks are fully and heavily exploited	This data is used for routine abundance and biomass information
7	Small Pelagic Fish	Common Sardine & Anchovy	Total catch biomass	Daily	Latitude and longitude known	no bias		Yes	Catch nº at age Standardized commercial catch	High value while stocks are fully and heavily exploited	This data is used for routine abundance and biomass information
8	Small Pelagic Fish	Common Sardine & Anchovy	Catch nº at age	Monthly	All zones	no bias		Yes	Standardized commercial catch rates	Vital, while stocks are fully and heavily exploited	This data is used for routine abundance and biomass information
9	Small Pelagic Fish	Common Sardine & Anchovy	Frequency of juveniles' birth dates	Annualy	Random	no bias		No	Individual age and reprodutive aspects	High value while stocks are fully and heavily exploited	This data will be used for monitoring reproductive changes and recruitment variability analysis
10	Small Pelagic Fish	Common Sardine & Anchovy	Gut contents of predator species	Quarterly	Random	no bias		No		Median value	This data will be used for analysis of causes of resources mortality
11	Small Pelagic Fish	Common Sardine & Anchovy	Pre-recruit abundance	Annually	All zones	no bias		No	Catch nº at age. Standardized commercial catch	High value while stocks are fully and heavily exploited	This data will be used for routine abundance and biomass information
12	Small Pelagic Fish	Common Sardine & Anchovy	Microscopic reproductive indexes	Monthly	Random	no bias		No	Reproductive aspects	High value, specially during El Niño events.	This data will be used for determining spawning success and is crucial for applying EPM
13	Small Pelagic Fish	Common Sardine & Anchovy	Hydroacoustic surveys	By-annually	30-40°S from coast-50 nm.	no bias		No	Catch nº at age. Standardized commercial catch rates	High value while stocks are fully and heavily exploited	This data will bring biomass and abundance information of stocks
14	Small Pelagic Fish	Common Sardine &	Feeding activity	Monthly	Random	no bias		No	Gut content and prey distribution	Median value	This data will be used for determining feeding aspects

Table V.2.2. Table of possible regional models and products for Southern-Central Chile

	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8		2	3				
Model Serial #	**Monitoring inputs (Numbers refer to serial numbers of observations in Table V.2.1 of LMR GOOS-II Report)**									**Model type or Requirement**	**Estimate outputs**				**Comments**
	In1	**In2**	**In3**	**In4**	**In5**	**In6**	**In7**	**In8**			**Out1**	**Out2**	**Out3**	**Out4**	
Mod #1	6	7	8							Monthly Sequen-tial Population Analysis	Monthly abundance and biomass	Annual pulse of recruitment	Spawning biomass	Monthly fishing mortality rate	Monthly population estimates based on an ADAPTIVE Algorithm to calibrate a SPA
Mod #2	1	2								Growth modelling	von Bertalanffy growth parameters	Average length-at-age	Average body weight-at-age	Age-Length key	Changes in growth are modelled for analyzing of growth variability
Mod #3	3	4								Larval growth and mortality	Seasonal larval growth rates	Natural mortality rates	Larval production estimates		Outputs are used for evaluate recruitment variability
Mod #4	3	4	12							Egg production model	Egg produc-tion and mortality	Spawning biomass	Batch-fecundity	Spawning frequency	Outputs are used for evaluate spawning biomass
Mod #5	10	14								Feeding dynamic modelling	Feeding Selectivity indexes	Feeding Preference indexes	Consumpti on rate	Predation mortality rates	Outputs are used for evaluate feeding and trophodynamic role on system
Mod #6	4	6	8	9	11					Stock-recruitment modelling	Recruitment forecasting and control	Recruitment hypotheses testing	Recruitme nt variability assessment		Outputs are used for recruitment forecasting and assessment physical coupling
Mod #7	5	7	11							Fishing grounds spatial/temporal patterns	Short-time scale fishing grounds forecasting	Catch yieds/ SST relationships	Formation/ disruption fish schools variability		Outputs are used for determining fishing grounds variability

Table V.2.3 Table of regional capacity and capacity building needed to support regional monitoring products in Southern-Central Chile.

	1	2	3	4	5	6	7
See parameters and products in Table V.2.1 and V.2.2 (As indicated)	**Existing Capacity**	**Requred capacity building**	**Likely route of capacity building information**	**Funding implications**	**Linkage to other observations**	**Priority (Vital/Hi/Med/low?)**	**Comment particularly on 6**
Table V.2.1 #: 1,2	Fishery sampling techniques (discharge sites)				Catch nº at age	Vital	This data is used for routine abundance estimation.
Table V.2.1 #: 1	Fishery length-frequency sampling				Catch nº at age	Vital	This data is used for routine abundance estimation.
Table V.2.1 #: 2,3, 14	Carry out fish biological sampling (*e.g*., weigth, stomach, gonads, otoliths)	Disease and parasites identification skills	Regional universities and research centers		Individual age, gut contents, macroscopic reproductive indexes	High	This data is used for routine abundance estimation.
Table V.2.1 #: 5,6,7,8	Collect and processing fishery statistics.				Catch nº at age, fishing effort and commercial catch rates	Vital	This data is used for routine abundance estimation.
Table V.2.1 #: 4, 9	Reading larvae/ juvenile daily growth increments				Growth and mortality rates	High	This data is used to explain abundance and biomass fluctuations and, year-class strength
Table V.2.1: # 3,12	Reproductive (macroscopic) atributes skills	Reproductive (microscopic)atributes skills	Regional universities and research centers			High	Indexes are used to understanding temporal and spatial reproductive dynamic
Table V.2.1: # 4	Fish eggs and larvae sampling and processing				Reproductive indexes	High	This data are understanding recruitment variability
Table V.2.1: # 10,14	Gut contents skills				Feeding activity	Median	This data are used on analysis of feeding activity and trophic role of species
Table V.2.2: # 1	Produce model algorithms and software	To incorporate fishery-independent abundance indexes to calibrate outputs			Catch nº at age, commercial catch rates.	Vital	This data is used for routine abundance estimation.
Table V.2.2: # 2	Capacity to model growth and to estimate growth parameters				Individual age, length-frequency data, length-weight relationships	Vital	The outputs of this model provide weight and length at age and their fluctuations.
Table V.2.2: # 3	Model larvae and juvenile growth and mortality		Regional universities and research centers		Growth and mortality rates	High	This data is used to explain abundance and biomass fluctuations and, year-class strength
Table V.2.2: # 4	Apply the egg production method	Microscopic reproductive indexes (batch fecundity, POF, maturity)	Regional universities and research centers		Reproductive indexes and catch nº at age	High	This data is used for routine abundance estimation.
Table V.2.2: # 5	Capacity to quantify trophic flows	ECOPATH and related ecosystem analysis skills	Expertise centres, e.g., ICLARM-Fisheries Centre UBC		Gut contents, feeding activity.	High	The outputs of this model provide rol of species in the ecosystem and to model changes in components related to fishing pressure for example.
Table V.2.2: # 6	Model the Stock-recruitment dynamics	Recruitment forecasting and control	Expertise centres, e.g. ORSTOM		Catch nº at age, egg and larvae surveys, juvenile birdth date, environmental	Vital	Outputs can be used for forecasting recruitment. Data is used to estimate future biological production which is vital for Quota management.
Table V.2.2: # 7	Apply multivariate spatial statistical techniques				Physical variables and grounds fishing distribution	High	Allow to carry out geostatiscal analysis of factors forcing fish and fishing grounds distributions

Annex V.3 - Table of possible regional monitoring products.

TOP PREDATORS, COMMERCIAL FINFISH, SMALL PELAGIC FISH, FORAGE FISH

Monitored Parameters	Indices	Utilization
Population Level		
• Spawner Stock Biomass	Percent Relative to Pristine	Operational management
• Recruits	Relative to Median	“
• Growth	Relative to Median	“
• Natural Mortality	“	
• Fecundity	“	
• Condition	“	
• Age at maturity	“	
Fishing Activity		
• Fishing Catch Rates	Median Tendency	Population estimate
• Fleet Behavior	Effort/Area/Duration	modify catchability coefficient
• Catch/Lengths/Age/Weights	Availability/Catchability	modify population abundance
• Spatial Extent of Catch	Relative to Historical	“ “ “
• Bycatch/Incidental Mortality	Percent Target Species	conservation/fishing practice
• Discards	Percent Target Species	“ “ “
Community Structure		
• Biodiversity	Richness, Eveness	not operational
• Length spectrum	Slope	not operational
• Biomass/Abundance Ratio	Dominance	detection of regime shift
• Diet	Percent Change, Composition	Inputs to Multi-species Models

PELAGIC ENVIRONMENT

Monitored Parameters	Indices	Deliverables
Planktonic Size Spectrum	Slope	
Zooplankton		
• Macrozooplankton		
Biomass/Abundance	Means/Trends	
Species Composition	Diversity Index	
Aliens		
• Mesozooplankton		
Biomass/Abundance	Ditto	
Species Composition		
Aliens		
• [Microzooplankton] (Process studies, not monitoriing)		
• [Bacteria]		
Zooplankton Community Structure		
• Biodiversity	Richness, Eveness	
• Length spectrum	Slope	
• Biomass/Abundance Ratio	Dominance	
• Diet	Percent Change, Composition	Inputs to Multi-species Models
Phytoplankton		
• Net-Phytoplankton	Ditto	
• Nano-Phytoplankton	Ditto	
Phytoplankton Community Structure		
• Biodiversity	Richness, Eveness	
• Length spectrum	Slope	
• Biomass/Abundance Ratio	Dominance	

ENVIRONMENTAL PARAMETERS

Remote Sensing

• Ocean color	Phytoplankton Biomass, Primary Productivity, Turbidity, Some Species, e.g. coccolithophores
• SST	Means, Deviations, Trends, Proportion of Area, Stratification Gradients, Upwelling Activity, Frontal Activity, ,
• Sea Height	Mesoscale eddies
• Winds	Divergence/Convergence, Mixing, offshore losses
• Advection,	
• Precipitation	
• Other	Combination Indices, Inputs to (Artificial Intelligence/ Expert Systems

InSitu

Temperature	Means, Deviations, Trends, Proportion of Area, Stratification, Gradients,
Vertical	Upwelling Activity, Frontal Activity.
SST	
• Salinity	
• Dissolved Oxygen	proportion of shelf/water column above/below threshold
• Nutrients	Eutrophication index
• Currents	Advection index, filaments, eddies
• Wave Height	
• Winds	
• Rainfall/precipitation	stratification,
• River Discharge	Eutrophication, mixing, entrainment
• Atmospheric Pressure	Gradients, alongshore and cross shore

ANNEX VI

DEEP SEA AND SEA FLOOR ISSUES

The monitoring system that is currently the major focus of attention and discussion by the GOOS LMR Panel concentrates on monitoring the state and variability of the upper part of the ocean, wherein lie nearly all the significant exploited fishery resources. However, the Panel recognizes that the deeper layers of the ocean deserve some attention from GOOS, particularly in cases where direct effects of human activities may be acting to change the form and structure of the solid substrate of the ocean floor and of the associated biological communities, particularly of certain very narrowly distributed sessile organisms associated with special habitats of very limited spatial extent.

A working paper, entitled *Extreme Marine Environments: the Abyssal Ecosystem* was distributed to the Panel by panel member B. von Bodungen. The point was made that the bathypelagic and abyssal regions of the ocean are extremely extensive and important areas in the global sense, but are very little known or studied. The Panel's collective opinion was that the current anthropogenic impacts on the large scale, particularly within the pelagic environment are probably slight, and certainly very difficult to measure or monitor. On the other hand, certain severe effects of fishing and mining activities, either current or potential, may be very important to marine biodiversity and habitat issues and probably worthy of specific attention by GOOS.

For example, the effects of bottom trawling were highlighted in the ICES-SCOR Workshop on Ecosystem Effects of Fishing which took place, also in Montpellier, the week prior to this Second GOOS LMR Panel Session. Fishing by means of dragging heavy trawls over the sea floor is widely practiced in most coastal regions of the world's oceans. This acts to destroy sessile communities, subject infauna to mechanical damage, expose delicate organisms to predation, etc. In many areas of the continental shelves, parts are trawled repeatedly in a given year. Even a single trawl may cause striking changes in the appearance of the sea floor surface.

The situation appears to be critical in the cases of seamount fisheries such as that for orange roughy. These are valuable fisheries but appear to have little sustainability. Of great importance is the fact that studies have shown that the local primary production is only about ten percent of that needed to sustain the local fish populations. The conclusion is that the productivity of these systems rests on the ability of the sessile community (deep water corals, etc.) to filter large volumes of water that are carried over the sea surface by locally enhanced current flows. These corals are very slow growing and long-lived, and exhibit a high degree of endemism. It is found that the trawling operations in the orange roughy fisheries rapidly destroy the sessile communities, leaving essentially bare rock. The likelihood of associated loss of essential biodiversity is strong.

Another habitat that is not currently under exploitation, but potentially extremely fragile, are the areas directly adjacent to deep-sea seeps, vents and smokers. There tend to be rich localized faunas at these locations existing in food chains which are based at their lowest levels on sulfide metabolism. These features in the sea floor are often associated with deposits of minerals or hydrocarbons. Mining operations on these resources could potentially devastate the unique biological communities and do significant damage to unique examples of marine biodiversity.

Some panel members were of the opinion that GOOS should initiate some low frequency monitoring of such features. An opinion was expressed, for example, that maps of trawling frequency of sea floor areas, state of damage of seamount surface biota, as well as decadal scale changes in these characteristics, might be extremely useful GOOS outputs.

ANNEX VII

IOC CIRCULAR LETTER ON GLOBAL INVENTORY OF NATIONAL MARINE OPERATIONAL OBSERVING SYSTEMS

IOC Circular Letter No. 1619 July 29, 1999

To: All IOC focal points

cc: ICES, PICES, SCOR, LabNet, LOICZ, GLOBEC, FAO, WRI, UNEP, EuroGOOS, MedGOOS, NearGOOS, PacificGOOS, CariGOOS, GOOS Africa

Subject: **Global inventory of national marine operational observing systems**

The IOC is in the process of compiling an inventory of existing national marine operational observing systems (see Resolution EC-XXXI.9 from the 31st Executive Council meeting in Paris, November 17-27, 1998). The inventory will be used to help to identify observing systems which might be appropriate candidates for the Coastal and Living Marine Resources modules of GOOS, and to assist the Integrated Coastal Area Management (ICAM) programme in the design of supplementary marine monitoring projects. The landward marine limit includes beaches and estuaries. Such a global inventory does not presently exist.

The IOC would appreciate your help in obtaining information on the marine operational observing systems in your country (perhaps by passing on this letter on to the appropriate marine environmental, fisheries, hydrographic, meteorological or navigational authorities in your country). It should be stressed that we are only interested in information on parameters that are measured repeatedly for operational purposes. Short term scientific cruises and projects are not the focus of this inventory.

The following web pages provide an example of the information sought for the inventory:

The World Meteorological Organization has compiled a global inventory of meteorological stations (see http://www.wmo.ch/ goto fields WWW, On-line data and info, operational publications, Volume A, flat file of observing stations).
An inventory of fixed physical/chemical monitoring stations in the North Sea can be viewed at http://www.minvenw.nl/projects/seanet/

The Danish National Environmental Research Institute carry out 5-8 cruises yearly in Danish waters at a fixed set of stations in Danish waters in order to monitor the marine environment
(http://www.dmu.dk/MarineEcologyandMicrobiology/CruiseReports/index.htm)

The ICES International Bottom Trawl Survey (IBTS) is an international survey conducted each year in the North Sea since 1970 which provides an annual index of fish abundancebyICES Statistical Rectangle. Please see http://www.ices.dk/committe/rmc/ibtswg/ibtswg99.pdf for the 1999 report of this survey.

The Sir Alister Hardy Foundation for Ocean Science monitor the near-surface plankton of the North Atlantic and North Sea on a monthly basis, using Continuous Plankton Recorders on a network of routes in the area. Please see
http://www.npm.ac.uk/sahfos/introduction.html for further information.

(Examples of monitoring parameters are listed in the appendix).

For the inventory we are interested in information on:

- location (latitude, longitude) of the observations;
- which parameters are measured and what methodologies are used;
- the temporal frequency of observations (daily, weekly, monthly, seasonal, etc.)
- when the time-series was initiated
- contact person for each observing programme (name, address, telephone, e-mail)

We would prefer to get this information in digital form (tables or spreadsheet). **Any actual datasets should not be submitted.**

IOC is aware of other programmes like LOICZ, GLOBEC and EuroGOOS which are in the process of or have compiled inventories of marine monitoring information for different purposes or regions. We are in close contact with those programmes and will consider the already available information to the fullest extent possible.

The inventory will be made available to all interested parties via the Internet.

Please e-mail information to Thorkild Aarup (t.aarup@unesco.org) and Ned Cyr n.cyr@unesco.org), or mail diskettes to them at:

IOC/UNESCO
1, rue Miollis
75732 Paris cedex 15
France

Note that the deadline for submissions to the inventory is 31 October 1999.

Thank you very much.

Yours sincerely,

Patricio Bernal

Executive Secretary IOC

CODE LIST OF DATA TYPES FROM ROSCOP

PHYSICAL OCEANOGRAPHY

H71	Surface measurements underway (T,S)
H13	Bathythermograph drops
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T, S)
H72	Thermistor chain
H16	Transparency (e.g. transmissometer)
H17	Optics (e.g. underwater light levels)
H73	Geochemical tracers (e.g. freons)
D01	Current meters
D71	Current profiler (e.g. ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys
D06	Neutrally buoyant floats (ALACE, PALACE)
D09	Sea level measurements (including bottom pressure recorders and inverted echo-sounders)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements (e.g. HFradar, Airborne remote sensing, SeaSoar, Yo-Yo, etc.)

CHEMICAL OCEANOGRAHY

H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total-P
H24	Nitrates
H25	Nitrites
H75	Total-N
H76	Ammonia
H26	Silicates
H27	Alkalinity
H28	pH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

CONTAMINATION

P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements

BIOLOGY & FISHERIES

B01	Primary productivity
B02	Phytoplankton pigments (e.g. chlorophyll, fluorescence)
B71	Particulate organic matter (e.g. POC, PON)
B06	Dissolved organic matter (e.g. DOC)
B72	Biochemical measurements (e.g. lipids, amioacids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs/larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fishery measurements
	Bottom type/substrate
	Coral reefs
	Submerged aquatic vegetation