Oceanography Committee

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REPORT OF THE

ICES/IOC STEERING GROUP ON GOOS

Southampton, UK
23–25 October 2000

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 INTRODUCTION

The Chair (R. Saetre, Norway) welcomed members to the meeting. Apologies were sent by the IOC co-Chair (M. Sinclair, Canada). W. Turrell (UK) was appointed as rapporteur. The participants were welcomed by N. Flemming (EuroGOOS) who gave a brief introduction to the venue, the Southampton Oceanography Centre. The participants to the meeting are listed in Appendix 6 and the agenda is in Annex 7.

2 BACKGROUND AND TERMS OF REFERENCE

An ICES Steering Group on GOOS (SGGOOS) was formed in 1997 in order to prepare an action plan as to how ICES should take an active and leading role in the further development and implementation of GOOS at a North Atlantic regional level, with special emphasis on operational fisheries oceanography. The group reported to the 86th Statutory Meeting (1998) recommending that ICES should initiate a regional GOOS component and that a Workshop should be convened to take these ideas forward. The Workshop took place in 1999 in Bergen, where a draft Design and Implementation Plan was conceived.

This had three essential components:

1) To promote global / regional linkages in a GOOS context
2) To promote the ICES Annual Ocean Climate Status Summary as a contribution to GOOS in cooperation between ICES member states and regional agencies such as EuroGOOS
3) To design and implement a regional component of GOOS in the North Sea, focussing on ecosystem dynamics with a special emphasis on the needs for improving the management of fish stocks. In this context, the Bergen workshop proposed to develop concrete plans for establishing networks of operational fisheries oceanography for the North Sea, referring to this as a regional ICES-GOOS ecosystem component for the North Sea.

In order to develop these suggestions further the Steering Group was reconstituted in 1999 as a joint ICES/IOC Steering Group on GOOS with R. Saetre-ICES and M. Sinclair-IOC as Chairs. The terms of reference for this group are to develop the ICES-GOOS Programme Implementation Plan described in the report of WKGOOS (C.M. 1999/C:14) including:

i) development of co-operative arrangements to enhance mutual awareness with IOC and EuroGOOS;
ii) develop an ICES-Ocean Observing System (I-OOS) based on the ICES Ocean Climate Summary and other relevant products and to find ways to produce and tailor products exploiting the results of the ICES Ocean Observing System;
iii) desirability and possible ways to establish a co-ordinated and harmonised observation network and design a system for operational oceanography on appropriate time scale for the North Sea(in co-operation with EuroGOOS);
iv) develop and oversee the role of the North Sea IBTS quarterly surveys in the Initial Observing System of GOOS, and liase with and report to GOOS bodies as appropriate;

b) advise and support the Secretariat on GOOS-related matters;
c) define and promote the role of ICES in GOOS taking into account input from ICES Advisory and Scientific Committees
d) identify a programme of workshops to facilitate the implementation of ICES-GOOS and to improve awareness of GOOS in ICES, including special sessions at the ICES Annual Science Meeting
e) identify those IOC-GOOS design panels and committees of relevance to ICES-GOOS with a view to proposing the appropriate ICES representatives at these meetings, with the approval of the ICES Council, and to prepare the briefs for these representatives.

The objective in broadening the original ICES Steering Group on GOOS into a joint ICES-IOC body was to ensure that, in considering how it might best contribute to and benefit from GOOS in the North Atlantic area, ICES also received the best possible advice from the international GOOS organisation and from EuroGOOS. Using text from the Bergen report, the ICES Resolution therefore requires that 'ICES should also invite representatives of appropriate regional GOOS bodies such as EuroGOOS to participate'. It goes on to note in justification that an ICES-EuroGOOS co-operation is expected to design common plans for development of operational oceanography to support the management of living resources, coastal areas, and health of the ocean and to increase the understanding of climate change. It was in part to ensure close collaboration between EuroGOOS and the ICES-IOC Steering Group on GOOS that the first meeting of that body was hosted by EuroGOOS in Southampton.

3 BACKGROUND INFORMATION

The meeting commenced with a series of presentations, which supplied relevant background material.

3.1 Cooperation and Interaction Between ICES, IOC (GOOS) and EuroGOOS

GOOS is a global project with regional sub-components established in some parts of the world. EuroGOOS is such a regional GOOS component and includes all the European adjacent seas, the northern Mediterranean, the eastern Atlantic and the adjacent Arctic. ICES has members from northern Europe and North America.. To get the best out of both the EuroGOOS Association of agencies with their primarily physical focus, and of ICES agencies with their primarily biological/fisheries focus, it is necessary for ICES and EuroGOOS to collaborate in northern European GOOS developments, to share data, and to exploit the potential for synergy between them, while each specialising in the kind of product generation in which they hold appropriate expertise. This linkage should be facilitated by the fact that ICES has been an Associate Member of EuroGOOS since its foundation in 1994, and attended the pre-foundation planning meetings.

Dr N. Flemming (Director EuroGOOS) made a presentation on the status of and plans for EuroGOOS. From a EuroGOOS perspective, the actions which are needed to establish the basis for collaboration with ICES may be defined from consideration of the following questions:

i) What observations, measurements, and data products generated by EuroGOOS, and which are not measured or processed by ICES, would be useful to ICES?

ii) What observations, measurements, and data products generated by ICES, and which are not measured or processed by GOOS, would be useful to GOOS?

iii) What observations, measurements, and data products generated by ICES, and which are not measured or processed by EuroGOOS, would be useful to EuroGOOS?

iv) Are there any redundant observational programmes or measurements which are being duplicated by ICES members and EuroGOOS members?

v) What new observations, measurements and data products are required, which are presently being obtained by none of the three bodies, and which would be of mutual advantage, and which could be planned collectively?

Since several national agencies are simultaneously members of both ICES and EuroGOOS, or are members of national ICES and EuroGOOS Working Groups and Committees, many observations are already available to both organisations.

EuroGOOS is subdivided into sub-areas including the North Atlantic, the Mediterranean, the Baltic, the Northwest Shelf, and the Arctic, and has interests in the Black Sea. EuroGOOS has already published its plans for the Baltic Operational Oceanographic System (BOOS), and has begun drafting plans for a Northwest Shelf Operational Oceanographic System (NOOS), which includes the North Sea. The draft NOOS report was made available to meeting participants.

EuroGOOS has a well-defined approach to the development and application of operational oceanography. This involves a cycle commencing with customer needs research, cost/benefit analysis, underpinning scientific research, development of necessary technology, trials, implementation of operational modelling, introduction of forecasting, product design, and finally customer use. The EuroGOOS membership is particularly strong in operational modelling, particularly through the participation of several European Meteorological agencies. In April 2000 ICES and EuroGOOS collaborated in the organisation of a joint Workshop on Bio-ecological observations in operational oceanography, held at the RIKZ in the Netherlands. The participants at this Workshop supported the policy that bio-ecological modelling was approaching the status of operational capability. The draft report of this workshop was provided to participants at the SOC meeting, and more details were presented by Dr J. Fischer (Section 3.6).

When considering cost/benefit analysis of operational oceanography, it should be noted that within Europe, despite the vast public good benefits to society, operational weather forecasting routinely achieves a cost recovery of the order of 3–10% through direct commercial sales of data. Operational oceanography cannot therefore be expected to achieve a high percentage of cost recovery, but will provide great benefits to society and many industrial sectors, particularly by its contribution to climate change prediction and impact assessment. EuroGOOS is presently preparing a summary of the pre-operational research it has performed since its formation in 1994.

EuroGOOS is also involved in the cataloguing and development of relevant new technologies, such as moored instrumentation and AUVs, operational satellite observations of the ocean, profiling floats, and other systems of use to establishing operational observing systems. EuroGOOS has catalogued existing operational models in the EuroGOOS area, and has examples of potential products from such models.

In "Forward Look" assessments, EuroGOOS has identified the following key activities:

1999–2002

1) Development of regional and Atlantic operational systems and services.
2) Support for ecosystem modelling and operational development.
3) Agreement over EuroGOOS real time Data sharing policy.
4) Development of self-funding status for EuroGOOS.
5) Development of national operational projects.
6) Application for FP5 support for pre-operational development projects.

2003–2008

1) Development of high resolution operational real-time services in the Mediterranean.
2) Expansion of forecast variables to include nutrients, water quality and ecosystem parameters.
3) Development of fully operational ocean basin and shelf edge models.
4) Development of strong regional seas operational systems such as BOOS, MSF, NWSTT.
5) Expansion of the network of deployed ocean profiling floats and time-series from fixed stations (ARGO, GODAE etc).
6) Development of greatly increased computer modelling capacity and high data rate real time networks.
7) Development of ocean satellite missions scheduled on an agreed programme at European level.
8) Development of fully functional real-time data sharing agreement
9) Development of agreements to deliver products to non-research directorates and European agencies.

During discussion of EuroGOOS it was noted that the OSPAR and HELCOM Commissions, as key customers, must be involved in regional GOOS developments. However, many such intergovernmental organisations have been slow to develop policies in step with the rapid developments within operational oceanography, and ecosystem approaches to management. Many international conventions were formulated after the 1972 Stockholm meeting, and were then based on single species, single discipline approaches. All are aware of the need for change, and this is now occurring. Within OSPAR and HELCOM change is presently being planned, and it is therefore timely for ICES and EuroGOOS, with the help of the IOC where appropriate, to be considering how to take GOOS initiatives forward in the North Atlantic and northern Europe.

There is the potential for significant savings or efficiency increases to be obtained, by observing systems being used to support multiple customers. Operational modelling can be used to assimilate observational data, and use this data to provide enhanced value-added products for a variety of customers. N. Flemming drew participants' attention to the real-time displays available on the PC in the meeting room where it was possible to view real time data and forecasts based on models for the Mediterranean and the Baltic. These products are provided by the EuroGOOS Regional Task Teams.

3.2 The Strategic Design Plan for Living Marine Resources and for Coastal GOOS

C. Summerhayes, Director of the GOOS Project Office in the IOC, explained that the structure of GOOS was being consolidated, with the three advisory panels dealing mostly with coastal seas being integrated into one. As of mid November 2000, the Living Marine Resource (LMR), Health of the Oceans (HOTO), and Coastal (C-GOOS) advisory panels of GOOS would combine to form COOP, the Coastal Ocean Observations Panel of GOOS. The natural counterpart to COOP would be the OOPC (Ocean Observations Panel for Climate). This would give GOOS an open ocean remit, where both observations and potential user interests were relatively sparse, and a coastal remit, where both observation density and user interests were relatively high.

COOP's members were a subset of the membership of the former LMR, C-GOOS and HOTO panels, with the addition of some new members to cover gaps not previously dealt with by these three panels. One of these gaps was nearshore/coastal fisheries (as opposed to those of the continental shelf, which were well-covered by LMR).

COOP would have its first meeting in the week of November 13-15 in Costa Rica. It would begin with a User's Forum, at which users' interest would be represented by members of the various National GOOS Coordinating Groups, and of the regional GOOS groups, like EuroGOOS.

In preparation for COOP, the three former panels had each drawn up a strategic design plan to offer guidelines on implementation. Two of these three plans - LMR and C-GOOS - were made available to the meeting participants beforehand. Executive summaries of both are presented in Appendix 1 and 2 respectively. All three plans would be published in hard copy by the IOC and placed on the GOOS web site. One of the main tasks of COOP would be to integrate these three separate plans into a comprehensive design for observations of coastal seas, coastal meaning everything from the shoreline across the continental shelf and out over the continental slope.

C. Summerhayes thanked ICES for its involvement in the development of the design plan for LMR GOOS, noting that in order to assist the ICES-IOC Steering Group on GOOS to contribute to and benefit from GOOS, the IOC had recommended that M. Sinclair from the LMR-GOOS Panel be invited to co-chair the group. He expressed his thanks to the Bedford Institute of Oceanography for making available the services of K. Swanenberg as a short-notice replacement for M. Sinclair on the Group.

3.3 GOOS and Climate

C. Summerhayes went on to explain that GOOS now exists in concrete form as an Initial Observing System (GOOS-IOS), which includes several coastal components, such as the Global Coral Reef Monitoring Network (GCRMN), the California Cooperative Fisheries Investigations (CalCOFI), the ICES International Bottom Trawl Survey (IBTS), and the Global Sea Level Observing System (GLOSS), as well as other biological components (such as the Continuous Plankton Recorder Programme - CPR), plus a range of physical observations mostly from the open ocean by ships, buoys, drifters, floats and satellites.

In the open ocean, GOOS is being developed especially through the Argo float programme, which is part of the Global Ocean Data Assimilation Experiment (GODAE). Argo will seed the ocean with 3000 floats between 2003 and 2005, to provide the first ever global coverage of the temperature and salinity of the upper ocean, as a complement to global satellite coverage of the ocean surface. Integrating the satellite and Argo data into global numerical models would provide a comprehensive test of the viability of GOOS for forecasting weather and climate globally, and for providing the boundary conditions needed for regional numerical models of shelf seas.

GODAE and Argo are key projects of the OOPC. Updates on the GODAE and Argo programmes can be seen on the GOOS web site (http://ioc.unesco.org/goos/gsc4_d12_GODAE.pdf). General information on GODAE and Argo can be obtained at:

http://WWW.BoM.GOV.AU/bmrc/mrlr/nrs/oopc/godae/homepage.html
and
http://WWW.BoM.GOV.AU/bmrc/mrlr/nrs/oopc/godae/Argo_Design.html

Several of the design features for the open ocean component of GOOS, related especially to numerical weather prediction and climate forecasting, have been published on the GOOS web page (http://ioc.unesco.org/goos) under the heading: GOOS Implementation, in a report entitled "Global Physical Ocean Observations for GOOS/GCOS: an Action Plan for Existing Bodies and Mechanisms", which was produced in 1998. Since it appeared, GOOS and CLIVAR jointly sponsored a workshop in St Raphael (October 1999) on ocean observations for climate. At that meeting the research and operational communities reached consensus on what observations were required to provide the information needed for both climate forecasts and climate research. Their recommendations for the climate observing system are published on the Internet at (http://WWW.BoM.GOV.AU/OceanObs99/Papers/Statement.pdf).

In addition, consensus was reached in June 2000 between the *in situ* ocean observing community and the remote sensing community as represented by CEOS, the Committee on Earth Observing Satellites. Both are members of the Partnership for an Integrated Global Observing Strategy (IGOS-P). In order to focus their efforts, and to be more cost effective through working together, the partners are developing a series of themes on key environmental topics. The first of these is the Oceans. An Oceans Theme document has been prepared indicating consensus on what are the main challenges for implementing an operational observing system involving both in situ and satellite measurements, and for the research to provide new measurements. The Oceans Theme document is available on the Internet at (http://www.unep.ch/earthw/IGOS-Oceans-Final-0101.pdf).

In order to improve the collection, processing and dissemination of ocean data for operational purposes, IOC and the WMO have brought all of their previously existing ocean observing subsystems together under a common umbrella, the newly formed Joint IOC/WMO Technical Commission for Oceanography and Marine Meteorology, JCOMM. For the moment JCOMM (which has its first full scale intergovernmental meeting in June 2001, in Iceland) covers physical observations. But the door is open to the inclusion of biological and chemical measurements as demand for these grows. JCOMM will ensure a more cost effective delivery of operational oceanographic data through the integration of existing subsystems and plans.

GOOS is also being actively developed at the regional level. EuroGOOS is well advanced, and there is a maturing regional GOOS body covering the seas in the N.E. Asian Region (NEAR-GOOS). In addition there are new regional GOOS bodies for the Caribbean, Mediterranean, Pacific Islands, Baltic (within EuroGOOS), and western Indian Ocean. There are further developments afoot to cover the entire Indian Ocean, the southwest Atlantic and the southeast Pacific. PICES has an interest in a North Pacific GOOS. And there are tropical observing arrays in place in the Pacific and the Atlantic. There are still big gaps in the Southern Ocean and the Arctic.

In addition, several countries are developing their own national GOOS programmes in line with the GOOS Principles (published on the GOOS web site). The IOC would like to see all coastal states have a National GOOS Coordinating Committee or similar body to facilitate this process. This body should interact with users to ensure that GOOS was built as an end-to-end system starting from the products that the users required, and leading back from that to the observations needed to satisfy the requirement.

Key users were the UN Conventions and Action Plans, such as the UN Framework Convention on Climate Change, which was now asking all of its Parties to contribute action plans indicating how they were contributing to climate monitoring (including ocean measurements).

In response to particular questions, C. Summerhayes noted that GOOS was in the process of finalising a data and information management strategy that all future partners in GOOS would find useful. GOOS was also in the process of finalising a mechanism to facilitate the contribution of observations, e.g., from organisations like CPR, or from individual countries.

3.4 The Canadian Approach to LMR-GOOS

The Canadian Contribution to LMR GOOS aims to provide operationally useful information on changes in the state of living marine resources (organisms) and ecosystems to those concerned with the harvest, conservation, and scientific investigation of marine organisms of the deep ocean and shelf seas. In order to achieve this it requires a comprehensive ecosystem and environmental observational programme which identifies variables and parameters of importance for detection of change in structure, behaviour and biodiversity, including the state of fishery resources.

The Canadian LMR GOOS programme has a set of monitoring principles and approaches. Monitoring is defined as repeated (usually regular) and sustained observations over the long-term. The programme recognises that monitoring must encompass critical abiotic properties as well as biological ones. The biotic and abiotic components of ecosystems are inherently dynamic exhibiting regular cyclical as well as random changes. Therefore it is important to define what type of change is being sought and how to differentiate it from natural background noise.

Discerning directional changes and perturbations of cycles from regular normal change, and attributing cause to those changes are essential especially for developing mitigative or adaptive responses to the changes. Hence the general approach of LMR programme is to:

- Detect changes in state rapidly
- Define the spatial and temporal domain being monitored
- Define the indices and products
- Establish a data management strategy

In order to achieve these aims, the program has established six Ecosystem Objectives and Indicators:

- Maintenance of ecosystem diversity
- Maintenance of species diversity
- Maintenance of genetic variability in species
- Maintenance of exploited species
- Maintenance of non-exploited species
- Maintenance of emergent properties of ecosystems

In terms of the maintenance of ecosystem diversity, for benthic habitats this involves assessing the spatial extent of disturbance for each category of benthic habitat and mapping benthic community properties in undisturbed areas. Benthic communities are presently the least understood, especially with respect to invertebrates. The objective is that some proportion of each habitat type should remain undisturbed. For pelagic ecosystems, pelagic components inhabit a larger geographic scale (i.e., plankton and Longhurst areas; large pelagic fishes and ocean basins). It is important that the degree of interaction between the pelagic and benthic components is determined. For the demersal ecosystem components demersal fish and invertebrates are intermediate between the benthic and pelagic communities and are likely to be more closely linked to them. Maintenance of species diversity requires the determination of which species being monitored are at risk of extinction. Indicators are then developed for those at risk and for recovery plans, based upon the rate of population change, the change in geographic distributions, the number of spawning components, the effective population size, other population characteristics (age at maturity etc), the integrity of essential habitat and by-catch mortalities (in fishing and other human activities).

Maintenance of genetic variability within species, is particularly relevant for exploited species to determine and prevent loss of spawning components and genetic variability. Indicators include the population size (total and effective), the number of populations, the number of progeny per parent, the sex ratio in populations, the selection differential for size at age / maturity at age, evolvability, co-evolution and nearest neighbour estimates for sessile invertebrates.

Maintenance of exploited species can employ many classic indicators (stock size/exploitation rate / recruitment rate/etc). However, new indicators include size composition, growth rate, condition, spatial distribution (prevalence vs. density), stock reproductive potential, predator abundance, prey abundance, spatial distribution of fishing effort / other significant activities, and the amount and fate of discards.

Non-Exploited Species (NES) are classified as not impacted by exploited species, or by-catch with, prey of, predator of or competitor with exploited species. There is a requirement to maintain the abundance of prey NES at levels above those needed to account for other trophic requirements in the system (CAMLLAR).

The maintenance of Emergent Ecosystem Properties (EEP) is more controversial with less theoretical grounding. EEPs are parameters such as indices of diversity / dominance, the slope of the size spectrum within groups, the FIB Index (Pauley), and aggregate removals by fishing at each trophic level.

In order to achieve the six objectives of the LMR program, there are required additions to the present monitoring performed in Canada (east). These include the identification of benthic communities, targeted surveys for species at risk and by-catch for species at risk (by-catch spectra), surveys of numbers and locations of spawning populations for exploited species, determination of selection differentials and sex ratios for exploited species and condition and abundance of selected predators on forages species. Improved monitoring of phytoplankton (primary producers), zooplankton (secondary producers), benthic organisms and forage species is also needed.

In addition to the increased monitoring, there are research needs in support of the monitoring. A key challenge is to assign causes to the observed effects. Questions such as what proportion of the change observed is the result of natural environmental variability and what is due to human activities including fishing require to be addressed.

As well as research, data integration from all aspects of LMR monitoring will be the key to success. Regional Analysis Centres will benefit from global perspectives allowed from data integration at this level.

3.5 A Retrospective Analyses of the Atlantic Canadian Monitoring During the Cod Collapse

Monitoring which is presently in place in Eastern Canada includes

- Fishing effort by gear and location (geo-referenced)
- Landings by species and location

- Size and age composition of landings
- Fishery independent trawl surveys (commercial and non-commercial fish and invertebrates) at various seasons of the year including detailed hydrographic observations at fishing locations)
- Air pressures
- Air temperatures
- Geostrophic wind
- Freshwater inflow
- Ocean features (Eddies, Gulf stream and slope boundary positions)
- Ice / Iceberg locations
- Monthly SST from SOO
- Halifax SST
- Sea level

This ecosystem monitoring program was in place (with some organismal groups excepted) during the cod collapse. Even with the bulk of the ecosystem monitoring program in place, the causes of the significant changes which occurred in the late 80s through 90s were not predicted, and have not yet been determined.

Several points arise when considering why this was so. Data collected through the monitoring program in place were sufficient to describe the changes in biotic and abiotic conditions. However, analyses were not sufficient to describe these in a timely manner. The theoretical framework was (is?) lacking to interpret these changes with regard to causes or with regard to predicting future states.

What is needed in order to address these problems are timely analyses of the full range of ecosystem monitoring data, and the generation of accurate data products, and institutional structures that generate and review the data products for management needs.

There is a potential role for ICES in LMR monitoring. ICES could support the concept of Regional Analysis Centres and co-ordinate their work in the ICES arena through Working Groups, develop data products from ecosystem level monitoring through Working Groups, and support ecosystem level data integration within the ICES arena and within the global community.

3.6 Report From the EuroGOOS/ICES Workshop on Bio-ecological Observations in Operational Oceanography (Den Haag, April 2000)

The report from the EuroGOOS/ICES Workshop on Bio-ecological Observations in Operational Oceanography (Den Haag, April 2000) was presented by J. Fischer (Germany) and its summary, introduction and recommendations are presented as Appendix 3.

Workshop Sessions

The Workshop was organised in four sessions. Session 1 focussed on users of bio-ecological products and their data requirements. The main discussion topics were impact indicators. There is a need for the harmonisation of definitions used, the development of new indicators, and the improved reporting of indicator monitoring to the EEA. A second topic was the development of an ecosystem approach to fish stock assessment. Here data types had to be determined. Primary productivity and extreme conditions in particular had to be considered, as well as the improvement of sampling bottom variables (e.g., oxygen). A third discussion topic concerned the users of biological operational oceanographic product. Again data requirements had to be determined, and contact with users had to be improved. There is a requirement to educate users in terms of what operational oceanography can provide, and there is a need for stakeholders to be involved in data collection in order to reduce costs.

The second session addressed sampling and the assessment of marine communities and processes. Main discussion topics included *in situ* sampling, where the points considered were autonomous samplers and analysers (optical and acoustic), sampling for phytoplankton composition, fish and benthos sampling, standardising sampling methods, determining the frequency and accuracy of measurements and linking *in situ* sampling with user needs. Remote sensing was discussed, and the session considered ways of integrating observational strategy with *in situ* data, and ways of improving the assessment of primary production.

Session three focussed on the long-term monitoring of ecosystem health. In terms of ecosystem health, there is a need to define what this means for each system individually. There is also a requirement to improve communication on this issue with politicians, and to improve the public awareness of the issues involved. Toxic algal blooms require early detection and their taxonomy to be determined. Eutrophication and pollution require the operational monitoring of nutrients, and the development of impact indicators, such as bioassays. In order to determine the impact of climate change, long-term observations are required, aided by improved data networks and augmented by using existing data through data mining techniques.

The final session addressed ecosystem modelling. Existing operational ecosystem models have been demonstrated in case studies (e.g., COHERENS, POM, ERSEM). There is a need for additional data in order to model the benthic-pelagic coupling, and to calibrate and validate 3-D ecological models. Future trends in ecosystem modelling will include addressing long-term ecosystem evolution, improved cooperation between modellers, and the development of integrated models, which combine natural and socio-economic processes.

Recommendations

The recommendations reached by the Workshop (see Appendix 3 for full recommendations) may be summarised as follows:

User involvement - user surveys needed, along with improved interaction with stakeholders.

Biological Monitoring Technology - biosensors need to be developed and improved. Methods require standardisation, and in situ time series are needed for the calibration of remote sensing.

Fish Stock Assessment - variables and models needed to describe and predict fish distribution and abundance should be identified, and a relevant monitoring strategy determined. Spawning areas should be monitored, and more attention should be paid to non-commercial fish.

Sampling Strategy - an integrated sampling strategy is needed, using operational bio-ecological models to determine type and resolution of variables required. The frequency and accuracy of biochemical measurements must be balanced against user needs. Existing data bases should be better used, as should smart moorings and ship of opportunity automatic sampling.

Impact Indicators and Pollution - common definitions of important impact indicators are needed. Existing indicators can be improved, and new ones developed. Indicators may be supplemented by the raw data itself. Local transport patterns for contaminants need to be determined.

Long-term Databases - long-term databases are needed in the Mediterranean and Black Sea. The systematic collection of biological data by national and international agencies is required, and data access should be facilitated. A repository for data analysis software is needed, and the Continuous Plankton Recorder programme must be continued.

Data Analysis - Virtual data analyses centres should be established, along with quality criteria for parameters, methods, processes and model results.

Modelling Requirements - Models need to be standardised. Shared models should be developed, with better cooperation amongst modellers. Models require high frequency data for calibration and validation, and new models are needed to meet user needs. Nested models can be used at different scales. Benthic processes and benthos-pelagic interactions require an improved understanding.

Products - The visualisation of data analysis and model results should be emphasised, and possible products listed.

Recommendations of Relevance to ICES

A number of the recommendations have specific relevance to ICES, and may require action by ICES:

1b Prepare a summary report listing all marine bio-ecological variables and indicators suggested for operational use: ICES science committees (Oceanography, Living Resources, Marine Habitat) should identify Working Groups to compile such a list, taking into account the past work of LMR, Coastal and HOTO GOOS modules, and all relevant GOOS and EuroGOOS documents and workshops.

1b National Governments should be influenced to a greater acceptance of coordinated international monitoring programs: The ICES North Sea workshop discussed later in the meeting will be a pilot in which national contributions will be required.

1c The contribution of stakeholders to sampling and monitoring should be used to reduce costs.

3b Once ecosystem variables have been established, EuroGOOS and ICES should cooperate to determine a monitoring strategy: The ICES-GOOS Programme component in the North Sea should address this issue. Monitoring was discussed at the Environmental Dialogue meeting. ACME will also take this issue forward.

3c A 3 year ichthyoplankton survey in European Seas is performed: ICES is already considering such a survey. It is suggested that this proposal of the workshop is rewritten in collaboration with the ICES GLOBEC office.

5d Progress should be made in revealing local transport patterns: The new Study Group in Biophysical Modelling will focus on such issues. OSPAR has also started a relevant initiative, coordinated by E Svendsen (Norway).

General Points: EuroGOOS / ICES collaboration could be enhanced by EuroGOOS sending representatives to ICES Working Groups. ICES Science Committees should consider how best to take the recommendations of the Workshop forward, to develop real work programmes, and identify gaps which research projects should address.

In the discussion which followed this presentation it was noted that the lack of homogeneity in biological data was a common problem, and made merging data from different sources difficult. There was also a difficulty with defining key parameters for each area individually, while at the same time allowing between-area comparisons to take place. Although biological data does pose more difficulties than physical data, it can all be geo-referenced, and modern hierarchical data structures allow transparency to the user.

It was noted that biosensors and biofouling were to be a key topic at a forthcoming EuroGOOS meeting. The importance of involving stakeholders in sound, statistically designed surveys was emphasised by the participants.

3.7 The European Directory of the Initial Ocean Observing System (EDIOS) as a Thematic Network

W Lenz (Germany) presented the EDIOS project, which is a proposal to the EU FP5 program, submitted for the second time, with the overall aim to create an electronically accessible directory of all routine and repeated stations or sections making operational oceanographic observations in European and Mediterranean waters. Each entry in the directory will show the geographical location, observing platform type, instrumentation, variables measured, and the institution or archive where the data can be obtained. The University of Hamburg is coordinator, and institutes from Germany, Greece, UK, France, Italy, Norway, Sweden and Holland form the partnership. The proposal is to develop regional co-ordinators to assist in the gathering of the meta-data, and these people will be responsible for contacting the agencies who deploy routine observation systems in their area. The inventory will provide a summary of observation stations currently available, for an initial GOOS observing system. The project is organised into 8 Work packages addressing user identification, sensor categorisation, and user questionnaire, regional metadata acquisition, data assembly, visual user interface development, classification of metadata, products and data dissemination and future planning. One product will be a web-based inventory of data acquisition systems, accessible through a map-based system. The completed directory will be made available to GOOS as part of the Initial Observing System.

The meeting noted this development, and endorsed its aims.

3.8 A Profiling Moored Instrument Carriers with Quasi On-Line Access to the Collected Data

C Waldmann (Germany) presented a proposal for moored profiler. The meeting acknowledge the information (Appendix 8).

4 DEVELOPMENT OF IMPLEMENTATION PLANS

4.1 Development of Cooperative Arrangements to Enhance Mutual Awareness with IOC and EuroGOOS

The Steering Group recalled the Draft ICES Implementation Plan for GOOS which was originally presented in the Report of the Workshop on GOOS (CM 1999/C:11). This Plan, slightly modified on the basis of the discussion held at this meeting, is reproduced as Appendix 11

The Steering Group reviewed progress in the implementation of the first element of the Plan, i.e., global and regional linkages. The following points were noted:

◊ Links between the relevant national representatives to GOOS and the members of the Steering Group remained poorly developed, which means that ICES interests are not being conveyed to the various GOOS Committees at national, regional and global levels. One mechanism to improve communication is to start a networking process that gets the national IOC-GOOS representatives in contact with the national representatives of ICES on the Steering Group. To achieve this EuroGOOS (for Europe) and the GOOS Project Office (for North America) will send to the ICES Secretariat the contact details for GOOS national representatives to be passed to the national ICES-GOOS programme representatives on the Steering Group, with a request that contact be made; similarly, ICES will send to the GOOS Project office and EuroGOOS the contact details for the ICES-GOOS programme national representatives on the Steering Group to be passed to the national GOOS representatives, with a similar request. It was also noted with regret that membership of this Steering Group was limited to only a few of the ICES Member Countries in spite of the fact that an appeal for additional members had been made to ACME participants. We will use the networking process to appeal to countries to participate in the Steering Group.

◊ It was agreed that the inter-secretariat consideration of ”capacity building” was of sufficient importance to be listed as a separate element of the Plan.

◊ It was agreed that in the immediate future ICES should be represented at the following forthcoming GOOS meetings: (i) the first meeting of COOP (Nov 2000); (ii) the 4th meeting of the GSC (March 2001); (iii) the5th I-GOOS meeting (June 2001), with the ICES representative being chosen from among the participants who will attend the meetings, or from the ICES Secretariat. It was also agreed that consideration should be given to inviting EuroGOOS and/or the GOOS Project Office to attend the annual meetings of the Advisory Committee on the Marine Environment, and/or the Oceanography Committee, as appropriate.

◊ With regard to the participation of regional GOOS groups, it was noted that the western Atlantic was represented at this meeting by Canada alone. In future efforts should be made to ensure participation of the USA as well in order to balance European participation.

4.2 Develop an ICES Ocean Observing System (I-OOS) Based on the Ocean Climate Status Summary

The discussion commenced by a summary of the present arrangements for the ICES Annual Ocean Climate Status Summary (IAOCSS) presented by W. Turrell (UK). The IAOCSS as it presently stands summarises results from a sub-set of the ICES Standard Stations and Sections, an informal grouping of regularly repeated full-depth, mainly oceanic hydrographic stations and sections carried our by national members of the Working Group on Oceanic Hydrography. Presently 12 regions within the ICES area are represented. These are, with relevant ICES member countries:

1) W Greenland (Denmark)
2) NW Atlantic (Canada)
3) Icelandic Waters (Iceland)
4) Bay of Biscay and Eastern Atlantic (Spain)
5) Rockall Trough (UK)
6) Faroe Bank Channel (Faroe)
7) NW European Shelf (UK)
8) Northern North Sea (UK, Germany, Norway)
9) Southern North Sea (Germany)
10) Norwegian Sea (Norway)
11) Barents Sea (Norway, Russia, Poland)

12) Greenland Sea (Germany)

All time-series are at least a decade in length, most are greater than 3 decades, 2 are longer than a century. The national efforts of Denmark, Canada, Iceland, Spain, UK (part), Faroe, Norway, Russia and Poland are from fishery institutes using fishery research vessels, and necessary ship time and staff resources are committed by the relevant authorities. However, many are only on a seasonal basis, some (e.g., Rockall Trough) are on an annual basis, and results are presented using a wide range of measurement, data processing and analysis methods. The sections presented also only represent a subset of the available regular, repeat hydrographic sampling performed by ICES member countries with some notable gaps such as from the Baltic region. A variety of data policies exist throughout the IAOCSS national data suppliers resulting in varied data dissemination, ranging from almost real-time dissemination of hydrographic data (e.g., Canada), through annual submission of data to the ICES data centre (e.g., UK), to no data submission to ICES.

In terms of developing product from the observations, up until 1998 results were summarised as lengthy appendices attached to the annual report of the Working Group on Oceanic Hydrography. However, this group recognised the value of the expert interpretation they developed from the original data, and wished these summaries to be more widely known and used. Hence a short, non-technical summary was prepared, and in 1998 was issued as a stand alone "flyer" produced by IMR Bergen (Norway) and distributed at the ICES ASC. In 1999 this was continued, and the IAOCSS was produced by the Marine Laboratory Aberdeen (UK). In 2000 the IAOCSS was produced by ICES, but was not distributed separately and returned to being an Annex of the Working Group on Oceanic Hydrography report. However, ICES also developed the web version of the IAOCSS, and this now allows the summary to be easily accessed and the detailed annexes from each sub-region downloaded in PDF format.

In the discussions which followed it was noted that the ICES Oceanographic Data Centre should be used as a Regional Data Centre for the ICES Standard Sections and Stations. Results from the Baltic could certainly be included in the IAOCSS. GOOS itself could be classified as a customer for the ICES Standard Sections and Station results. ICES was the principle customer for the IAOCSS itself, and that some fish stock assessment Working Groups already use such environmental status reports. Canadian data which underpins the NW Atlantic sub-regional section of the IAOCSS are already nominated as national contributions to GOOS. While the dissemination of climate status summaries such as IAOCSS via the web was needed, dissemination in paper form was also essential in order to reach the intended customers. In terms of timing of the production of the IAOCSS, it will always be a compromise, as stock assessments are continually occurring throughout the areas covered by the IAOCSS. The varied production methods for the IAOCSS will be solved in 2001 by its production as a Cooperative Research Report, and asked if the IAOCSS might appear as a joint ICES/IOC publication.

It was emphasised that while annual production of a climate status summary was good, the unique nature of the underpinning data, being repeat, full depth, oceanic sections, is the principle component of the work in a GOOS context, and that the data resulting from this network needs to be delivered in a near-real time manner. The IAOCSS is not a complete description of North Atlantic climate status, rather it is a summary of the ICES Standard Stations and Sections, performed by ICES for an ICES audience. The unique aspect is the underpinning network of observations, which could form an ICES Repeat Hydrographic Program, which would form one contribution to the understanding of North Atlantic Climate, and which would be of use to the wider climate research and operational ocean modelling communities.

These ideas were discussed further, and the underlying concepts were accepted. The work of the Working Group on Oceanic Hydrography should be focussed two ways; into the identification from the network of ICES Standard Stations and Sections of an ICES Repeat Hydrographic Program which would form part of a regional, multinational contribution to GOOS, and into the continued development of the IAOCSS into a product tailored for the ICES community, but which will also be of general interest to the wider community and public. Several members stressed that it is in the self-interest of the suppliers of data, and their national authorities, that they become a recognised part of a regional Repeat Hydrographic Program, because:

1) Local observations may be placed into a basin scale context, allowing better interpretation of local change.
2) Data providers can acquire enhanced assessment of ocean climate variables, and their variability, in their individual region when sparse data is assimilated into numerical basin-scale models.
3) The funding which supports the observations carried out by the ICES Standard Sections and Stations will form unacknowledged national contributions of relevance to the UN Convention on Climate Change, and hence this recognition will help member nations meet UN targets
4) If recognised as an internationally relevant regional observing system, funding for individual components could be better defended in the future.

In the context of rapid data submission in order to form a regional GOOS contribution, it was noted the ability of semi-automatic routines to extract sub-sets of modern CTD data for automatic transmission via the GTS. Software to do this could be made available to the Working Group on Oceanic Hydrography.

Generally there is a problem in many countries caused by different Governmental ministries being individually responsible for climate and fishery related concerns. This separation has resulted in data being collected for fishery customers not being utilised or acknowledged for the contribution, which they may make to climate studies or operational modelling. Appendix 4 presents the key international Conventions which many ICES member countries are signatories to, and notes the contribution ocean monitoring performed by ICES members make to these conventions.

Before progress may be made, the Steering Group decided that further work is required of the Working Group, ICES and IOC, thus;

It was recommended that:

1) ICES, with guidance from IOC, should develop a clearly defined and identified sub-set of the ICES Standard Stations and Sections, presently provided by national members to prepare the IAOCSS, into an ICES regional Repeat Hydrographic Program which will allow the ICES Oceanographic Data Centre to be a Regional Data Centre which rapidly collates and disseminates a low-resolution, preliminary data set targeted at the international GOOS/GCOS climate community and the North Atlantic operational modelling community.

In order to do this, it is recommended that:

i) The ICES Working Group on Oceanic Hydrography is asked to:

- Examine in detail the national data policies with respect to allowing the rapid-transmission data set to be submitted in a timely way to the ICES Data Centre
- Identify which of the ICES Standard Sections and Stations are already nominated as national contributions to GOOS
- Recommend to individual national authorities that those parts of the ICES Standard Sections and Stations which are not yet nominated are put forward as national contributions to GOOS
- Prepare a document which describes the set of national GOOS contributions which will form the ICES Repeat Hydrographic Program, for submission to I-GOOS in 2002, in time for I-GOOS to nominate the I-RHP as a contribution to both GOOS and to the Global Climate Observing System (GCOS).,
- Examine the Canadian example of rapid data transmission following monitoring surveys using software developed by IGOS, and the potential use of the Canadian data centre as a portal onto the GTS data network.

ii) IOC is asked to:

- Note the existence of the ICES Standard Stations and Sections, and the data product available as the IAOCSS
- Provide advice to the Working Group on Oceanic Hydrography and ICES Secretariat on preparing selected ICES Standard Stations and Sections as national contributions to GOOS
- Provide advice to the Working Group on Oceanic Hydrography and the ICES Secretariat on the preparation of a regional ICES Repeat Hydrographic Program in readiness for submission to the OOPC
- Examine ways of disseminating the IAOCSS to a wider audience, through its web site

iii) ICES Secretariat, in conjunction with the Oceanography Committee, are asked to:

- Review the ICES data policy with respect to the onward dissemination of data as rapidly as possible. Data should be flagged, after consultation with national contributors, as ‘essential’ (can be freely and rapidly passed on), or ‘additional’ (restrictions on dissemination).

2) ICES should develop further the IAOCSS as a data product produced by an ICES Working Group, for a mainly ICES customer base, but at the same time being openly available via the web.

The Working Group on Oceanic Hydrography, in order that the production of the IAOCSS becomes sustainable each year and is relevant to the core work of ICES now and in the future, is asked to consider how it might:

- Move towards a more regular and standardised submission of text and figures for the sub-regional paragraphs which appear in the IAOCSS, allowing its preparation to be more easily achieved

- Set a sensible deadline for the production of the IAOCSS which allows proper data analysis, while at the same time is timely for potential user needs
- Review the potential users within the Working Groups of the ICES Science and Advisory Committees and research their needs and requirements. This research may require the work of the Working Group on Oceanic Hydrography to be explained to key Working Groups and Committees (e.g., Working Group on IBTS), and feedback obtained
- Consider what additional data sources, whether from the ICES-based regular, repeated hydrographic observations or from the wider oceanographic community, may be used to enhance the IAOCSS.
- In the IAOCSS, to each year consider climate variability on a North Atlantic Scale, to examine how this relates to climate variability in shelf seas, to have regionally focussed assessments, and to make more clear linkages with fisheries ecology.
- Consider ways of permitting more frequent updating of the IAOCSS rather than on an annual basis.
- Consider closer partnerships with other Working Groups (e.g., Working Group on Cod and Climate Change, Working Group on Zooplankton Ecology) in order to link ocean climate with ecosystem variability and produce integrated status summaries.

(3) EuroGOOS is asked to:

- Collaborate with ICES to agree on identification of appropriate data sets which might be valuable in supporting the GODAE experiment in the North Atlantic
- Collaborate with ICES in developing efficient and mutually effective data transmission and exchange procedures within the appropriate conventions of IODE, GOOS and EuroGOOS data policies.
- Provide ICES with information of existing physical models (wind, waves, currents, sea surface temperature, temperature profiles, fronts, stratification, salinity, bottom currents, sea ice, suspended sediments, North Sea inflows from the Atlantic, etc.) in the North Atlantic and North West Shelf seas which may be useful to ICES Members.
- Consult with ICES on the design of model outputs from the North Atlantic and North West Shelf seas which will be of optimum value to ICES and national fisheries agencies.

In summary, the original concept, as expressed in the report of the Bergen meeting, of an ICES Ocean Observing System (I-OOS) based on the Ocean Climate Status Summary, has evolved. What is now being considered is the provision by ICES of valuable subsets of its climate relevant data for consideration as an element of the North Atlantic part of the ocean climate observing system that is the responsibility of the OOPC, and that is an integral part of both GOOS and GCOS.

4.3 A Regional Operational Observing System for the North Sea

R Saetre introduced this item. He reminded participants that at the workshop in Bergen 22–24 March 1999 organised by the ICES Study Group on GOOS (SGGOOS) it was recommended that 'ICES, in cooperation with EuroGOOS and other relevant partners……. establish a co-ordinated and harmonised observation network and design a system for operational oceanography on appropriate time scale for the North Sea'. This recommendation is qualified in section 6 of the Bergen report as follows: '….focussing on ecosystem dynamics with special emphasis on the needs for improving the management of fish stocks'. It is further qualified also in section 6 with the note that 'The workshop proposed to develop concrete plans for establishing networks of operational fisheries oceanography for the North Sea'.

A proposal by R Sætre that a Workshop in Bergen later in 2001 with the aim to agree on a strategy for the further development of a "Pilot North Sea Ecosystem GOOS Project" was presented to the Group. He explained that all institutions that carry out operational oceanographic activities in the region would be invited to participate, and relevant organisations should be invited to co-sponsor the Workshop.

In further elaborating his proposal R. Sætre pointed out that all the North Sea countries operate national monitoring and reporting systems for the marine environment where the end products contain elements of hind-casting, now-casting or forecasting. There is some co-ordination of the data collection within OSPAR projects, such as SeaNet and JAMP, and assessment reports have been worked out within the framework of OSPAR and the North Sea Conferences. However, no attempt has been made to establish a permanent integrated information system to obtain the synergetic effect of all the national activities, especially with regard to ecosystems, fisheries, and health of the ocean issues.

In the Statement of Conclusion from the Intermediate Ministerial Meeting for the North Sea on the Integration of Fisheries and Environmental Issues in Bergen, March 1997, the ministers adopted several guiding principles. One of these was that «further integration of fisheries and environmental protection, conservation and management measures, shall draw upon the development and application of an ecosystem approach». Different human uses impact directly or indirectly the same components of marine ecosystems. In management of these systems there is a need for continuous updated information. An ecosystem approach for the management of the North Sea will need an integrated monitoring and information system which could be provided by a North Sea element of GOOS building on developments by ICES and EuroGOOS. Such an approach will probably be the main focus for the next North Sea Conference in 2002. Internationally, there is clearly a need for a demonstration or pilot project on the ecological approach to management and the North Sea is an obvious candidate for that. Reference is here made to the report from the Workshop on the Ecosystem Approach to the Management and Protection of the North Sea, Oslo 15–17 June 1998 where one of the main conclusions was:

> «The present monitoring of the North Sea is often insufficient to reveal human impacts on the ecosystem. There is a need for improved, integrated monitoring through co-ordination and harmonisation of existing national and international monitoring activities, as well as through implementation of new methods and technology»

Similar ideas are expressed in the Strategic Design Plans of both the Living Marine Resources Panel and the Panel for the Coastal component of GOOS.

ICES has acknowledged that GOOS will ultimately serve as the overall framework for many programmes including environmental monitoring programmes. The implementation of the global GOOS programme will have to be based on national and regional contribution through bilateral and multilateral agreements. The five GOOS modules were devices that serve their purpose in the planning stage. In the implementation phase, however, the thrust would be thematic rather then modular.

The challenge for the fisheries research and management community is to assemble, assess and use environmental data within the annual fish stock assessment cycle. ICES has already started this work and in the future it will probably be a need for integrated environmental-fish stock assessment working groups with a regional or ecosystem focus.

For marine ecosystems climatic variability is a primary driving force for ecosystem variability. Improved knowledge of the relationship between climate and ecosystem variability would greatly benefit the difficult task of distinguishing impact by man from natural variability. Consequently, there is a need to develop a harmonised system for monitoring, assessing, and forecasting the ocean climate for the European seas. This will be of relevance not only for environmental assessment but also for the assessment and management of living resources, coastal zone management and marine operations. It is recognised that much of the groundwork for such a system has been laid by the national monitoring activities, the cooperation within ICES and the latest EuroGOOS's development, such as the proposal for NOOS, which could be seen as a European North West Shelf Seas component of GOOS which would provide a framework for co-operation to fulfil the needs of the regional conventions and other international organisations such as ICES.

There is clear overlapping and commonality of the interests of ICES, OSPAR, and EuroGOOS in exploring the feasibility and ways of establishing an Operational Oceanographic System for the North Sea which is routinely collecting, disseminating and interpreting measurements to provide:

- Continuous forecasts of the future condition of the sea as far ahead as possible
- Provide the most useful accurate description of the present state of the sea including living resources
- Assemble climatic long-term data sets that will provide data for description of past states, and time series showing trends and changes.

The system should be based on the principle of shared tasks and responsibility between nations and/or agencies. In the discussions that followed, it was accepted by all participants that there was a growing need for ecosystem monitoring in order to underpin the move towards integrated fishery and environmental management. Such monitoring should build upon existing observing systems. To these, ICES can add a particular emphasis on ecosystem monitoring. OSPAR monitoring presently does not cover the driving forces, such as meteorology, ocean circulation and the cause of river flow variability. The underpinning physics is presently absent from the OSPAR approach. Thus there is great merit in cooperation between the various organisations involved in fishery, environment and ecosystem management and monitoring, with ICES, EuroGOOS, OSPAR, the North Sea Commission, EEA specifically listed.

The meeting recognised the need for further planning before progress may be made, with an emphasis on addressing whether collectively there is real potential for servicing a wide range of customers in a more effective manner. Connections have yet to be made between some of the varied disciplines involved in monitoring in the North Sea, especially between physical oceanography and fisheries ecology. A comprehensive operational oceanographic system for the North Sea will have to address the problem of different physical and temporal scales. In terms of spatial scale, physically there are arguments to include the entire NW European shelf, and adjacent enclosed seas. In terms of fish stocks, there are distinct sub-areas that should be treated independently, and politically there is a focus on the North Sea. A nested approach may therefore be required, as well as consideration of how to deal with open boundaries.

A further workshop to develop these issues was thought to be necessary. The results of such a workshop will be of relevance to the next North Sea Ministerial meeting to be held in March 2002 in Norway. Appendix 5 presents a draft recommendation, with supporting arguments, for such a Workshop*. This draft was immediately circulated so that Workshop participants might commence internal national discussions.

In summary, the original concept, as expressed in the report of the Bergen meeting, of a Regional Operational Observing System for the North Sea, has evolved. What is now envisaged is a demonstration of the ecosystem based approach focusing on the North Sea and nested in the northwest shelf oceanography provided by NOOS.

4.4 International Bottom Trawl Surveys

A. Newton (Chair of the ICES Working Group on IBTS) introduced this item. He explained that, in the North Sea, pre-recruit surveys are made chiefly for the four gadoid species: cod, haddock, whiting and Norway pout and for herring. There are differences in both the times of spawning and the main spawning areas of these species. Cod and saithe spawn relatively early in the year, from January to April, haddock from January to May and whiting from February to July. However, there is considerable geographic variation in spawning time within the overall spawning area of each species; spawning begins three to four weeks earlier in the southern than in the northern North Sea. The North Sea gadoids do not have well defined spawning grounds, but in general terms one can state that spawning by haddock, saithe and Norway pout takes place mainly in Division IVa (northern North Sea), whereas for cod and whiting Divisions IVb (central North Sea) and IVc (southern North Sea) are of greater importance.

Herring are quite different from the gadoid species in that the majority spawn in the North Sea in the autumn-winter period and have well defined spawning areas. There is a progression in the time of spawning as one goes from north to south with spawning taking place in August/September around Orkney and off the Aberdeenshire coast; in September/October off the northeast coast of England and over the Dogger Bank, and in November in the Channel and Sandettie area. Less than 10% of the North Sea stocks are spring spawners and they are to be found in the German Bight and along the continental shelf. Surveys in the North Sea aimed at measuring the abundance of the young stages of fish species of commercial importance have a fairly long history, e.g., Scottish demersal surveys, with the main emphasis on 1-group haddock and whiting in Division IVa, date back to 1919. International young fish surveys (then known as the International Young Herring surveys) in the North Sea started in 1967.

In recent years, however, there has been an increase in participation in young fish surveys, largely because of the need for earlier and more accurate forecasts in relation to management of stocks. As the size of many of the important fish stocks are now dependant on the strength of one or two young year classes it is important to have an early indication of the strength of the incoming year class. The young fish surveys offer an opportunity to sample these year classes prior to the time that they enter the commercial fishery.

History of the Surveys: The International Young Herring Survey (IYHS) started off as a joint programme by Germany, Denmark, the Netherlands, England and Scotland to investigate herring recruitment. Four extensive surveys were made in the spring and autumn of 1960 and 1961. The objectives of these surveys were:

1) to identify the main centres of abundance of pre-recruit herring
2) to determine their racial characters in relation to those of the adult stocks.

The first objective was readily achieved. Main centres of abundance were located to the east and west of the Dogger Bank, with subsidiary ones in the Skagerrak, Moray Firth and the Southern Bight.

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* This proposal was supported by the Bureau at its meeting in January 2001

The second objective, however, turned out to be far more difficult to achieve. Immatures of the three main adult stocks (Bank, Buchan and Downs) occurred mixed together in all nursery and the separation of immatures into sub-populations on the basis of meristic characters required a complicated analysis of the material.

After the last survey in 1961, the programme was temporarily halted pending the analysis of the material. In 1965, however, the ICES Herring Committee recommended the revival of the joint surveys. The main emphasis of the surveys would now be on abundance estimates of immature herring, as a means of forecasting recruitment to the adult fisheries. The surveys were re-started in 1966 when two ships participated in the survey. Their objectives were to find out whether:

1) catch rate could be used to estimate the abundance of young herring
2) echosounders could be used for the same purpose.

They found that the variance on a single haul is lower in spring than in autumn. Echo traces normally did not coincide with concentrations of juvenile herring.

Because the results for spring surveys looked promising, it was decided to repeat the Young Herring Survey in 1967 and the years afterwards. Since 1967 there has been a steady increase in participation in the survey. In 1970 the number of nations increased to five and this further increased to eight in 1974. In 1976 France joined the survey and the number of nations remained at nine until the USSR withdrew in 1983 and England in 1991.

One of the reasons for greater participation was the realisation that data obtained on gadoids could be used in a similar fashion to the herring data for estimating year class strengths. There are undoubtedly problems in using one survey to obtain data on both demersal and pelagic fish as they differ in geographical distribution and behaviour. However, the large number of ships participating means that a large geographical area can be surveyed and by restricting the hauls within the herring standard area to daylight hours an effort has been made to accommodate the deil vertical movement of herring. At the same time in order to recognise the wider impact of the surveys they were renamed the International Young Fish surveys. In 1990 the surveys underwent another name change - they are currently the International Bottom Trawl surveys.

Gear Used During Surveys: Prior to 1977 there was no standardisation of gear although all ships used bottom trawls with a small mesh cover. In 1977 ICES recommended that all vessels should use a GOV trawl as specified by the Institut des Peches Maritimes, Boulogne. A detailed description of the net is to be found in the ICES IBTS manual. The GOV trawl has been gradually been phased in, e.g., in 1979 only 3 vessels were equipped with this particular net but by 1983 all 8 nations were using this gear. It should be noted that although the gear is now standard, variations in the rigging exist between the various countries.

In 1977 ICES also recommended that the duration of a tow should be reduced from an hour to half an hour with the catch data to be expressed in numbers per hour. All nations have now accepted this recommendation.

Data Activities - Trawl catch: For the early years the gadoid data are very patchy e.g., in 1965 only whiting were measured as a routine, cod were split into size groups and counted, haddock were counted only. Numbers at age were only calculated for I and II groups; the calculation was done by either using an Age Length Key (ALK) or by the Petersen method. By 1969 most nations were measuring cod, haddock and whiting but up to, and including, 1971 the numbers at age for I, II and older fish were calculated from Scottish ALKs. 1972 saw the start of other nations (Netherlands, England and Norway) taking otoliths and by 1975 all nations were providing length frequencies for the 3 main gadoid species. 1977 saw the beginning of routine production of ALKs by all countries(Sweden, Germany and the USSR being the last to produce these data). The ALKs continued to be based on 3 groupings (I, II and older) until 1980. In 1981 the ALKs were expanded to include the age groups I to VI. At the same time sex and maturity data were recorded for each otolith taken. The resulting keys (known as SMALKs) exist for 1981 and each subsequent year. Until 1982 the data gathered by the individual nations were submitted to RIVO, IJmuiden. The latter provided a provisional index of I group abundance, based on the catches of each major species below a species-specific size limit, for use by the Assessment Working Groups. Later they ran the entire material through a set of programs to produce the definitive Standard Indices, together with other data such as mean length at age etc. In 1983 ICES assumed the role previously played by the Dutch in producing the final indices although RIVO have continued to produce the provisional indices.

Data Activities - Additional data: Further information related to the trawl catch are the gross weight of the individual major species, day or night and the bottom temperature and salinity. All on a per haul basis.

Data Activities - Hydrography: Since 1970 the surface and bottom temperature and salinity have been recorded. These data are maintained in the ICES oceanographic database but there is, in theory at least, a cross reference (via haul number) between the ICES oceanographic database and the ICES Fisheries database; the latter holding all the North Sea survey data. In 1984 ICES asked for the collection of additional data, i.e., nitrate, phosphate and silicate, on a routine basis. These data are used to establish a base line of nutrients available for the annual spring bloom.

Other Surveys of Relevance to GOOS (North Sea): In 1990 it was agreed that ICES should co-ordinate a 5-year series of quarterly surveys in the North Sea. This series commenced in 1991 and actually lasted until 1997 although for the last two years only a limited number of institutes participated in the co-ordination. The quarterly surveys were based on existing independent national surveys and only a minimum number of extra surveys were required to fulfilled the stated objective. However, as always, there were resource pressures on these surveys and by the end of 1996 it became obvious that institutes were only willing to support two surveys on a long-term basis:

1) The existing quarter 1 survey
2) A quarter 3 survey

The quarter 3 surveys are based on existing national surveys (in Scotland's case, started in 1984) and provide almost exactly the same coverage as the quarter 1 survey although at a lower level (301 hauls against 401). Support for this survey was forthcoming mainly due to the fact that the fisheries data are used to fine tune the North Sea assessments calculated in October of each year.

Other Surveys of Relevance to GOOS (Western Division): France, Ireland and Scotland have been running a series of independent surveys in ICES sub-areas VIa and VII for a number of years but in recent years there has been an increasing level of co-operation concerning a quarter 4 survey which originally was started to assess mackerel stocks. This co-operation has increased since 1998 as, again, there was the realisation that other indices could be calculated from the data gathered. Currently these surveys are co-ordinated within the ICES framework by Ireland.

Other Surveys of Relevance to GOOS (Southern Division): From the end of the 1970's France, Spain and Portugal have been conducting national surveys from the south of Ireland to the Strait of Gibraltar. In 1997 the surveys that occurred in October/November were co-ordinated within an EU project (SESITS - DGXIX 96/029) for a period of two years. This contract built a strong foundation for continuing co-operation and these particular surveys are now co-ordinated within the ICES framework by Spain.

The ICES Database: All fisheries data from the co-ordinated surveys in the North Sea are submitted via the IBTS Exchange format to ICES in Copenhagen. Initially the submitting institutes using a checking program developed by ICES check the information. ICES make final checks before loading into the IBTS database. This still leaves the survey data from the western and southern divisions in a peculiar position. Although co-ordinated through ICES and undertaken to an agreed international standard, ICES is unable to provide the additional resources required to archive them at Headquarters; thus the data are stored in individual institutes. This situation has caused considerable unease at IBTS Working Groups and several approaches have been made to ICES and the European Commission about the problem. However, at the ICES ASC in Bruges (2000) it was finally decided that a 5th Framework project would be developed for submission in 2001 to the Commission. This project will be co-ordinated by Gerjan Piet (Chair of Beam Trawl Survey Working Group) with the intention of creating a new database which will be capable of holding all fisheries data from the IBTS (North Sea, western and southern divisions), the Baltic surveys (BITS) and the Beam Trawl surveys.

With the inclusion of IBTS data into the Initial Observing System of GOOS it would appear to be appropriate that the new database should be designed so that it could accessed via a portal on the GOOS website. A possible 'front end' approach could be that developed by Canada (http://seaserver.nos.noaa.gov/projects/ecnasap/ecnasap.html). To ensure that the products derived from the new database are consistent with the ideals expressed by the Steering Group there should also be input from the ICES Oceanographer and GOOS at the planning stage.

The access policy of GOOS is that all data are free and transparent to all that access the GOOS web site (or its portals to other web sites). This is against the current policy of the IBTS Working Group and will have to be discussed at the next Working Group meeting. A possible solution is that the original raw data are treated as confidential whilst aggregated data are released into the public domain.

The Implications of GOOS: GOOS is developing a system, which opens up the general public (but also fisheries scientists) a comprehensive data set on physical oceanography and other disciplines garnered from a number of sources. As C. Summerhayes explained, in terms of living marine resources, the GOOS approach is an ecosystem one, firmly based on the recognition that living resources are products of their physical and chemical environment, and can only be comprehensively understood when considered in the light of the physical and chemical properties of ocean circulation. The role of currents in distributing larvae is self evident, as is the role of nutrients in supplying food, and the role of climate in changing the environmental conditions in which organisms live. Consideration of the IBTS fisheries data in the context of their changing physical and chemical environment may go some considerable way to explaining why the fish are distributed the way they are from year to year and place to place. Another fundamental feature of the GOOS approach is NOT to use raw physical and chemical data by themselves, but rather to incorporate those data into sophisticated numerical models that can EXPLAIN why the variables are the way they are, and FORECAST changes in the environment. Models are capable of revealing processes like fronts that may be of fundamental biological significance, yet that are not revealed by hand contouring the raw physical oceanogrpahic data collected by the IBTS. This GOOS approach would immediately change the approach to IBTS data from a static one to a dynamic one, in which the fish data could be seen against a simulation of their real dynamic environment, thereby providing much more information to fisheries agencies. In this way the GOOS approach ADDS VALUE TO DATA. The GOOS approach cannot add value to data that are not released. Thus, if the GOOS approach could be allied to the extensive fisheries data sets already existing within the ICES community it could form the basis for a valuable application of ecosystem models to stock assessments. This development should be encouraged as a benefit to ICES agencies. At present the physical and chemical data gathered by the IBTS are largely unused, which means their potential value remains unexploited by the collectors.

In the discussions, several issues were raised. There was concern that ICES must investigate what will be needed from them, after nominating the IBTS as part of the GOOS Initial Observing System. There is also a difference in data policy covering the environmental data collected, and the fishery data. This discrepancy needs to be resolved. The improvement of the link between biology and oceanography with respect to the IBTS could be taken forward as a component of the workshop to develop an Operational North Sea GOOS component for ecosystem assessment and management.

The Canadian example of map based, web products to allow a rapid comparison between fishery and environmental data was discussed. That process required a review of data national and institutional policy. There is presently a discussion with respect to obtaining funding to improve the IBTS database, and as such it is timely to consider a) better integration of environmental data and b) better data visualisation. The opportunities for additional observations from the research vessels participating in the IBTS should be examined, particularly with increasing automation of ocean monitoring from vessels. There is therefore a need to a) utilise existing data in a better way, b) improve data collection using automation and c) add parameters to those already observed.

Finally the meeting suggested that a Theme Session for an ICES ASC be considered to examine the issues raised by the utilisation of the IBTS as a GOOS observing system, and the integration of fishery and environmental data.

5 HOW TO ADVISE AND SUPPORT THE ICES SECRETARIAT ON GOOS RELATED ISSUES

The role of the Steering Group informing the ICES Secretariat on GOOS related issues. The components of an ICES involvement in GOOS discussed in 4 above all involve Secretariat functions. In addition, if ICES becomes involved with EuroGOOS and others in regional GOOS initiatives, additional Secretariat staffing may be required, funded externally. This led to the following recommendation:

5.1 Recommendations to the ICES Bureau Working Group Reviewing the ICES International Programme Office

The goal is to ensure that the monitoring activities of ICES are used to best effect for ecosystem assessment and management, by embracing the principles and practices of GOOS. This will require employment of a Co-ordinator, funded by external contributions, for the following tasks.

1) To service the needs of the IOC-ICES GOOS Steering Group on GOOS, including arranging meetings and related activities;
2) To assist as appropriate in ICES involvement in the development of GOOS projects or programmes, or the research in support of them;
3) To enhance the ICES database by incorporating existing and new ICES data that can be used for GOOS products;
4) To stimulate the use of the expanded ICES database for the development of operational products, especially for ecosystem management;

5) To facilitate the use of GOOS products in the ICES advisory process;
6) To develop and maintain an ICES-IOC Steering Group for GOOS web site of products and services involving ICES data and information and relevant to ICES;
7) To communicate on matters concerning ICES involvement in the implementation of GOOS projects with appropriate national ICES and GOOS representatives and EuroGOOS.

6 ECOSYSTEM APPROACH TO MANAGEMENT

H.R. Skjoldal made an presentation "Ecosystem monitoring and assessment to support an ecosystem approach" which is included as Appendix 10 of the report.

7 PREPARATION OF A FLYER DESCRIBING GOOS PRINCIPLES IN AN ICES CONTEXT

A sub-group consisting of C. Summerhayes (IOC GOOS Office), H. Dooley (ICES), N. Flemming (EuroGOOS), A. Newton (Chair ICES Working Group on IBTS) and R. Saetre (Chair) have undertaken to prepare descriptive material in order to explain GOOS principles in an ICES context, with particular reference to the work of the Working Group on IBTS. This sub-group should also consider that the IBTS has been nominated by ICES as a component of the GOOS Initial Observing System, and should outline what this will require additionally from ICES and from members of the Working Group on IBTS, and what changes in data policy may be needed.

8 NEXT MEETING

It was agreed that the next meeting of the Steering Group will be an informal one in connection with the planned North Sea Strategic Workshop in Bergen. The meeting will evaluate the progress in the work, including the outcome from the workshop. It will plan and initiate further action in accordance with the Terms of Reference of the group.

APPENDIX 1 – EXECUTIVE SUMMARY OF LMR PANEL

STRATEGIC DESIGN PLAN FOR THE IOC-WMO-UNEP-ICSU-FAO LIVING MARINE RESOURCES PANEL OF THE GLOBAL OCEAN OBSERVING SYSTEM (GOOS)

DRAFT: OCTOBER 11, 2000

EXECUTIVE SUMMARY

The sustainability of the oceans' living marine resources (LMR) is threatened by a wide variety of factors. Overfishing, habitat disturbance and loss, pollution and the potential effects of a changing climate all combine to reduce the health of the world's oceans. Key to addressing these issues is better information regarding the status of the world's LMRs, and the factors driving change. With this in mind, the goal of LMR GOOS has been to:

"provide operationally useful information on changes in the state of living marine resources and ecosystems. The objectives are to obtain from various sources relevant oceanographic and climatic data, along with biological, fisheries and other information on the marine ecosystems, to compile and analyse these data, to describe the varying state of the ecosystems, and to predict future states of the ecosystems, including exploited species, on useful time scales. A consequence of these efforts should be the identification and development of the more powerful and cost-effective means for monitoring marine ecosystems required to meet the LMR-GOOS goal."

In achieving this goal the LMR-GOOS monitoring programme should attempt to provide information that:

i) describes changes in ecosystems over time, including fluctuations in abundance and spatial distribution of species;

ii) helps interpret the observed changes in relation to such factors as natural environmental variability, anthropogenic climate change (including increased ultraviolet radiation), predation/disease, and fishing activities; and,

iii) contributes to forecasting of future states of marine ecosystems.

To address these needs, LMR GOOS developed a broad, ecosystem-based approach. Recognizing the increasing heterogeneity of marine ecosystems as one moves from the open ocean toward shore, the approach is structured according to three systems B open ocean, coastal ocean and inshore. Open ocean observations are necessarily minimalist, relying on ships of opportunity, remote sensing and fishing industry statistics. The inshore system was not addressed by LMR GOOS due to its heterogeneity and complexity and the lack of specialists in inshore studies on the panel

Because of its productive capacity and proximity to anthropogenic influences, the coastal ocean is a primary focus of LMR GOOS. Unlike observing systems for climate, marine pollution and ocean service, there is no >one-size-fits-all' observing system that is equally valid or useful for all coastal marine ecosystems under consideration. Coastal ocean ecosystems, and the processes which drive them, are simply too variable, and the design of specific observing plans must be based on the knowledge of local scientists. Four examples of regional LMR observing systems B Scotian Shelf, Gulf of Guinea, Yellow Sea/East China Sea and coastal upwelling systems - are presented as examples, as are design principles for regional LMR GOOS programs. These are intended to be adapted and customized by local experts elsewhere.

Data and information management, and the process of transforming data into useful products, comprise an essential element of the LMR GOOS approach. LMR data products, such as forecasts of ecosystem states, are logically produced on an ecosystem scale, which typically involves large ocean areas. Regional Analysis Centres (RACs), which would serve to compile data and information on appropriate ecosystem scales, and to generate appropriate forecasts and other data products, should be the fundamental unit on which LMR GOOS is developed. Existing regional marine science organizations such as ICES or PICES could host RACs as could existing regional ecosystem observing programs.

A key linkage between the observing program and useful predictions of system dynamics is process studies and modelling. Programs such as GLOBEC will provide critical information on physical-chemical-biological processes, develop advanced observing technologies, and identify crucial variables and locations for long time series analyses of climate variability and marine ecosystem response. In turn, LMR GOOS will provide time series data for research programs.

The first steps toward implementation of a global LMR GOOS must be the integration of existing observing systems into a more consistent, ecosystem-based approach utilizing the regional design principles, and a significant increase in capacity to enable full participation throughout the developing world. In many areas, ongoing observing programs such as those identified as LMR components of the GOOS Initial Observing System comprise significant components of a regional system which need only minor augmentation and linkage through a RAC. In other areas, not even rudimentary monitoring capacities exist. The challenge now is to identify existing programs and gaps, and to find resources to develop the program on a global scale.

SUMMARY OF KEY RECOMMENDATIONS

These recommendations are aimed toward the national and international agencies that have ultimate responsibility for the implementation of LMR GOOS.

- Adopt a broad, ecosystem-based approach to living marine resources assessment and monitoring. Recognize that all marine ecosystems are unique, that no uniform global-level observing system will be valid, and that observing systems must be tailored to specific local conditions and requirements.
- Develop monitoring systems at three biogeographical scales - open ocean (basin or sub-basin scale), coastal ocean (large marine ecosystem scale) and inshore (embayment or estuary-scale) B with increasing system complexity from open ocean to inshore. A design strategy and examples for open ocean and regional observing systems are provided here.
- Establish Regional Analysis Centres (RACs) for each major ecosystem. RACs will manage, analyse and synthesize ecosystem data from monitoring and assessment programs, and produce the specific products for end-users. Capacity building will be facilitated as scientists from countries at different stages of development work together to make observations and interpret them in ways consumers will find useful.
- Utilize fully existing and developing observing technologies for cost effective, synoptic sampling, e.g., remote sensing (ocean colour, wind fields, sea surface height, temperature and salinity), instrumented continuous plankton recorders and optical plankton recorders.

Strengthen linkages with national and international research and observing programs that may contribute to LMR GOOS, most notably GLOBEC and Census of Marine Life.

APPENDIX 2 – EXECUTIVE SUMMARY OF COASTAL GOOS

THE STRATEGIC DESIGN PLAN FOR THE COASTAL COMPONENT OF THE GLOBAL OCEAN OBSERVING SYSTEM (GOOS)

EXECUTIVE SUMMARY

Purpose

The coastal zone is a unique environment in that it is the only place on the globe where terrestrial, oceanic, atmospheric, and human inputs of energy and matter all converge. It also supports the greatest concentration of living resources and people on the planet. As the number of people living, working and playing in coastal ecosystems increases, the demands on these systems to provide commerce, recreation, and resources and to receive, process, and dilute the effluents of human society will increase. Likewise, the risk that natural hazards pose society also increases. Thus, it should come as no surprise that coastal ecosystems are experiencing unprecedented changes from habitat loss (tidal wetlands, sea grass beds, coral reefs), oxygen depletion, harmful algal blooms, fish kills, and declining fish stocks to beach closures, coastal erosion and flooding. The resulting conflicts between commerce, recreation, development, the utilization of natural resources, and conservation will become increasingly contentious, politically charged, and expensive.

Resolving these conflicts in an informed, timely and cost-effective fashion requires a significant increase in our ability to detect and predict the changes that are occurring coastal ecosystems. This is the purpose of the coastal component of the Global Ocean Observing System. The goal is to build on, enhance and supplement existing observing programs to develop a sustained and integrated observing system that provides the data and knowledge required to:

C manage and restore healthy coastal ecosystems and living resources;
C enable safer and more cost-effective marine operations;
C forecast and mitigate the effects of storms;
C detect and predict the effects of climate change; and
C protect public health.

To address these needs, the observing system must ultimately provide information on a broad spectrum of environmental changes that reflect interactions between natural variability and human activities in a complex environmental setting. The system is intended to serve the needs of many user groups including industries (shipping, oil and gas, compliance monitoring, fishing, aquaculture, agriculture, and recreation), government agencies and ministries (management of resource and the environment, land-use and economic development plans), teaching institutions, and the community of research scientists.

This report describes the initial design for the coastal component of the Global Ocean Observing System (C-GOOS). The development of C-GOOS will take place in the context of the Integrated Global Observing Strategy through coordination and collaboration with the GOOS modules (Ocean Observations Panel for Climate, Health of the Oceans, and Living Marine Resources), the Global Climate Observing System (GCOS) and the Global Terrestrial Observing System (GTOS). The plan proposed herein is intended to be the first step in the development of an internationally accepted and supported design plan for C-GOOS.

A Global System for the Coastal Environment

C-GOOS is primarily concerned with the coastal marine and estuarine environments of the coastal zone. These are complex environments composed of a diverse mosaic of ecosystems from intertidal beaches, rocky shores and tidal wetlands to lagoons, coral reefs, estuaries, bays, fjords, sounds and the open waters of the EEZ. Since most of the changes the observing system is intended to detect and predict (from changes in the weather and sea state to harmful algal events and oxygen depletion) are local to regional in scale, it is reasonable to ask why a global observing system for coastal ecosystems needed in the first place? A global system is needed for three reasons: (1) local changes are often related to or caused by changes occurring on larger scales in the ocean, on land or in the atmosphere (the propagation of variability from large to small scales); (2) marine ecosystems are highly under-sampled and the actual scale of changes are often larger than is perceived; and (3) marine ecosystems are complex and the development of a predictive understanding of the changes occurring in them will require a comparative analysis of many systems (local changes that are globally ubiquitous). Differentiating the effects of human activities from the effects of natural processes requires knowledge of the coherence of changes that are occurring locally on global scales and comparative analysis of such changes in the context of larger scale forcings (the propagation of variability from large to small scales). Furthermore, the problem of under-sampling, which severely limits our ability to detect and predict change, cannot be solved by any one nation by itself. Although many changes are local to regional in scale, their boundaries rarely, if ever, correspond to political boundaries. Consideration of larger scales and the development of appropriate technologies will require the sharing of knowledge, data, infrastructure and expertise among nations; capacity building to enable all nations to participate and benefit; and financial commitment on the part of the industrialized world. Clearly, this will require an unprecedented level of coordination and collaboration among nations with coastal interests.

Design Considerations

Three general observations form the basis for the design of the observing system: (1) most of the changes occurring in coastal ecosystems are local in scale and are globally ubiquitous; (2) physical processes structure the pelagic environment and are of fundamental importance to changes in the physical, biological and chemical characteristics of coastal ecosystems; and (3) changes in these characteristics are related through a hierarchy of interactions that can be represented by robust models of ecosystems dynamics (e.g., numerical models of physical processes and coupled physical-biological models). Thus, it is likely that there is a relatively small set of core variables that, if measured with sufficient resolution, for extended periods over large scales, will provide the data and information required to detect and predict changes in coastal ecosystems that benefit a broad spectrum of user groups.

Both detection and prediction depend on the development of an integrated and sustained observing system that provides effective linkages between measurements and data analysis for more timely access to data and delivery of environmental information. The system must be integrated to provide multi-disciplinary (physical, chemical and biological) data and information to many user groups. This is the "value-added" aspect of C-GOOS. The system must also be sustained to capture the scales of variability that characterize the changes of interest and to provide continuity in the data streams and resulting data products. There are no systems that are integrated (multi-disciplinary observations servicing the needs of many user groups), sustained and global in scope.

C-GOOS will come into being by selectively enhancing, networking and supplementing existing programs. It must also be recognized at the onset that many of the measurements and models required for a comprehensive, fully integrated, multi-disciplinary observing system are not operational, that much work is needed to develop and determine those products that are most useful, and that capabilities and resources vary enormously among nations. These realities underscore the importance and need for enabling research and capacity building. In addition to becoming integrated and sustained, the observing system must achieve the following as it grows and matures:

- produce information that meets the needs of a broad spectrum of user groups;
- provide a more cost-effective means of obtaining and applying environmental data;
- enable a constructive and timely synergy between the detection of changes and the hypothesis-driven research required to understand and predict such changes;
- promote the development of new technologies and models required for a fully integrated, multi-disciplinary system; and
- develop mechanisms to evaluate the functioning of the system and the value of the information it produces, to incorporate new technologies, and to increase the diversity of user groups it serves.

Design Framework

The observing system is conceived as a global network for the measurement and analysis of a common set of key (core) variables that is regionally and locally customized (e.g., more variables, greater resolution, additional products) to address those issues that are of greatest concern to participating countries. The global network is the focus of the C-GOOS design strategy. Linking user needs to measurements to form an end-to-end, user-driven system requires a managed, two-way flow of data and information among three essential subsystems:

- the observing subsystem (detection);
- the communications network and data management subsystem (integration); and
- the modelling (prediction) and applications subsystem.

The observing subsystem is the measurement end of the system. It consists of the global infrastructure required to measure core variables and transmit data to the communications network and data management subsystem. Recommended core variables are surface winds, air pressure and temperature, precipitation, sea level, bathymetry, temperature, salinity, surface currents and waves, turbidity, sediment type, dissolved nutrients, phytoplankton pigments, and water clarity. The infrastructure must incorporate the mix of platforms, samplers, and sensors required to measure core variables with sufficient spatial and temporal resolution to capture important scales of variability in 4 dimensions. This will require the synthesis of data from remote sensing and in situ measurements involving six interrelated categories of observing elements: (1) coastal observing networks for the near shore (CONNS); (2) global network of coastal tide gauges (GLOSS); (3) fixed platforms, moorings and drifters; (4) ships of opportunity (SOOP) and voluntary observing ships (VOS); (5) remote sensing from satellites and aircraft; and (6) remote sensing from land-based platforms.

Data communications and management link measurements to applications. The objective is to develop a system for both real-time and delayed mode data that allows users to exploit multiple data sets from disparate sources in a timely fashion. A hierarchical system of local, national and supra-national organizations is envisioned to provide data, information, and access to users at each level. Some national and supranational organizations will be developed into synthesis centres that will provide highly processed products (e.g., assimilating data from remote and in situ sources for numerical model predictions requiring substantial computing power). The development of this component of the system should be of the highest priority.

Data assimilation and modelling are critical components of the observing system. Real-time data from remote and in situ sensors will be particularly valuable in that data telemetered from these sources can be assimilated to (1) produce more accurate estimates of the distributions of state variables, (2) develop, test and validate models, and (3) initialize and update models for improved forecasts of coastal environmental conditions and, ultimately, changes in ecosystem health and living resources. A variety of modelling approaches (statistical, empirical, theoretical) will be required. The challenge of developing a cost-effective observing system underscores the importance of the interaction between measurements and modelling. Due to the complexity of coastal ecosystems and the cost of observing them, Observation System Simulation Experiments (OSSEs) will become increasing valuable as tool for assessing the efficacy of different sampling schemes and the usefulness of measuring different variables.

Building C-GOOS

Programs that are relevant to the development of C-GOOS are divided into 3 categories: (i) operational programs, (ii) pre-operational pilot projects, and (iii) enabling research. Operational programs provide products to user groups that are in demand and are made possible by sustained data streams and data management systems that guarantee data quality. Pilot projects and enabling research are organized, planned sets of activities with focussed objectives, a defined schedule, and a finite life time that are expected to produce results that significantly benefit the global ocean observing system in general and C-GOOS in particular. An important function of pilot projects is to demonstrate the utility of the GOOS "end-to-end, user-driven" approach. Enabling research develops the technologies and knowledge (e.g., sensor and models) required to detect and predict changes.

It is expected that C-GOOS will develop along two tracks: (1) the building of an initial global network through the incorporation of existing operational elements that meet GOOS design requirements and (2) the implementation of pre-operational pilot projects that demonstrate the utility and cost-effectiveness of the "end-to-end, user driven" approach and contribute to the development of the global network and regional enhancements. Pilot projects will also be an important vehicle for the incorporation of new scientific knowledge and technologies into the observing system (transformation from research applications to operational modes). Both pilot projects and enabling research programs will be essential to capacity building and the scientific advances required to grow the system into a fully integrated and operational observing system. In this regard, mechanisms are needed to enable the exchange of information and technologies among pilot projects so that they may learn from each others successes and failures and to insure the incorporation of GOOS design principles and the development of common techniques, models, and data processing strategies. This is particularly important for the data management subsystem if data and data products are to be exchanged in a timely fashion on regional to global scales.

The successful development of C-GOOS depends on broad-based international support and ongoing sponsorship by nations and private institutions. The annual operating cost of the World Weather Watch in 1992 was about $2 billion U.S. The annual cost of a GOOS at that time was also about $2 billion U.S., most of which was for satellites. Although a cost analysis has yet to be performed for C-GOOS, these figures provide an order of magnitude estimate of the investment that will be required to initiate the core network proposed here. Although government funding will be essential, especially for large capital-intensive components of the observing system such as satellites, funding from the private sector will be required in the long term. In these regards, the importance of National and Regional GOOS Programmes cannot be overemphasized. These programmes are vehicles for implementation. They provide an important means for facilitating the user input required to implement and enhance the core program and for institutionalising mechanisms for sustainable funding.

Collaboration with key research programs will provide the scientific basis for continued development toward a fully integrated system. The first step is to coordinate and integrate existing efforts to insure continuity and to achieve larger scale regional and global perspectives, minimize redundancy, improve access to data, and produce timely analyses that benefit a broader spectrum of user groups. By building on existing capabilities and infrastructure, and by using a phased implementation approach, work can start immediately to achieve the vision. New technologies, past investments, evolving scientific understanding, advances in data communications and processing, and the will to address pressing societal needs combine to provide the opportunity to initiate an integrated observing system for coastal ecosystems. The major pieces missing are an internationally accepted global design; national and international commitments of assets and funds; and an unprecedented level of collaboration among nations, institutions, data providers and users.

APPENDIX 3 – SUMMARY, INTRODUCTION AND RECOMMENDATIONS FROM THE EUROGOOS/ICES WORKSHOP ON BIO-ECOLOGICAL OBSERVATIONS IN OPERATIONAL OCEANOGRAPHY (THE HAGUE, APRIL 2000)

EuroGOOS/ICES Workshop on “Bio-ecological Observations in Operational Oceanography”, 6–8 April 2000, The Hague, Netherlands.

Summary

EuroGOOS and ICES organised a workshop on "Bio-ecological Observations in Operational Oceanography" (held in The Hague, 6–8 April 2000). The goal of this meeting was to advance an ecosystem approach for ocean monitoring by describing existing surveys, technologies, and concepts of bio-ecological oceanography and by discussing strategies of how to meet present and future user requirements in this sector. The workshop covered user requirements, sampling technology, anthropogenic and climatic influences on the ecosystems, and ecosystem modelling.

Workshop participants recommended that user involvement in the sampling strategy should be given high priority. Identified users were: the scientific community, environmental and public health agencies, coastal managers and decision makers, the public in general, fisheries and aquaculture business, shipping and tourist industry, and the navy. Participants recognised a need for further user requirement surveys as well as for an improvement of the interaction between marine scientists/operational agencies and politicians/ public. In addition, it was felt that a contribution of stakeholders to sampling and monitoring could reduce costs and improve acceptance of operational oceanography.

Sampling strategy should include different monitoring types and schemes. Cost reduction of expensive monitoring could be achieved through the improvement of error models and through a responsive sampling strategy. Participants suggested that progress of the bio-ecological monitoring technology could be achieved through the improvement of existing and development of new bio-sensors, through a standardisation of the most common methods, and advances in the use of remote sensing for the assessment of primary productivity.

Workshop participants agreed that improvement and development of impact indicators for the monitoring and control of pollution in coastal environments should be prioritised, and that a common definition, harmonisation and standardisation of the most important indicators must be achieved.

Another major point of discussion evolved around ecosystem considerations for fish stock assessment that will require new type of data. Workshop participants recommended that scientific efforts to identify those ecological variables and models that have a significant effect on fish distribution and abundance should be greatly increased. The importance of spawning areas for fish monitoring was recognised and adequate research recommended. It was also felt that non-commercial fish species deserve more attention than they are given at present.

Improvement and extension of bio-ecological data analyses was deemed necessary. Participants suggested the establishment of data analyses centres and of quality criteria for parameters, methods, processes, and model results. Strengthening the co-operation among modellers from different institutions and regions was seen as the only way to develop indispensable bio-ecological operational models. Such models should be based on identified user requirements. Among the processes deserving more attention from a bio-ecological operational perspective, were transport and ecosystem models, benthic processes, and benthic-pelagic interaction.

Participants strongly recommended improvement in building and using long-term databases. They suggested the initiation of such databases in hitherto neglected areas (e.g., Mediterranean, Black Sea) and advised that systematic collection of biological data should be performed by national and international agencies. In addition, easier access to databases was judged necessary and establishment of a “data analyses and data mining” software depository recommended. The "Continuous Plankton Recorder" was specifically commended for quality and accessibility.

Workshop participants identified a number of products from bio-ecological monitoring, some of which already result from existing models. They recommended emphasising visualisation of data analyses and model results in order to ensure wide use and easy access to operational oceanographic products. Among the products mentioned were: high quality data sets for scientific research (e.g., primary productivity); early warning systems for harmful algal blooms, oil spills, etc.; habitat mapping for different benthic organisms; measurement of fluxes and transport tracking of hazardous

substances and nutrients; monitoring and forecasting of stratification patterns; size of physically defined feeding areas for many fish species; and many others.

Recommendations

These recommendations were formulated in sub-groups after the workshop sessions and discussed during a plenary session. They are supplemented by suggestions voiced during workshop sessions. Please note that the recommendations do not have the same titles as the workshop sessions because some more detailed topics emerged.

1. <u>User involvement</u>

User involvement in the sampling strategy is of great value and must be given high priority. Users of bio-ecological operational oceanographic products identified by workshop participants are: the scientific community, environmental and public health agencies, coastal managers and decision makers, the public in general, fisheries and aquaculture business, shipping and tourist industry, and the navy. The following recommendations to improve the interaction with users were made:

a) EuroGOOS should initiate an additional user requirement survey directed at customers of biological operational products and assess their specific data needs and possible contributions to sampling and monitoring.

b) An improvement of interaction between marine scientists/operational agencies and politicians/public can be achieved through the following steps:

- Elaboration of a summary report that includes all marine bio-ecological variables and indicators suggested for operational use by groups of scientists should be made available for discussion with end users by GOOS, EuroGOOS and ICES
- Education of users of bio-ecological products as well as politicians and the public in general is important to help with strategic funding and the creation of useful and popular products. Scientists could play a crucial role in this process and help identify present and future needs of different applications in view of new technologies and products
- Public awareness of bio-ecological marine topics could be enhanced by an improved presence in the Internet of agencies and programmes
- EuroGOOS, ICES, and international conventions (OSPAR, HELCOM) should influence national governments and agencies towards greater acceptance of co-ordinated international monitoring. This includes preparation of material (possibly from projects such as Ferrybox and SeaFlux) showing the value of an approach that uses harmonised measurements throughout a region. This task is so important and labour intensive that an EU project initiated and/or supported by EuroGOOS, ICES, and EEA appears to be a good way to solve it
- EU directives could help turn national agencies into users of EuroGOOS products to improve environmental protection, human health, and resource management.

c) Contribution of stakeholders to sampling and monitoring could reduce costs and improve acceptance of operational oceanography. Many industries are collecting their own data due to a lack of oceanographic products and could greatly benefit from a co-ordinated system. Possible candidates mentioned are the shipping industry (that is already contributing in Ferrybox projects), fish and mussel farmers, port authorities, offshore industry, etc.

2. <u>Biological Monitoring Technology</u>

The main developments necessary to make biological monitoring technology fit for operational sampling, were viewed as follows:

a) Bio-sensors must be improved and new types developed:

- New medical technology should be regularly scrutinised for its potential usefulness in operational oceanography
- The development of acoustic assessment of zooplankton should be completed
- Development of visual sensors for ichthyoplankton (see below)
- Development of autonomous benthic sampling systems including optical imaging

b) Standardisation of the most common methods is desirable for data merging and quality control

c) Time series are needed for the calibration of remote sensing images in order to use them for primary productivity assessment

3. Fish Stock Assessment

Ecosystem considerations in fish stock assessment will be more important in the future and will require a new type of data in fish stock assessment. In this context, participants recommended:

a) Multiply scientific efforts to identify ecological variables and models that can be shown to have a significant effect on fish distribution and abundance. Re-evaluate the significance of primary productivity for different fish species in view of improved PP assessment methods. Also, consider the use of bottom variables instead of surface variables. Extreme physical or chemical conditions (e.g., high and low temperature, oxygen deficiency, etc) that can cause mass mortality or illness, should be taken into account.

b) Once these ecosystem variables have been established (including ichthyoplankton, see next recommendation), EuroGOOS and ICES should co-operate to determine a monitoring strategy, especially regarding spatio-temporal resolution and precision. As extreme events can have a distinct effect on biological organisms even at very short periods of duration, high temporal resolution of certain measurements might be necessary.

c) Spawning areas of commercial and non-commercial fish species should be regularly monitored by fisheries agencies. This, however, requires an improvement of our understanding of spawning patterns and environmental requirements in different fish species as well as the development of autonomous technology. It was therefore recommended to:

- Initiate a comprehensive 3-year ichthyoplankton survey (project to be initiated and supported by EuroGOOS and ICES) in European Seas. Perform spot checks every decade (ICES)
- Develop optical instrumentation that is already used in ichthyoplankton monitoring to reach an operational state

d) Non-commercial fish species should be given more attention by fisheries agencies than at present

e) Routine tracing of fish routes via radio tags should be given consideration

4. Sampling Strategy

a) It is highly recommended to adopt an integrated sampling strategy that co-ordinates different monitoring types and schemes (e.g., in situ, remote sensing and cruises) whenever possible. Such an approach requires intercalibration of related data and relies on the standardisation of methods and minimum quality requirements.

b) Operational bio-ecological models should be used as a starting point to determine the type of variables monitored and the spatio-temporal resolution of measurements.

c) The monitoring of many biological and chemical variables is time consuming and costly. Frequency and accuracy of such measurements will have to be carefully balanced against user requirements. To overcome some of these problems, it was suggested that we should:

- Create error models specifically for such variables
- Adopt a responsive sampling strategy, i.e., increase the frequency and/or accuracy of measurements when other data suggest a change in the ecosystem that might effect the variable of interest

d) For many variables, the optimum ratio between accuracy and spatio-temporal sampling resolution can be gained by extracting the necessary information from existing databases. More use should be made of this approach

e) Better use should be made of the high-frequency monitoring potential of smart moorings or ferry box programmes in order to improve model (forecast) precision.

5. Impact Indicators and Pollution

Impact indicators are crucial for coastal monitoring of pollution and eutrophication but are at present still lacking the required quality. An internationally co-ordinated, optimised, and standardised monitoring of inputs (from rivers, the atmosphere, and adjacent seas) and effects (on organisms and ecosystems) of chemical compounds (natural and xenobiotic) to the marine environment is therefore of great importance. Specifically, workshop participants recommended:

a) A common definition of important biological or ecological indicators is necessary in order to standardise and harmonise assessment in different areas
b) The development of new and improvement of existing indicators should be encouraged
c) For the time being, impact indicators should be supplemented by raw data
d) Progress should be made in revealing local transport patterns of contaminants in the water and the sediment for all European areas (OSPAR, EuroGOOS, ICES, EEA)
e) EuroGOOS and EEA should join forces and co-operate with other organisations (mainly OSPAR, Helsinki and Barcelona Conventions) to determine the types and spatio-temporal distribution of measurements (indicators) that could be integrated in a European Ocean Observing System

6. Long-term Databases

Workshop participants emphasised the necessity of supporting existing efforts of building long-term databases and of harmonising existing monitoring operations. In addition, data must be stored and preserved for future comparison. Finally, methods that can be used to extract the useful information from databases must advance. Specifically, participants recommended:

a) Start long-term bio-ecological databases in hitherto neglected areas, especially Mediterranean and Black Sea areas with the help of MedGOOS
b) Systematic collection of biological data should be performed by national and international agencies and not left to research institutes
c) Facilitate data access by
    - Using networks to improve and combine data sets from existing centres
    - Promoting the integration of modern user interfaces to important international databases that enable easy extraction and input of data
d) Develop more and new methods of extracting data from large databases. Establish a "Data analysis and data mining" software repository
e) Ensure that existing archives of biological material held by institutes and museums are appropriately curated and maintained as potential sources for retrospective study in the future as new techniques are developed
f) Ensure the continuation of the CPR, also in view of hindcasting changes in benthic communities through the variance patterns of meroplankton (Echinoderm larvae)

7. Data Analysis

Data analysis must be improved and extended. Workshop participants thus recommended

a) Establishment of (virtual) centres for data analyses which tasks it would be to assist with:
    - Education and training
    - Taxonomic identification
    - Modelling
b) Establishment of quality criteria for parameters, analytical and statistical methods, processes, and model results. This should be done in co-operation by international programmes and agencies, e.g., ICES, EuroGOOS, EEA etc.

8. Modelling requirements

a) Different transport and ecosystem models should be compared with each other and standardised before using them on an operational basis. They could be tested using data from projects such as Ferrybox and SeaFlux

b) The efforts of EuroGOOS in bringing together European modelling expertise are greatly appreciated and the importance of a continuation and broadening of the co-operation among modellers from different institutions and regions must be emphasised. Development of shared bio-ecological operational models that could become components of a European Ocean Observing System is only possible through the sharing of data and joint validation of models

c) High-frequency data are needed for the validation and calibration of ecosystem models, a few of which have been identified by workshop participants:
   - Flux data for the aquatic carbon cycle
   - Chlorophyll
   - Oxygen
   - Turbidity
   - Nutrients

d) The development of new ecosystem models should be based on identified user requirements, e.g., in consultation with EuroGOOS and using EuroGOOS and GOOS documentation

e) Nesting of models on different scales (mega, micro) is encouraged

f) Benthic processes and benthic-pelagic interaction deserves further efforts in understanding ecosystem dynamics and modelling

9. Products

Workshop participants identified a number of products from bio-ecological monitoring, some of which already result from existing models. Others will have to be developed. Initiation and support of research projects to develop such products is seen as a task of EuroGOOS. In addition, it was felt that visualisation of data analyses and model results should be given more importance to ensure wide use and easy access to operational oceanographic products. The following list should be analysed by the EuroGOOS Products Working Group and then transferred to the appropriate EuroGOOS Task Teams.

a) From the monitoring of primary productivity:
   - High quality data sets for scientific research (biodiversity, long-term trends in biological variability and community shifts)
   - Early warning systems for harmful algal blooms (based on transport patterns)
   - Detection of non-indigenous species among phytoplankton communities
   - Risk-assessment of environmental damage

b) From additional biological monitoring except fish:
   - Habitat mapping for different benthic organisms (EEA with EuroGOOS)
   - Zooplankton abundance and composition (EuroGOOS to establish formal links to the Working Group on Zooplankton Ecology)

c) From chemical monitoring:
   - Measurement of fluxes and transport tracking of hazardous substances (pollution) and nutrients (eutrophication)
   - Early warning (transport patterns) of oil spills, harmful algal blooms etc. to enable rapid response

d) From physical monitoring:
   - High-frequency measurements of many physical variables, e.g., temperature, salinity, turbidity, turbulence, currents, tides, wave height, etc. (already available in many places)
   - Monitoring and forecasting of stratification patterns

- Systematic quantification of oceanic inflow/outflow to European shelf seas, the Mediterranean and the Baltic Sea (product from existing models)
- Transport patterns by eastern boundary/shelf edge current (product from existing models?)
- Timing and intensity of spring stratification (spring bloom) (product from existing models)
- Measurement of the area/volume of Norwegian deep water areas (research necessary)
- Size of physically defined feeding areas for many fish species, e.g., salmon, herring, cod (temperature/salinity important in this context, research necessary)
- Parameterisation of deep water formation in the North Atlantic and Mediterranean Sea (product from existing models)
- Measurement of sediment re-suspension (long-term research)
- Sediment budgets at regional sea scale (long-term research)

e) From long-term monitoring (climate change):

- Evaluation of physical oceanographic and associated economic and social impacts for different periods into the future (research necessary)
- Prediction of effects using models in >what if' scenarios (ensemble modelling)
- Evaluation of regional and global consequences of North Atlantic thermohaline shutdown
- Feedback effects from ecosystems to physical climate models

APPENDIX 4 – USE OF MARINE ENVIRONMENTAL AND OCEANOGRAPHIC DATA TO MEET REQUIREMENTS OF INTERNATIONAL CONVENTIONS AND ACTION PLANS

Oceanographic data collected by fisheries agencies may have considerable and unexpected uses to other parts of the ocean user community, in particular to meeting the requirements of (i) the Framework Convention on Climate Change (UNFCCC), (ii) the Global Plan of Action for the Protection of the Marine Environment from Land-Based Activities (GPA), and (iii) Agenda 21.

This potential contribution may go unrealised because the ministries responsible for particular conventions may not know (or ask) what is going in other ministries that may be relevant to meeting the obligations of the conventions. It might prove possible to eliminate this problem if individual countries had mechanisms for conveying information across ministerial boundaries about the potential of their activities to contribute to meeting the obligations of conventions.

UNFCCC.

The Conference of the Parties to the UNFCCC has called for the climate system to be monitored as a means of detecting change and as the basis for differentiating between changes due to nature and those caused by humans. The relevant text is Decision 14/CP.4 on Research and Systematic Observation, in FCCC/CP/1998/16/Add.1, the Report of the Conference of the Parties on its Fourth Session, held at Buenos Aires from 2 to 24 November 1998, Addendum, Part Two: Action Taken by the Conference of the Parties at its Fourth Session; item 1. Decisions Adopted by the Conference of the Parties; which reads:

Recognising the significant national contributions made to the global observing systems for climate:

1) Urges Parties to undertake programmes of systematic observation, including the preparation of specific national plans, in response to requests from agencies participating in the Climate Agenda, based on information developed by the Global Climate Observing System and its partner programmes;
2) Urges Parties to undertake free and unrestricted exchange of data to meet the needs of the Convention, recognising the various policies on data exchange of relevant international and intergovernmental organisations;
3) Urges Parties to actively support capacity building in developing countries to enable them to collect, exchange and utilize data to meet local, regional and international needs;
4) Urges Parties to actively support national oceanographic observing systems, in order to ensure that the elements of the Global Climate Observing System and Global Ocean Observing System networks in support of ocean climate observations are implemented, to support, to the extent possible, an increase in the number of ocean observations, particularly in remote locations, and to establish and maintain reference stations;
5) Requests Parties to submit information on national plans and programmes in relation to their participation in global observing systems for climate, in the context of reporting on research and systematic observation, as an element of national communication from Parties included in Annex I to the Convention (Annex I Parties), and, as appropriate, from Parties not included in Annex I to the Convention (non-Annex-I Parties).

Annex I countries are the developed world. Consequently they are now asked by the UNFCCC to make ocean observations in support of climate and to submit their plans for doing so to the UNFCCC. Clearly many of the repeat hydrographic observations made by ICES could contribute to ICES nations' contributions of climate change measurements. But it is likely that they are made by agencies working for ministries other than those that attend the meetings of the UNFCCC, and so are unwittingly ignored. If they were reported, this would add value to the climate observing network, and to countries' abilities to show that they were in compliance.

GPA

In the case of the GPA, information on nutrients could be of special use. Nations are called upon to develop comprehensive, continuing and adaptive programmes of action within the framework of integrated coastal area management which should include provisions for:

◊ identification and assessment of problems;

◊ establishment of priorities;

◊ setting management objectives for priority problems;

◊ identification, evaluation and selection of strategies and measures, including management approaches;

◊ criteria for evaluating the effectiveness of strategies and programmes;

◊ programme support elements.

The problem areas focus on five elements:

(i) identifying the nature and severity of problems in relation to:

◊ food security

◊ public health

◊ coastal and marine resources and ecosystem health

◊ economic and social benefits and uses;

(ii) contaminants, including: sewage, persistent organic pollutants, radioactive substances, oils, nutrients, sediment mobilisation, and litter.

(iii) physical alteration, including habitat modification and destruction;

(iv) sources of degradation

(v) areas of concern, including: critical habitats, habitats of endangered species; shorelines, coastal watersheds; estuaries and drainage basins; specially protected marine and coastal areas; and small islands.

Among the activities required under >nutrients' are the following:

- identify areas where nutrient inputs are likely to cause pollution directly or indirectly;
- identify point sources and diffuse sources of nutrient inputs into these areas;
- identify areas where changes in anthropogenic nutrient inputs are causing or are likely to cause pollution, either directly or indirectly, and prioritisation of these areas for action;
- monitoring all aspects of eutrophication
- identifying marine areas in the region where nutrient inputs are causing or are likely to cause pollution directly or indirectly.

AGENDA 21

There is the general call for a GOOS by the UN Conference on Environment and Development (UNCED, through its Agenda 21. The first UNCED conference was in Rio in 1992. It will be followed up in a Rio + 10 progress meeting in 2002. Clearly observations from fisheries agencies could be seen as making considerable contributions to the achievement of the goals of Agenda 21. However, the attendees at the UNED follow-up are likely to be environment ministries unfamiliar with the potential contribution from fisheries ministries and their agencies.

APPENDIX 5 – TOWARDS A NORTH SEA ECOSYSTEM COMPONENT OF GOOS FOR ASSESSMENT AND MANAGEMENT

Proposal for a strategic workshop in Bergen, Norway, 5-7 September 2001, co-sponsored by IOC, ICES, OSPAR, the North Sea Conferences and EuroGOOS*

Background

In the Statement issued by the Intermediate Ministerial Meeting on the North Sea in Bergen, March 1997, on the Integration of Fisheries and Environmental Issues, the ministers adopted several guiding principles. One of these was that "further integration of fisheries and environmental protection, conservation and management measures, shall draw upon the development and application of an ecosystem approach". Until now such an approach has not been applied to a regional sea and internationally there is a need for a demonstration study. The North Sea, because of the intensive work that has already been carried out in this area, is an obvious candidate for a pilot project. Developing an ecosystem approach for the management of the North Sea will need an integrated monitoring and information system and a continuous updating of information which could be seen as a North Sea ecosystem component of the Global Ocean Observing System (GOOS).

Objective

To take forward the recommendation of North Sea ministers the workshop will aim to:

- agree on a strategy for a co-ordinated and harmonised observation network in order to progress the development of an ecosystem approach to North Sea management,
- develop the strategy in order to increase the efficiency and cost effectiveness of current national and international monitoring systems through the implementation of a pilot North Sea Ecosystem GOOS project which will integrate fisheries and oceanographic data.

The aim is to present the resulting strategic plan to the Ministerial meeting of the North Sea in March 2002.

Justification

All North Sea countries operate national monitoring and reporting systems for the marine environment, which have as end products elements of hind-casting, now-casting and forecasting. Some of this data collection is coordinated by OSPAR through the Coordinated Environmental Monitoring Programme (CEMP), by ICES through its fisheries related activities e.g., the International Bottom Trawl Surveys (IBTS), by the EU for various Directives or through initiatives such as SeaNet and EuroGOOS. Much of the ecosystem information produced, however, does not contribute to international programmes and is only available nationally. A considerable effort has been directed towards the production of assessment reports within the framework of OSPAR (QSR 2000), the North Sea Conferences and the Nordic Council of Ministers. All these reports identify the inadequacy of current systems for the collection of information on the North Sea. Until now no attempt has been made to establish a permanent and integrated information system for the North Sea, an approach which would have the synergistic effect of integrating all current national activities.

One of the main conclusions of the report of the ‘Workshop on the Ecosystem Approach to the Management and Protection of the North Sea’ held in Oslo on 15-17 June 1998 was:

“The present monitoring of the North Sea is often insufficient to reveal human impacts on the ecosystem. There is a need for improved, integrated monitoring through coordination and harmonisation of existing national and international monitoring activities, as well as through implementation of new methods and technology”.

These ideas reflect those expressed in the 'Strategic Design Plans' for both the Living Marine Resources Panel and the coastal component of GOOS.

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* This proposal was updated and revised after the meeting.

For marine ecosystems, meteorological and climatic variability are primary driving forces for ecosystem variability. Improved knowledge of the relationship between climate and changes in ecosystems would greatly benefit the difficult task of distinguishing between anthropogenic impacts and natural variability. A particular and new challenge in the future will be the use of environmental data within the annual assessment cycle for fish stocks by the fisheries research and management community. Such an approach will involve the bringing together of very large data sets and the application of new approaches to fishery assessment modelling.

There is thus a need to develop a harmonised system to monitor, assess and forecast the environment and ocean climate of European seas, taking into account existing operational collaborative mechanisms within meteorology, oceanography, modelling and remote sensing. The information from such a system will be of relevance not only to environmental assessment, but also for the assessment and management of living resources, coastal zone management and marine operations. The development of a harmonised and coordinated pilot observation system for the North Sea could be considered as a European contribution to international GOOS and would provide a framework for an improved input to regional conventions and other international environmental agreements.

Two co-conveners, one a fisheries biologist and the other an oceanographer will progress the workshop with advice from a planning group that will include representation nominated by the sponsoring organisations.

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APPENDIX 7 – AGENDA FOR THE MEETING

Meeting of ICES/IOC Steering Group on GOOS

Southampton 23 – 25 October 2000

Monday, 23 October

1000 – 1015	Welcome and opening of the meeting
1015 – 1030	The Chair: Background, objectives and expected results from the meeting

Background information

1030 – 1045	Nic. Flemming: Cooperation and interaction between ICES, IOC and EuroGOOS.
1045 – 1115	C. Summerhayes: The strategic design plan for Living Marine Resources and for the Coastal GOOS.
1115 – 1130	C. Summerhayes: GOOS and climate – A status report.
1130 – 1145	K.C.T. Zwanenburg: The Canadian approach; Monitoring the Scotian shelf ecosystem off Atlantic Canada.
1145 – 1200	J. Fischer: Report from the EuroGOOS/ICES Workshop on Bio-ecological Observations in Operational Oceanography in Den Haag, April 2000.
1200 – 1215	W. Lenz: The European Directory of the Initial Ocean Observing System(EDIOS) as a Thematic Network
1215 – 1230	M. Sinclair: A retrospective analyses of the Atlantic Canada monitoring during the cod collapse.
1230 – 1400	**Lunch**
1400 – 1700	***Development of the ICES-GOOS Implementation plan***

i) Harry Dooley/Mike Sinclair: Development of co-operative arrangements to enhance mutual awareness with IOC and EuroGOOS.

ii) Bill Turrell: Develop an ICES-Ocean Observing System (I-OOS) based on the ICES Ocean Climate Summary and other relevant products and to find ways to produce and tailor products exploiting the results of the ICES Ocean Observing System

iii) Roald Saetre: Desirability and possible ways to establish a coordinated and harmonised observation network and design a system for operational oceanography on an appropriate time scale for the North Sea (in co-operation with EuroGOOS),

iv) Newton/Harry Dooley: Develop and oversee the role of the North Sea IBTS quarterly surveys in the Initial Observing System of GOOS, and liase with and report to GOOS bodies as appropriate

Tuesday, 24 October

0900 – 1030	***Development of the ICES-GOOS Implementation plan***
	Discussion continue - conclusions
1030 – 1045	**Coffee Break**
1045 – 1100	C. Waldmann: Profiling moored instrument carriers with quasi on-line access to the collected data. – Background information
1100 – 1230	Harry Dooley: How to advise and support the Secretariat on GOOS-related matters. – Discussion and conclusions
1230 – 1400	**Lunch**
1400 – 1700	H.R.Skjoldal: Operational fisheries oceanography – the role and opportunity of ICES. How to define and promote the role of ICES in GOOS, taking into account input from ICES Advisory and Science Committees. – Discussion and conclusion.

Wednesday, 25 October

0900 – 1100	Roald Saetre: Identify a programme of workshops to facilitate the implementation of ICES-GOOS and to improve awareness of GOOS in ICES, including special sessions at the ICES Annual Science Conference. Discussion and conclusions.
1100 – 1130	**Coffee Break**
1130 – 1300	Finalising the discussion and closing of the meeting.

APPENDIX 8 – PROFILING MOORED INSTRUMENT CARRIERS WITH QUASI ON-LINE ACCESS TO THE COLLECTED DATA - BACKGROUND INFORMATION

Christoph Waldmann, University of Bremen, MARUM, Germany

The driving force for picking up the idea of moored instrument carriers results from the scientific need of doing multidisciplinary measurements to assess the effect of natural or anthropogenic induced changes of the system OCEAN. These instruments are supposed to enable long-term observations to investigate processes that occur episodically. These processes have a stronger impact on the variability of physical and biogeochemical processes in the ocean then have been accounted for in the past. Furthermore as the variability of the intrinsic parameters of the water column in time and space is high, instruments that allow to resolve these processes are needed. Moored systems are especially of interest as they have a more comprehensive observing capability than drifting systems especially in areas of high currents. They deliver data over long time periods in an unattended manner and complement surface satellite observations. As an additional important component the possibility of getting quasi real time data access will be implemented in the near future.

What are the advantages of using a moored profiler? First they are cost efficient as a single set of sensors for a wide depth range can be used. Second they deliver a coherent data set as no additional errors due to divergent sensor drifts as in the case of individual sensor arrays occur. Biofouling of the sensors will be prevented if the profiler is made to rest in the non euphotic zone. Continuous flushing of the sensors during the measurement enable high quality data or even more are required for some sensors like the optical plankton counter. Last not least due to the monotonic profiling capability high resolution measurements in time and space are made possible.

With all these advantages in mind it seems to be surprising that only few operational systems exist or are in use. Basically the building blocks for such a system are available. But current systems still show some technical deficiencies that have to do with limitations in energy or simply with technical malfunctions. By pushing this technology more vigorously a solution to these problems can be achieved.

It should be recommended to find ways to make this technology available for the monitoring of the coastal and deep sea environment. Together with an adequate communication link these approach will deliver valuable data for the long term observation of the changes of the global climate.

APPENDIX 9 – MONITORING THE SCOTIAN SHELF ECOSYSTEM OFF ATLANTIC CANADA

A. INTRODUCTION

Physical Features

The Scotian Shelf ecosystems cover about 185,000 km^2 of continental shelf (<400 m) off the southeast coast of Canada (Figure 1). Characterized by complex bottom topography with numerous offshore shallow (< 100 m) banks and deep (> 200 m) basins, they are separated from the southern Newfoundland Shelf by the Laurentian Channel and border the Gulf of Maine to the southwest. Surface circulation is dominated by a southwestward flow with low salinity waters from the Gulf of St. Lawrence discharging onto the Scotian Shelf on the south side of the Cabot Strait. Part of this flow rounds Cape Breton to form the southwestward moving Nova Scotia Current on the inner half of the shelf while the remainder flows along the Laurentian Channel, turns at the shelf break, and eventually enters the Gulf of Maine through the Northeast Channel. The amplitude of the annual cycle in sea surface temperature (16°C, Petrie *et al* 1996) in the region from the Laurentian Channel to the Middle Atlantic Bight is the largest anywhere in the Atlantic Ocean (Weare, 1977) and one of the largest in the world.

The vertical structure of the water column on the Scotian Shelf undergoes large seasonal variations. In winter, strong winds and cold air temperature result in rapid heat loss and water becomes vertically mixed to depths of 50–150 m. In spring and summer, solar heating combined with reduced salinity (due to ice melt and advection), make the surface waters less dense and lead to rapid stratification, trapping the cold, winter-mixed water below. In the central and western shelf generally warm offshore Slope water (a mixture of Gulf stream and Labrador current waters) moves in along the bottom beneath the winter-cooled waters because the offshore water is more saline and hence denser. The winter-chilled cold intermediate layer (CIL), with temperatures varying from 2–5°C, is sandwiched between warmer surface and bottom layers. The relative proportions of warm Gulf Stream and cold Labrador Current waters comprising the Slope water determines whether incursions of this water have a cooling or a warming effect. The amplitude of the North Atlantic Oscillation (NAO) is implicated in the relative volumes of these two water masses in the Slope water. A significant difference between the western and eastern shelf is that on most of the eastern Scotian Shelf bottom topography prevents the warm offshore waters from penetrating inshore and the CIL (< 5°C) extends to the bottom depths> 200-m). Therefore, bottom temperatures vary from 2^{o}–4oC in the northeast to 8^{o}-10^{o}C in the deep basins in the central and west (Zwanenburg *et al*. 2000). There are little to no seasonal variations at these depths

Annual changes in near bottom temperatures on the Scotian Shelf are among the most variable in the North Atlantic. Near bottom waters of the western shelf generally remained warmer-than-average from the 1970s to 1997 (Figure 2). The highest sustained temperature anomalies in the approximate 50-year record were observed in the mid-1990s. In 1998, cold Labrador Slope water again appeared with a subsequent lowering of temperatures in Emerald Basin by over 3°C (Drinkwater *et al.,* 2000). From the late-1960s to the mid-1970s, bottom temperatures in the northeast oscillated near or above average. They rose above normal around 1980 but by the mid-1980s, temperatures fell sharply. Below approximately 50 m, temperatures have generally remained colder-than-normal and the coolest in the approximately 50-year record occurred in the early 1990s. In recent years, the waters have been warming and are now approaching normal.

Dominant Biological Resources and population fluctuations

Fauna of temperate shelf systems such as the Scotian Shelf are relatively diverse and biomass is distributed over a wide range of trophic levels from marine mammals to interstitial benthic meiofauna. Fish fauna is the best studied and relatively species rich (100+ species) with dominance alternating between demersal and pelagic types over time. Overall contributions of primary, secondary and benthic productions to system biomass are not well understood because of a lack of synoptic monitoring at these trophic levels. The eastern and western parts of the Scotian shelf are considered closely linked but separate ecosystems because of differences in physical environment and in fish and invertebrate communities. The different temperature regimes also result in differences in growth rates for trans-shelf species. The eastern shelf fishes have traditionally been dominated by cod (*Gadus morhua*), redfish (*Sebastes spp*), haddock (*Melanogrammus aeglefinus*) and American plaice (*Hippoglossoides platessoides*), while the western shelf fishes are dominated by dogfish (*Squalus acanthias*), haddock, redfish and pollock (*Pollachius virens*). Zwanenburg *et al*. (2000) show that over the past 3 to 4 decades, there have been changes in the abundance and distribution of many marine species on the Scotian shelf. In both areas biomass and average size of demersal fishes have decreased significantly, particularly in the past 15–20 years. Some demersal fish populations have declined precipitously (particularly true of the commercially exploited species like cod and haddock) while at the same time the abundance of other species, both invertebrates, small pelagic fishes, and marine mammals has increased. These changes suggest that there may have been changes in the trophic structure of these ecosystems.

Although the changes in demersal fish abundance and species composition can be relatively well described, information on other trophic levels is less available. There are no synoptic time series of primary, secondary, or benthic production for the Scotian Shelf. Some data for specific years or for limited areas of the shelf are available but these are not sufficient to describe long-term dynamics. Information on biomass of dominant small pelagic species (mainly *Clupea harengus*, *Scomber scombrus*) is also inadequate due to lack of effective monitoring. Information on marine mammals is equally sparse with the exception of pinnipeds, in particular grey seals, whose population has been increasing at a rate of some 12% per annum since the early 1960s (Zwanenburg and Bowen 1990). Large migratory pelagic fishes (tunas, sharks, and swordfish) are seasonal transitory residents in these systems whose dynamics are best described at ocean basin scales rather than the Scotian Shelf scale. Seabirds form an important component of both systems, however there is little information on changes in distribution or abundance.

Environmental Influences on Living Marine Resources

For the eastern shelf we observe significant increases in the abundance of cold-water species concurrent with the negative temperature anomaly of the last 15 years. We observed significant increases in the numbers of capelin (*Mallotus villosus*), turbot (*Rheinhadtius hippoglossoides*) northern shrimp (*Pandalus borealis*), snow crab, (*Chionoectes opilio*), and sand lance (*Ammodytes dubius*). Although the increase in these species is partly attributable to the negative temperature anomaly, the low biomass of cod, a predator of all but turbot, must also be contributing.

Since the 1970s average weights of commercially targeted demersal fish decreased by 51% on the eastern shelf and by 41% on the western shelf. For both systems the integrated community size frequency showed long-term declines in proportions of large fish, and trawlable biomass of most targeted species is presently at or near the lowest observed. In the east these changes were coincident with a doubling of fishing effort, and a decline in bottom temperature to the lowest in 50 years. In the west fishing effort more than doubled while bottom temperatures reached the highest in 50 years. In both systems declines in biomass and average weight were more prevalent for commercially targeted species than for non-target species. Since the closure of the cod fishery on the eastern shelf in 1993 and the restrictions on landings on the western shelf, average weights and the integrated community size structure have stabilized. In the east this stability is associated with increasing bottom temperatures and reduced effort while in the west it is concurrent with reduced landings and high bottom temperatures. Although both fishing and changes in bottom temperature have influenced demersal fish size, the relative effects cannot be determined from current observations.

Fishing and other human activities such as oil and gas exploration and extraction are conducted within this dynamic physical and biological framework. The systems “upstream” of the Scotian Shelf (Gulf of St. Lawrence and Grand Banks) are generally colder more boreal systems. Although the causal mechanisms are still topic of debate, a shift in the boundary between these systems and the Scotian Shelf was evidenced by the build-up of cold-water species especially on the eastern shelf during the late 1980s trough mid 1990s. The interaction between Scotian Shelf and the adjacent open ocean system comes mainly through the incursion of warm-core rings, and entrainment of Slope waters.

B. Present Monitoring and Additional Requirements

I Atmospheric and Oceanographic Information

1. Atmospheric Information

- Air pressure;
- Air temperatures;
- Geostrophic wind;

1. Oceanographic Information’

- Freshwater inflow;
- Ocean features (warm- core rings, 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;
- CTD (conductivity, temperature, depth) profiles are collected from ships of opportunity. These include all major research cruises, including the annual groundfish trawl surveys. These casts provide extensive information on salinity and temperature profiles as well as bottom temperature over much of the Scotian Shelf seasonally.
- Sea level;

II Plankton Information

- A 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 during the putative 'regime shift'.
- Additional requirement for a more synoptic coverage of zooplankton diversity and production
- Additional requirement for seasonal / annual estimates of primary productivity based on analysis of satellite imagery.

III Fisheries Information

- Fishing effort by gear type and location (geo-referenced);
- Landings by species and location (geo-referenced);
- Size and age composition of landings for several commercially important species;
- Additional requirement for by-catch of non-commercial species caught during commercial fisheries or killed during other human activities, this is especially true of species that are deemed at risk of extinction.

IV Fish Biological Information

- Commercial and non-commercial groundfish abundance, distribution, size structure, state of maturity, and diet composition (annual trawl surveys 1970 to present);
- Additional requirement for number and locations of spawning locations is required
- Additional requirement for selection differentials for certain commercially exploited species is required
- Additional requirement for bottom areas disturbed by ocean use activities including fishing.
- Additional requirement for improved knowledge of species composition, abundance and distribution of benthic invertebrate fauna of disturbed and undisturbed areas. These invertebrates are not currently monitored and have not been well characterized.
- Additional requirement for distribution and abundance information on species at risk of extinction. Although present trawl surveys provide good information on distribution and abundance of most demersal fishes, small pelagic fishes, small demersal fishes, and demersal forage fishes are not well sampled.

V. Predation Monitoring

- Grey seal abundance;
- Additional information on condition abundance and food habits of selected key predators on forage species

VI. Monitoring Scheme

Monitoring of marine ecosystems should be designed such that they detect changes in the abundance and distribution of at least the dominant organisms at all trophic levels. They should also detect changes in ocean structure and processes, particularly changes in boundary conditions with adjacent marine systems. The key is that the biotic and abiotic components of ecosystems are inherently dynamic exhibiting regular cyclical as well as random changes. Therefore it is important to define what type of change is being sought and how to differentiate it from natural background noise. Discerning directional change and perturbations of cycles from regular normal change, and attributing cause to those changes are essential especially for developing mitigative or adaptive responses to the changes

C. Modelling Requirements

Over the past 3 to 4 decades, we have observed changes, at times dramatic, in environmental conditions, exploitation, and the abundance and distribution of many marine species on the Scotian shelf. Attempts to disentangle the fishery and environmental effects leading to ecosystem change have, so far, been inconclusive. Multidisciplinary and ecological approaches are being undertaken to better understand the changes that have occurred in the Scotian shelf ecosystems. Specifically, these projects are aimed at determining how the physical and biological components of these ecosystems have changed over time and space and what the relative contributions of environment and fisheries have been.

D. Capacity Building Requirements

The additional monitoring requirements are identified in Section C. Further capacity building requirements are discussed in the context of the retrospective analysis of Scotian Shelf monitoring reported in Section E.

E. Retrospective Analysis of Scotian Shelf Monitoring

At the first LMR-GOOS session, 23–25 March 1998 it was recommended that several well monitored shelf seas that have been characterized by 'regime shifts' be evaluated in a retrospective sense. The monitoring program of the eastern Scotian Shelf in support of fisheries management was one of the case histories. The retrospective analysis was restricted to the 1987 to 1994 time period. During these years the cod stock in this area declined from moderate levels to the lowest on record. A moratorium on directed commercial fishing of this stock was put in place in September 1993. The North Atlantic Oscillation (NAO) anomaly was strongly positive from the mid-1980s to the mid-1990s. During the same time period, major changes in the ecosystem occurred (see above). Thus the 1987 to 1994 time period brackets the decision-making period during which there was a 'regime shift', the cod stock collapsed and the fishery was closed. The analysis is published as Annex IV of GOOS Report No. 74. A summary of the monitoring program and the conclusions of the retrospective analysis are provided below.

The Scotian Shelf ecosystem has been monitored to some extent for over two decades. Monitoring includes the extensive list given in Section B and indicates that the monitoring activities focused on fishing, trawlable fish and invertebrates, grey seals, and ocean/atmosphere physical parameters.

It was concluded that the monitoring programme itself was adequate for the needs of the fisheries management system. 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 some gaps, including trends in plankton production added to the core-monitoring programme in 1999 (Theriault *et. al.* 1998).

It is instructive to separate out two functions of the monitoring programme - 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 above listed monitoring activities are adequate to describe aspects of ecosystem and fishing changes (fishing patterns, seals, fish communities, state of the ocean/atmosphere). The programme on its own was not, however, sufficient to interpret the causes of the cod collapse. It should have been sufficient to support the decision-making process in support of achievement of the conservation objectives of fisheries management.

There is significant caveat to the above conclusions. 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 cod natural mortality (M). Without a fishery since 1993, it has recently been possible to estimate M directly from the trawl survey data. The stock assessments had assumed a constant level of M (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 clearly limits to what a monitoring programme can capture.

It was concluded that the analysis of the monitoring data was inadequate. The reasons for the inadequate analysis were both institutional and scientific. Only part of the data available from the monitoring programme was routinely analysed; and some informative data products for fisheries effort, oceanographic properties and fish community information were only available in retrospect. It was also concluded that limits to theoretical understanding of ecosystem structure and function were (and still are) a constraint to the interpretation of the data products. 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 cod growth rate and poor fish condition are also not well understood. The observed trends in cod population characteristics are no doubt responses to a contribution of overfishing and ecosystem change. There are limits to explanatory power within marine ecology, even for major 'regime shifts' in a well monitored system such as the eastern Scotian Shelf.

Key points for LMR-GOOS are:

- The monitoring programme itself was sufficient to describe the 'regime shift' changes in near real-time and to meet the advisory needs for fisheries management.
- The programme was not sufficient to interpret the causes of the collapse of the cod stock, even in hindsight.
- Timely analyses of the full range of ecosystem monitoring data, and the generation of accurate data products, are essential for the provision of credible advice to fisheries management.
- This requires institutional structures that generate and review the data products for management needs.

Changing Needs for Scientific Advice

The Convention on Biological Diversity (CBD) the Straddling Stocks Convention (UNFA), and the Code of Conduct for Responsible Fishing have generated broader conservation objectives for the management of ocean use activities. The 1997 Oceans Act obliges Canada to incorporate ecosystem objectives within an integrated oceans management framework. The pending legislation addressing species at risk of extinction will generate recovery plans for endangered marine species. Thus we are in a transition period with respect to the need for scientific advice on management of ocean uses (oil and gas, aquaculture, marine transportation, eco-tourism, recreational use and fisheries). Management will continue to occur at the sectoral level, yet the aggregate activities need to meet some yet to be defined ecosystem objectives. The scientific advisory context for LMR-GOOS is in transition. Fisheries management needs to take into account ecosystem considerations, and other ocean uses have impacts on the ecosystems that need to be evaluated in relation both to the fisheries impacts and the broader conservation objectives inferred under new international conventions and national legislation.

Ecosystem Objectives, Indicators and Reference Points

The ICES/SCOR Symposium on the Ecosystem Effects of Fishing, which was held in Montpellier in March 1999, provided some guidance on a framework for the incorporation of ecosystem considerations within fisheries management. The Symposium overview paper (Gislason et. al. 2000) lists six potential ecosystem objectives for ocean management, three address biodiversity and three habitat productivity. The traditional conservation objective for the target species of fisheries management is subsumed within the latter three. For each objective there will be a need to define indicators of relevance as well as reference points that trigger management action. The objectives, as well as examples of indicators and reference points are provided in Table 1.

At a March 2000 Canadian LMR-GOOS workshop at the Bedford Institute of Oceanography there was a detailed review and discussion of indicators for each of the six objectives. To the degree that a region wants to achieve a particular objective, LMR-GOOS for that ocean area needs to monitor properties that will generate data products on the respective indicators.

Maintenance of Ecosystem Diversity

The benthos is considered separately from the pelagic component of the marine biota. Due to recent advances in multi-beam and side-scan sonar it is now possible to routinely map the bottom sediment type and define the number and geographic pattern of bottom communities in 'benthic ecosystems' that need to be maintained. The indicators to be monitored are 1/ the spatial extent of disturbance (by fish gears, oil/gas operations, aquaculture sites, etc.) for each category of benthic habitat in the classification scheme, and 2/ benthic community properties in 'no disturbance' areas (MPAs) and disturbed areas for each benthic ecosystem type. For this objective it is assumed for planning purposes that some percentage of each habitat type would need to be undisturbed.

The indicators would be measures of geographic patterns in plankton and fish community structure. The present monitoring activities on the Scotian Shelf (CPR line, seasonal zooplankton net hauls on transects, ecosystem trawl survey from Cape Hatteras to Cape Chidley) should be sufficient to generate the data products.

Maintenance of Species Diversity

The minimum required for this objective is to provide indicators for the Recovery Plans of the species at risk of extinction. For the Scotian Shelf the species for which Recovery Plans are already in place, or are expected to be developed, are Right whale, Harbour porpoise, Leatherback turtle, Bay of Fundy Atlantic Salmon, and Nova Scotia 'Uplands' Atlantic Salmon. Other species of particular concern are sharks and skates (due to their low productivity) and possibly cusk. The indicators need to be considered at the geographic scale of evolutionary significant units, and are species specific. They include:

- Rate of population decline
- Contraction in distributional area
- Number of spawning components
- Number of individuals and effective population size (Ne)
- 'Integrity' of essential habitat
- By-catch, or mortalities

Maintenance of Genetic Variability within Species

The indicators for this objective have some overlap with that above, but need to be considered for a much wider range of species, in particular for species that are commercially exploited. There are at least two high profile concerns, the loss of spawning components and the reduction in genetic variability within populations (both due predominantly to fishing practices). The indicators include:

- Number of populations for exploited species
- Sex ratio
- Selection differential for life history parameters such as size-at-age and age-at-maturity
- Nearest neighbour estimates for sessile invertebrates

Maintenance of Directly Impacted Species

This objective subsumes the need to prevent growth and recruitment overfishing of the commercial species targeted by the diverse fisheries on the Scotian Shelf. The targeted indicators are:

- Spawning stock biomass (B)
- Exploitation rate (F)
- Recruitment Trends

Recently there has been a move to broaden the scope of the indicators to include such measures as:

- Size/age composition of landings and of the population.
- Weight/length at age
- Condition factor
- Aerial distribution of landings and of the population
- Fishing effort
- Compliance of fishers
- Enforcement capability

With the use of a broader range of indicators a qualitative traffic light approach (green/yellow/red ratings by indicator) is envisioned, which would complement the present use of quantitative assessment models. The traffic light approach (Caddy 1999) considers the state of an array of variables or indicators relevant to the status of individual fish stocks, or at a higher-level organization, the status of the ecosystem as a whole. To evaluate the status of system, the state of each variable is evaluated relative to a limit reference point, if defined, or to its historical dynamic range. The state of each variable can then be judged as either good, bad, or intermediate (red, green or yellow) and the integration of the states of all variables gives an indication of the status of the system. The value of this approach is that it allows incorporation of a broad array of indicators into the determination of ecosystem status. It also allows for both qualitative and quantitative measures to be evaluated in a single framework within which judgements on reliability, accuracy, or importance of each indicator can be explicitly defined. The traffic light approach could allow for truly integrated evaluation in that it could incorporate stock indicators, ecosystem indicators, economic and social indicators, and indicators of regulatory compliance. Within such a framework ecosystem considerations or objectives can be defined as limit or target values for integrals of an array of indicators.

Maintenance of Ecologically Dependent Species

This objective addresses the importance of food-chain interactions amongst the target species of commercial fisheries and the key predators and such species. It is of particular interest for fisheries on forage species such as krill and small pelagics. CCAMLR has been a leader on how to deal with this ecosystem consideration. There are two approaches. The first was the traditional indicator for the target species (F and B), but takes into consideration that a larger biomass should be sustained than is the case under traditional fisheries management approaches. In essence the reference point for biomass of the target species changes, but the indicators stay the same. The second approach includes the monitoring of key predators of the targeted forage species under commercial exploitation. Indicators could include:

- Abundance of key predators of exploited stocks
- Condition of key predator
- Percentage of prey species in diet of predator

Maintenance of trophic level balance

This objective addresses emergent properties of ecosystems, and is somewhat controversial. There is a need to monitor properties of marine biological communities that are indicators of their structure and function, even though at this time there is no consensus on optional states of trophic level balance. Indicators include:

- Slope of the size spectrum
- Pauley's FIB index
- Aggregate removals by fishing at each trophic level

The data required for the above indicators are already being collected on the Scotian Shelf. The indicators, however, are not being routinely tracked over time.

Summary on Additions to Present Monitoring Activities

The Canadian LMR-GOOS workshop indicates that there is a need to augment the present monitoring programme for the Scotian Shelf (and the rest of Atlantic Canada waters) if the broader ecosystem objectives are a component of integrated oceans management. The additions include:

- Bottom areas disturbed by ocean use activities
- Benthic community monitoring in disturbed and undisturbed areas by habitat type
- Targeted surveys for species-at-risk
- By-catch of species-at-risk and other mortalities due to human activities
- Numbers and locations of spawning populations for exploited species
- Selection differentials for certain exploited species
- Sex ratio of exploited species
- Condition, abundance and food habits of selected key predators on forage species

Research needs in support of Monitoring

A key challenge in the transition to integrated management of ocean uses is the need to assign causality to observed charges in marine ecosystems. If a change is observed in an indicator will we be able to associate that change with natural environmental variability or impacts of a particular ocean industry (e.g., oil/gas, aquaculture, fishing). Thus it is essential to monitor a broader suite of oceanographic and atmospheric indicators that allow description of natural climate variability and modelling of impacts. A second key area of research is on benthic habitat classification and definition of geographic spacing of MPAs. What percentage of the benthos for a given 'ecosystem type' should be undisturbed and what geographic pattern is required.

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APPENDIX 10 – ECOSYSTEM MONITORING AND ASSESSMENT TO SUPPORT AN ECOSYSTEM APPROACH TO MANAGEMENT

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Marine ecosystems

Marine ecosystems are open systems. Ocean currents flow through them carrying plankton and chemical substances. Fish and other organisms can have extensive migrations across any defined ecosystem boundaries. Climate variability is a major driving force for ecosystem variability, affecting in particular fish recruitment and population size. The biological components are interlinked through more or less tight trophic or other couplings. A number of human activities such as pollution, eutrophication, fishing, etc., impact not only the same ecosystem but to a considerable extent, directly or indirectly, the same components of the marine ecosystem, (Figure 1).

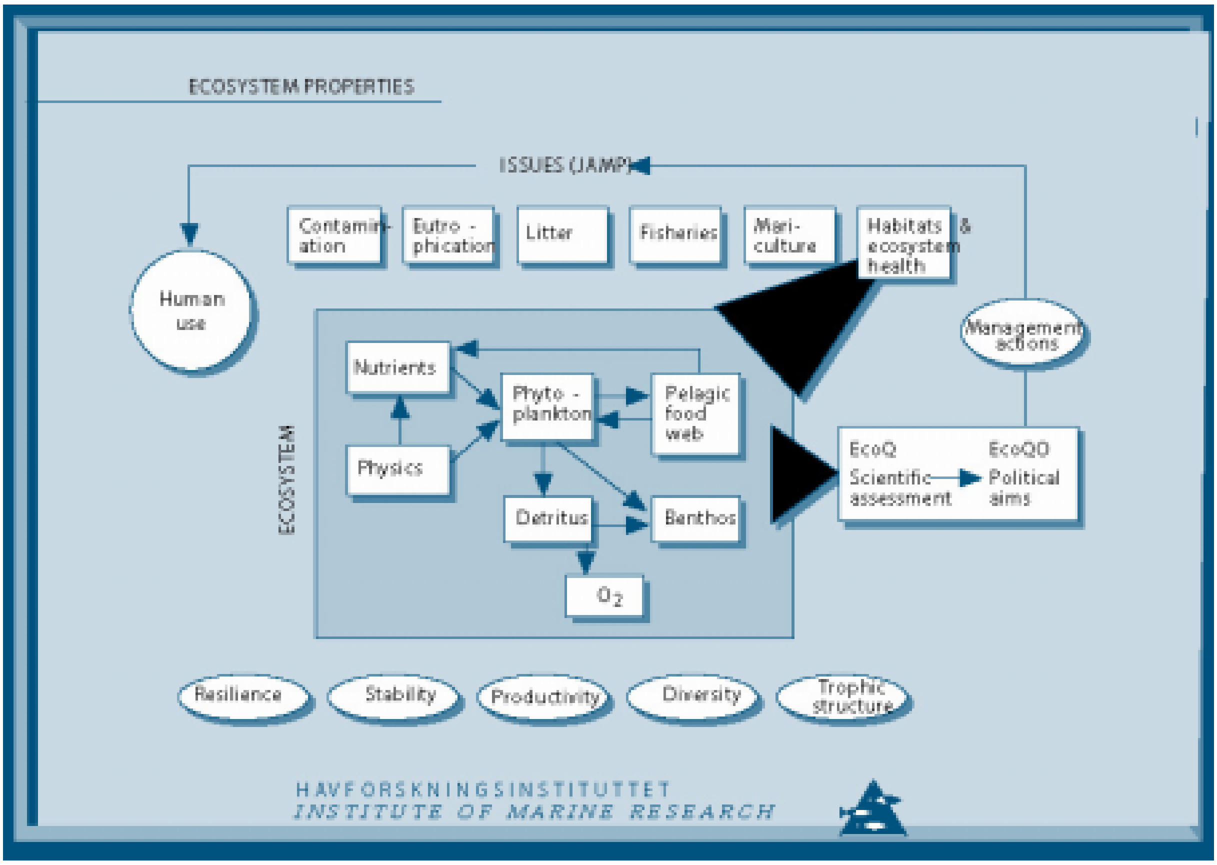

Figure 1. Conceptual framework for the methodology of describing Ecological Quality (EcoQ) and setting Ecological Quality Objective (EcoQOs). EcoQ is an integral expression of the state of an ecosystem, properties and human use. The human use variables are linked to the categories of issues of the OSPAR Joint Assessment and Monitoring Programme (JAMP), and provide a basis for setting objectives related to management actions. The various human uses impact the same ecosystem, and, directly or indirectly, the same components of the ecosystem.

The biological couplings and the multiple human impacts in open marine ecosystems are the main reasons why we need a holistic and integrated approach to our studies and management of marine ecosystems. The integration involves two different aspects or levels. The first level is the ecosystem, where we need to take into full account the integrated nature of marine ecosystems with their biological couplings and climatic driving forces. The second level is the management system where there is need for integration through close cooperation between the various sectorial management branches. These two levels of integration are the main principles and pillars of an Ecosystem Approach.

Ecosystem approach

An Ecosystem Approach (EA) is implicitly at the heart of the Large Marine Ecosystem (LME) concept which has been under development for more than 15 years by Ken Sherman from US NOAA with the support of scientists and managers from many countries world-wide. The EA is also considered to be a central concept for action to be taken under the Convention on Biological Diversity (CBD).

For the North Sea there is specific work ongoing to develop an EA. At The Intermediate Ministerial Meeting 1997 (IMM 97) in the North Sea Conference framework, the EA concept was discussed as a part of the integration of fisheries and environmental policies. In the Statement of Conclusions from the IMM 97, the ministers and commissioners stated (paragraph 2.6) that further integration of fisheries and environmental protection conservation and management measures should draw upon the development and application of an ecosystem approach, emphasising critical ecosystem processes and food web interactions.

At a "Workshop on the Ecosystem Approach to the Management and Protection of the North Sea" held in Oslo in June 1998, conceptual framework for an EA was developed. This and other similar frameworks were considered by ICES ACME in June 2000.

ACME proposed the following definition for an Ecosystem Approach to Ocean Management:

"Integrated management of human activities based on knowledge of ecosystem dynamics to achieve sustainable use of ecosystem goods and services, and maintenance of ecosystem integrity".

ACME also proposed a general framework for an Ecosystem Approach (Figure 2). This identifies five modules in repetitive sequence in a management process.

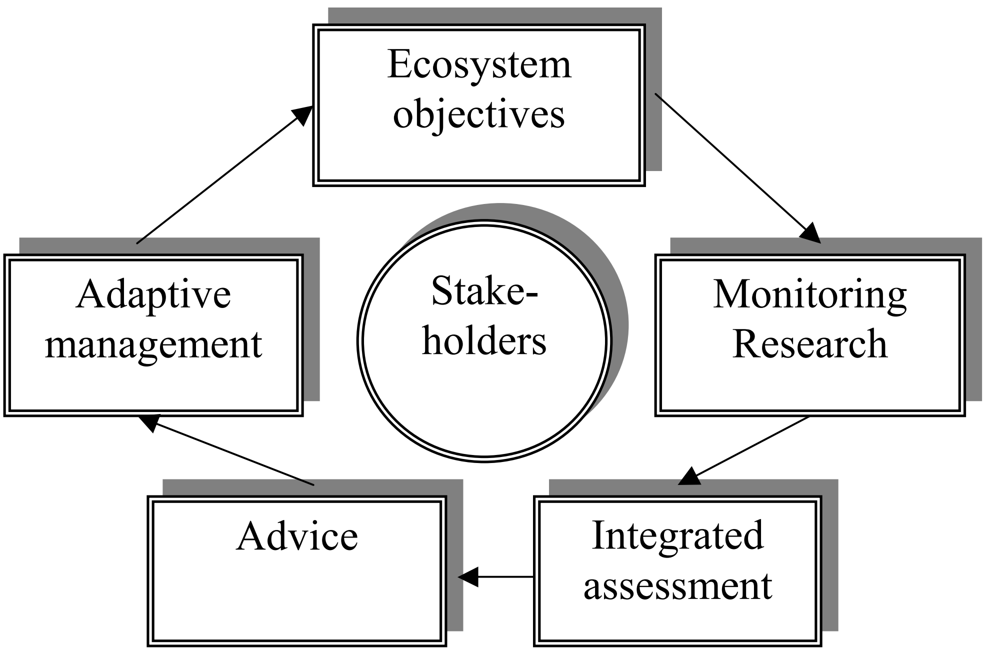

Figure 2. Proposed framework for an ecosystem approach for ocean management.

Ecological Quality Objectives

The need to establish operational ecological objectives has been clearly recognized.

A workshop on Ecological Quality Objectives (EcoQOs) for the North Sea was held in Scheveningen in September 1999. A set of 10 issues was agreed for which EcoQOs may be developed in the future work:

1. Reference points for commercial fish species
2. Threatened or declining species
3. Sea mammals
4. Sea birds
5. Fish communities
6. Benthos communities
7. Plankton communities
8. Habitats
9. Nutrient budgets and zooplankton
10. Oxygen consumption

ICES is working together with OSPAR and with contributions from the Netherlands and Norway as co-lead countries, in developing suggestions for specific EcoQOs. The aim is to present these at the 5th North Sea Ministerial Conference in March 2002.

Ecosystem monitoring

Monitoring and research need to be closely related for a number of reasons. Monitoring provides data and information on long-term and large-scale patterns of change, which is a major source of research into the mechanisms behind such patterns. Monitoring provides also a background and historic reference for short-term process-oriented research. Research, on the other hand, provides insight, which facilitates interpretation of monitoring results. It also contributes to improved methods and techniques for monitoring. With regard to environmental assessments, data from research activities contribute substantially as a supplement to monitoring results in describing the status and trends in the environmental situation.

Ecological management objectives must be supported by updated information from monitoring. Development of new EcoQOs may require adjustment of existing monitoring programmes. There is at present a considerable amount of monitoring being carried out for various purposes, much of it as national programmes. There is a considerable potential for improved collection and utilization of data through coordination and harmonisation of ongoing national and international monitoring activities.

Ecosystem assessment

Updated information from monitoring is used at regular intervals along with general knowledge from research, to produce assessments. Assessments of fish stocks are generally produced on an annual basis, while comprehensive environmental assessments (e.g., Quality Status Report) are prepared at several years intervals. There is a need to improve integration of these assessments. On one side, more information on environmental variability could be used to improve assessments and forecasts of fish stocks. On the other side, more information and expertise on fish stocks and fisheries could improve environmental assessments.

An environmental assessment is a comprehensive analysis and statement of the status and trends in the environment and the extent of impact by a range of human activities. There are two main challenges in conducting an environmental assessment:

1) Any influence of human activities must be distinguished from the background of large natural variability.
2) Effects from different human activities must be distinguished from each other.

For example, it may be difficult to conclude whether observed changes in benthic communities are due to natural variability or anthropogenic factors, and in the latter case, it may be difficult to distinguish between effects from fishing, eutrophication, and possible other human activities.

A conclusive assessment requires extensive data and careful analysis. It follows from the interlinked nature of components of marine ecosystems and the multiple human impacts upon them, That there is a large common element in the data and information required to assess the impacts of various human activities. (Table 1). Contaminants and nutrients are dispersed and transported by the same hydrodynamical and sedimentation processes. Nutrients lead to stimulated plant production an altered flows of energy and matter in pelagic and benthic food chains. Contaminants are taken up by organisms and transported in the same food chains, where they exert their biological effects, particularly at high trophic levels for toxic and persistent substances that biomagnify. Fisheries impact the same food chains with direct effects on targeted and by-catch species and direct effects through altered predator-prey relationships. Mariculture may involve release of nutrients and contaminants, organic enrichment and impact on benthic food webs, and spread of disease and genetic influence from cultured to wild organisms. While some of these effects are local, they need to be integrated and assessed in relation to the wider ecosystem.

Variables	**Contaminants**	**Eutrophication**	**Fisheries**	**Mariculture**
Physical				
Topography	X	X	X	X
Hydrodynamics	X	X	X	X
Hydrography	X	X	X	X
Chemical				
Nutrients	(x)	X	(x)	X
Oxygen	X	X	X	X
Seston	X	X	(x)	X
Contaminants	X	(x)	X	X
Biological				
Plankton	X	X	X	X
Benthos	X	X	X	X
Fish	X	X	X	(x)
Mammals	X	(x)	X	
Seabirds	X	(x)	X	(x)
Biological effects	X			

Table 1. Simplified representation of the need for data and information for thematic assessments of the ecological effects of contaminants, eutrophication, fisheries, and mariculture. Since the impacts are affecting to a large extent the same components of the ecosystem, either directly or indirectly through food-web interactions, there is a high degree of common data need.

Common data need

The large common element in data and information need for environmental assessment of impacts of different human activities is a strong argument for better coordinated and integrated ecosystem monitoring and assessment. At present there is a wide range of monitoring activities, which are operated for a number of different purposes both nationally and internationally. There is a great potential in better coordination and utilization of the results to achieve more cost-efficient ecosystem monitoring and assessment.

The present sectors of fisheries management, environmental management, and maritime operational services have to a considerable degree the same need for data and information although on different time scales (Figure 3). Ocean climate variability is a driving force affecting both commercial living marine resources as well as non-commercial biota. The commercial and non-commercial organisms interact and are being impacted by fishing activities. There is a need to take into account the ocean climate variability and interactions with non-commercial biota in the resources assessment and prediction used as a basis for fisheries management. The commercial living marine resources are major components of marine ecosystems. The ocean climate variability and status and interactions between commercial and non-commercial biota need also to be taken into account in environmental assessments supporting environmental management. Detailed descriptions of the physical state and short-term predictions are the basis for maritime operational services. While the operational services require the data in real or near-real time, resource assessment may require the data within weeks or months. Environmental assessments may have an even longer delay between the time period for which the environmental conditions are being assessed and the production of the assessment. The mere fact that there is a shared need for temporally resolved data on ocean climate variability, commercial living marine resources, and non-commercial biota, should have us move towards a goal of coordinated ecosystem monitoring and assessment programme for the various large marine ecosystems as part of the Ecosystem Approach.

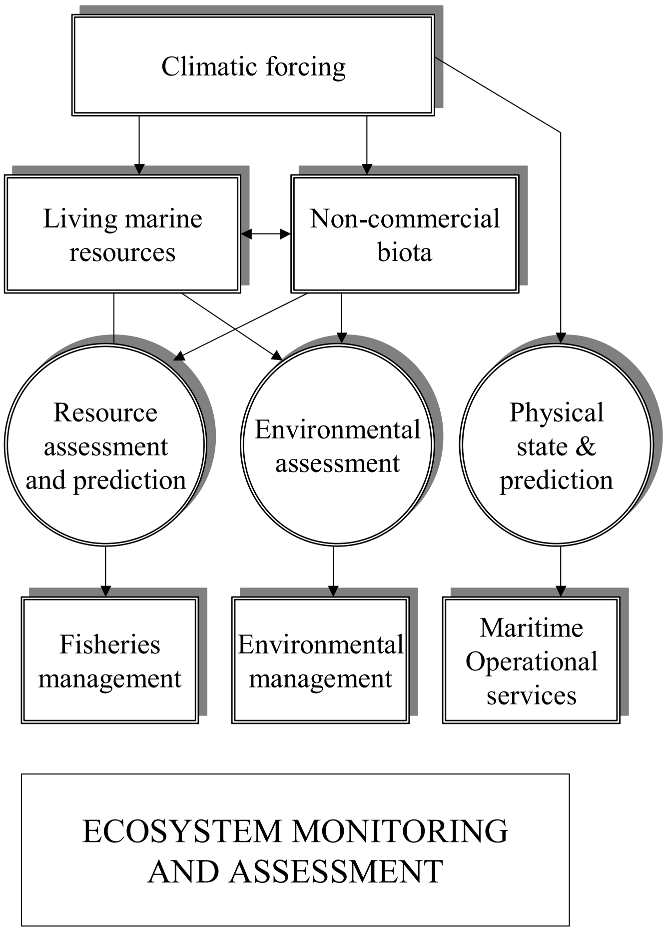

Figure 3. Common need for data and information on climatic and meteorological variability, living marine resources, and non-commercial biota for the purposes of the sectors of fisheries management, environmental management, and maritime operation services.

Scale consideration

Scale is an important aspect when defining ecosystems for practical purposes and for conducting ecosystem assessments. Large marine ecosystems (LMES) are defined as:

> *Extensive regions, typically greater than 200.000 km^2, having unique hydrographic regimes, submarine topography, productivity, and trophically dependent populations.*

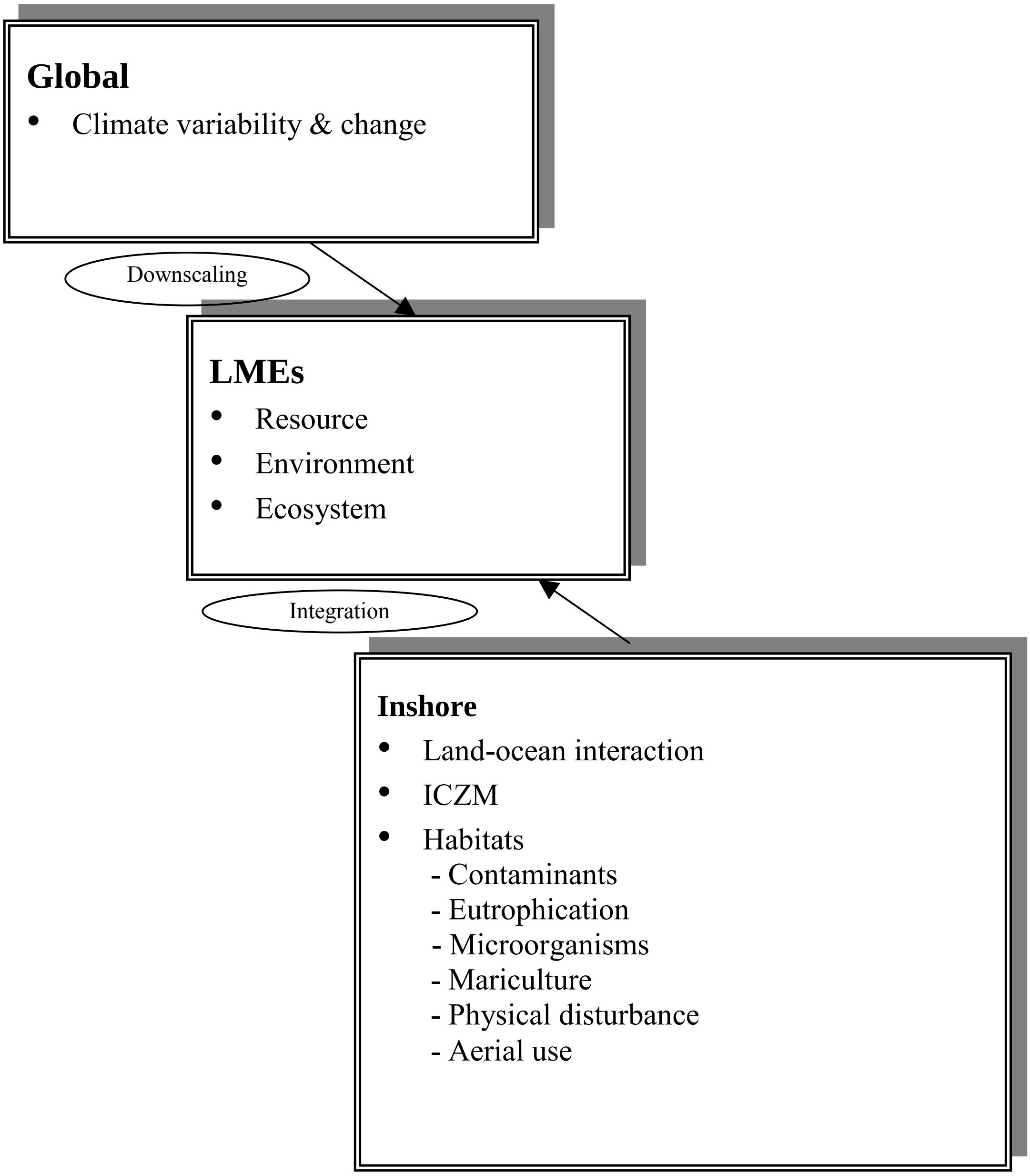

Figure 4. Linkages of three major scales. Assessments of living marine resources, environmental conditions and ecosystem state are most appropriately done on the scale of Large Marine Ecosystems (LMES). The effects of climate variability and change as ecological driving force are assessed through downscaling from global or large regional scale. The effects of multiple human uses and impacts on local scale in the coastal and inshore environment are assessed through integration for their summed and combined effects on populations and habitats at the scale of the larger ecosystem.

This is the typical scale of commercial fish stocks. Fish populations have a geographical closure of their life cycles, with spawning migration to defined spawning areas, drift of fish larvae to suitable nursery areas, and feeding migrations of juvenile and adult fish as major components. This geographical closure is against the dynamic and variable flow fields of ocean currents and circulation patterns. It is likely that variability in the flow fields has a directs impact on recruitment success and size of fish populations.

The climate variability (including meteorological variability) needs to be addressed and assessed at the global or large regional side. (Figure 4). Its biological effects and ecological consequences are most effectively dealt with at the scale of each individual LME. Downscaling from larger scale is a keyword in this respect. In contrast, a number of human use and impacts affect processes and features at the smaller scale, in the coastal and inshore environment. While many of these issues need to be addressed and dealt with at the local scale, there is also a great need to integrate their summed effects for populations and conditions in the larger ecosystem as part of an ecosystem assessment.

Scientific advice

Ecosystem assessment is seen as a key activity underpinning advice in the ecosystem approach framework. Based on assessments, scientific advice must be formulated to managers and policy makers. The scientific basis should be clearly outlined and the advice should be clearly stated. With more complex ecological relations to take into account in the ecosystem approach, this poses a particular challenge to the scientific advisory function.

APPENDIX 11 – IMPLEMENTATION PLAN FOR THE ICES-GOOS PROGRAMME

(Revised October 2000 by the ICES/IOC Steering Group on GOOS)

The Implementation Plan for the ICES-GOOS Programme consists of three main elements, viz:

1) the Global and Regional Linkage,
2) the ICES Ocean Observing System and
3) a regional ICES-GOOS Programme component for the North Sea.

Details of the three elements of the ICES Implementation Plan for GOOS are as follows:

1. The Global and Regional Linkage

a) IOC will co-sponsor the Steering Group on GOOS, including co-chairing it, and nominate GOOS representatives to join that Group as appropriate.

b) In order to ensure that ICES interests are being conveyed to the various GOOS Committees at national, regional and global levels a networking process will be established by putting national IOC-GOOS Programme representatives in contact with the national ICES representatives on the Steering Group. This will be achieved by the following procedures:

   i) IOC will provide the ICES Secretariat with the contact details for IOC-GOOS national representatives to be passed to the national ICES-GOOS Programme representatives of the Steering Group with a request that contact be made.

   ii) ICES will send to the IOC-GOOS Secretariat the contact details for the ICES-GOOS Programme national representatives on the Steering Group to be passed to the national IOC-GOOS representatives, with a similar request.

c) IOC will work with ICES to determine which of the ICES activities meet the GOOS Principles and would be best suited for adoption as elements of GOOS, either in an operational or a research sense including technology demonstrators or other forms of pilot projects

d) Consider how ICES might assist in “capacity building” to enable developing countries to participate in and benefit from GOOS.

e) Co-operative arrangements should be developed between IOC and ICES to enhance mutual awareness through the

   i) attendance of ICES Representatives at meetings of the Intergovernmental Panel for GOOS (I-GOOS), COOP, and the GSC

   ii) the attendance of GOOS Senior officer(s) or their representatives at the appropriate ICES meeting(s).

f) EuroGOOS and any other relevant regional GOOS Programme will participate in the Steering Group with a view to seeking common grounds and exploiting complementarity

g) The Steering Group will nominate ICES representatives, with the approval of the ICES Council, to serve as advisors to selected IOC-GOOS design panels and committees as appropriate.

2. The ICES Ocean Observing System

a) ICES should identify and propose existing operational (regular - at least once per year, routine - existing or planned for more than 10 years duration) ocean climate monitoring activities as ICES-GOOS Programme components. These may be standard sections or stations, spatial surveys or numerical model outputs.

b) Each member state should submit agreed results from each designated ICES-GOOS Programme activity within an appropriate time (e.g., one month from the end of a survey) through nominated national contact points and under the auspices of the Steering Group

c) The ICES Secretariat should maintain a list of all such ICES-GOOS Programme activities, monitor submission performance and produce summary data products (e.g. sub-sets of vertical profiles, averaged data) which will be rapidly communicated, using the Internet and the GTS network.

d) The Oceanography Committee and its working groups should work together to produce and tailor summary products on a periodic basis, at least annually, exploiting the results of the ICES Ocean Observing System. These will take into account the needs and timing of the Fish Stock Assessment Working Groups.

e) Develop further the pilot ICES Ocean Climate Status Summary produced by the Oceanic Hydrography Working Group, and other status reports as appropriate (e.g., that produced by ACME and also on behalf of the Nordic Council). The Working Groups, at the invitation of Steering Group, will consider on a regional basis which key environmental indices are most relevant, and present these in a brief, informative manner with the addition of expert interpretation. Once developed, member countries will undertake to supply the necessary input to each Working Group needed to produce the summary products on an annual or biannual basis.

f) The above activities should be identified as the ICES Ocean Observing System (I-OOS) which will complement ICES activities in fish stock assessment, which already has agreed data and model output collection, submission, and dissemination systems. The two components, the ICES Fish Stock Assessment products and the ICES Ocean Observing System, will form a substantial contribution to GOOS, while at the same time involving little additional effort than is already underway within individual ICES member states.

3) A regional ICES-GOOS Programme component for the North Sea

a) ICES, in cooperation with EuroGOOS and other relevant partners, and under the auspices of the Steering Group on GOOS establish a co-ordinated and harmonised observation network and design a system for operational oceanography on appropriate time scale for the North Sea. Such system may consist of a network of participating institutions with one institution acting as co-ordinator or “Lead institution”.

b) ICES should explore the feasibility to establish similar systems for other ICES regional seas, such as the Barents Sea, the Nordic Seas and the Labrador Sea.

c) Assuming the endorsement by ICES of the quarterly IBTS North Sea Surveys as an element of the Initial Observing System of GOOS, a formal liaison between relevant IOC-GOOS bodies and the Steering Group should be developed to ensure the continued application of GOOS Principles

d) The ICES-GOOS Programme component focused on the North Sea has the potential of offering the most comprehensive prototype integrated Coastal, LMR and HOTO system for the word community to consider.