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REPORT OF THE

STUDY GROUP ON ECOSYSTEM ASSESSMENT AND MONITORING

ICES Headquarters
8–12 May 2000

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 OPENING OF THE MEETING

The first meeting of the Study Group on Ecosystem Assessment and Monitoring (SGEAM) was opened by the Chair, Lars Føyn, at 10.30 hrs on 8 May 2000 at ICES Headquarters in Copenhagen. Six members of SGEAM were present from the start of the meeting. In his opening address Lars Føyn expressed his concern about the fact that the meeting had attracted so few participants. In preparation for the meeting, the Chair had sent several letters to potential participants, in particular the members of the former Working Group on Environmental Assessment and Monitoring Strategies (WGEAMS), asking them to forward the information to possible interested persons in their institutions. The Chairs of ACME and ACFM had also made efforts to attract new members to SGEAM, and had sent a letter about this to the members of their respective committees. The Chair of the Marine Habitat Committee had contacted the MHC members urging them to consider participation of national experts at the SGEAM meeting, and finally the General Secretary of ICES had sent a letter to the National Delegates asking for participation in SGEAM.

The Chair stated that three more participants would join the work of SGEAM later in the week, making a total of nine participants (see Annex 1 for the list of participants). Although the participants represented broad expertise in ecosystem matters, the lack of participation from the fisheries management side of ICES was particularly regrettable.

1.1 Terms of Reference

At the 86th Statutory Meeting, it was agreed that a Study Group on Ecosystem Assessment and Monitoring [SGEAM] (Chair: L. Føyn, Norway) would be established and meet from 8–12 May 2000 at ICES Headquarters to:

a) reflect on the scientific framework for an ecosystem approach for the sustainable use and protection of the marine environment, including living marine resources (based on the reports of the North Sea Conference's Oslo and Scheveningen workshops, and an ICES discussion document on ecosystem management of the Baltic Sea);
b) review the methodology and proposals for Ecological Quality Objectives for the North Sea;
c) evaluate the use of results from monitoring programmes and their effectiveness to support integrated (ecosystem) assessments in the ICES area using *inter alia* the OSPAR regional and 2000 Quality Status Reports for the North Sea, and the HELCOM Third Periodic Assessment of the Baltic Sea;
d) review existing regional monitoring programmes in order to:
    i. identify management questions/objectives and environmental issues,
    ii. identify ecological quality objectives,
    iii. identify indicators,
    iv. identify methods for integrating indicator results into a regional assessment;
d) review existing regional and international monitoring programmes in order to:
    i. synthesise management questions/objectives, ecological quality objectives, and environmental issues,
    ii. synthesise indicators for each management question/objective, and for each ecological quality objective,
    iii. identify best or most promising methods for integrating indicator results into regional assessments for the ICES area;
f) outline a programme of work for the next five years.

SGEAM will report to the ACME before its June 2000 meeting and to the Marine Habitat Committee at the 2000 Annual Science Conference.

2 ADOPTION OF THE AGENDA

The draft agenda (Annex 2) was adopted. It was, however, agreed that due to the workload and the importance of the topics in the terms of reference, SGEAM had to concentrate, in the first instance, on Agenda Items 5, 6, 7, and 10.

3 ARRANGEMENTS FOR THE PREPARATION OF THE REPORT

The members of SGEAM were asked to take proper notes of the various issues for discussion for the preparation of the report. Different parts for the report were prepared during the meeting and the Chair undertook to prepare a draft report to be sent to the participants via e-mail for comments and thereafter to ICES within two weeks, i.e., before 26 May, for the use of the June ACME meeting and further to finalise the report for presentation at the 2000 Annual Science Conference.

4 REPORTS OF ACTIVITIES IN OTHER FORA OF INTEREST TO THE MEETING

4.1 OSPAR

OSPAR has adapted a Joint Assessment and Monitoring Programme (JAMP) as the basis for its work to carry out environmental assessments and produce Environmental Quality Status Reports (QSR). The JAMP is based on a number of specific issues related to human use or influence on marine ecosystems. These issues are grouped into six major categories:

- Contaminants
- Eutrophication
- Litter
- Fisheries
- Mariculture
- Habitats and ecosystem health

Over the past few years OSPAR has been producing QSRs. The OSPAR maritime area has been divided into five regions:

I The Arctic (Norwegian Sea, Greenland Sea, Barents Sea, Iceland Sea, Iceland Shelf and East Greenland Shelf);
II The North Sea;
III The Irish and Celtic Seas;
IV The Bay of Biscay and Iberian Shelf;
V The Wider Atlantic (North-East Atlantic).

Separate QSRs have been produced for these five regions. These five regional QSRs were finalised and adopted in late 1999. A holistic QSR for the whole OSPAR area is now in the final stages of completion. The subregional QSRs and the holistic QSR 2000 are scheduled for publication in June 2000.

A conceptual framework of methodology for describing Ecological Quality (EcoQ) and setting Ecological Quality Objectives (EcoQOs) has been developed by OSPAR. EcoQ is defined as:

"An expression of the structure and function of the ecological system taking into account natural physiographic, geographic and climatic factors as well as biological, physical and chemical conditions including those resulting from human activities."

The information required for describing EcoQ and setting EcoQOs should, on the one hand, reflect basic ecosystem properties such as productivity, diversity, stability, and trophic structure and, on the other hand, reflect the various human uses. This will make it possible to identify connections between human uses and responses in the ecosystem, with the overall aim to safeguard the integrity of marine ecosystems.

The proposed framework methodology is flexible and can encompass a simple indicator approach as well as a more comprehensive information-based approach. It remains to work out the detailed content within the general framework for a given marine ecosystem. It has been agreed that this should be done for the North Sea as a first test case.

The work on developing EcoQOs for the North Sea has been done jointly within OSPAR and the North Sea Ministerial Conference (NSCs) framework, with Norway and the Netherlands as lead countries. The development of EcoQOs is seen as a necessary component of an Ecosystem Approach. A special workshop on EcoQOs for the North Sea was arranged in Scheveningen, The Netherlands, in September 1999.

4.2 EEA

The European Environment Agency (EEA) has adopted an indicator-based system for its assessment and reporting of environmental quality. The so-called DPSIR approach looks at a set of indicators linked in a chain from underlying

Driving forces (D) and Pressures (P), through State (S) and Impacts (I) in the environment, to management or political response (R). The use of indicators is related to the concept of bridging the gap between the complex environment and the political decision process and the information pyramid. The base of this pyramid is the detailed information required and provided from, e.g., environmental monitoring programmes and research. The indicators are aggregated information at intermediate or high levels, condensing and conveying the "message" provided by the detailed information at the base level of the pyramid.

EEA has been working through a number of European Topic Centres (ETCs). The ETC for Marine and Coastal Environment (ETC-MCE) is a consortium of scientific institutes from six countries. The ETC-MCE has been working on compiling and reviewing information on data collection and environmental assessments by the various international conventions for European marine waters. The work has focused on the development of indicators that can be used in the reporting and compilation by the EEA on the state of the European environment.

As part of its work programme, EEA and the ETC-MCE have convened so-called Inter-Regional Forum (IRF) meetings with participation from regional conventions and international organizations (HELCOM, OSPAR, AMAP, UNEP-MAP, BSEP, ICES, EC). There have been three IRF meetings focusing on common issues related to environmental assessments. At the Third IRF in Venice in September 1999, three working groups were established to consider further the issues of data management, indicators, and GIS (Geographical Information Systems), respectively.

5 DISCUSSION OF THE SCIENTIFIC FRAMEWORK FOR AN ECOSYSTEM APPROACH

In the terms of reference (TORs) for SGEAM, it states that the Study Group should reflect on the scientific framework for an ecosystem approach for sustainable use and protection of the marine environment, including living marine resources. As basic documents for the discussion the TOR mentions, SGEAM referred to reports of the North Sea Conference's Oslo and Scheveningen workshops and an ICES discussion document on management of the Baltic Sea.

In addition to these three documents, SGEAM members provided several documents of importance for the discussion. A list of the documents available for the discussion is presented in Annex 3.

SGEAM spent most of the available time on discussions on this agenda item. The results of the discussions would form the basis for further work of SGEAM. The opinion of the Study Group was also that the report of the discussion would be an important introduction to necessary discussions on a new approach and direction for ICES in management matters.

In the discussion, a need for clarification of terminology and definitions was clearly demonstrated, and it was decided that a common understanding of these terms would be important for the discussion in the Study Group and for further discussion within ICES. Section 5.1 reflects the view of SGEAM on definitions and terminology. Section 5.2 reports on the discussions on establishing a framework for an ecosystem approach. Section 5.3 presents scientific elements in the framework for the ecosystem approach.

5.1 Terminology and Definitions

Ocean management is a complex field encompassing multidisciplinary interests and expertise, including fisheries management and aquaculture, conservation and protection of marine resources and habitats, contaminants assessment and control, oceanographic and climate research, and the development of new technologies. Ocean management is also evolving within the context of international conventions and laws, emerging national legislation and initiatives, and the participation of multi-level governmental and non-governmental organizations.

There was agreement between the members of SGEAM that there is a need to define key terms used in an ecosystem approach to management. The main reason for this is that there are a number of confusing (sometimes synonymous) terms used in the broad context of environmental management (see SGEAM 5/1/00 and 5/2/00). These terms often lack clear definition, which leads to a lack of consistency in their use among different countries or among different organizations within a country. For example, the environmental quality objective approach to pollution management adopted by the United Kingdom is analogous in many ways to the North Sea Ecological Quality Objectives approach.

The UK approach uses the terms "ecological quality objective" (EQO) and "ecological quality standard" (EQS). An "EQO" is a desirable environmental goal which should be aimed for (e.g., maintenance of environmental quality so as to protect aquatic life). Fulfilment of each EQO is judged by establishing "environmental quality standards" (EQSs) for certain ecological criteria (e.g., sediment quality, benthic fauna, turbidity). This approach is analogous in many ways to the EcoQ/EcoQO approach. The environmental criteria are synonymous to the ten issues proposed for the development of EcoQOs, with each criterion/issue measuring a single component of the whole ecosystem. An "EQS" is a measurable component of the ecosystem, through which progress towards reaching the EQO can be measured. This illustrates how different management concepts, coupled with analogous terminology, can lead to confusion.

The following is a list of terms that the SGEAM considered important to define in order to set a solid foundation on which to build a scientific framework for an ecosystem approach to the management of marine resources.

(1) Ecosystem

There was debate among SGEAM members on whether or not humans are part of marine ecosystems. Some members of SGEAM consider that humans are not a marine species *per se* and thus are not part of the marine ecosystem, with which they interact. The other view is that humans are part of the marine ecosystem because of their strong linkage (exploitation and impacts) to that system. Whether humans are included or not is important because it has profound implications on how an ecosystem approach is structured. For example, if humans are part of the marine ecosystem, their impacts become an integral component of the ecosystem approach. **SGEAM came to the conclusion that humans have to be considered as part of the ecosystem since an ecosystem approach is about managing human activities**.

Ecosystem is a broad concept that can be approached from many different perspectives, but two common themes running throughout most definitions are that both organic (*biotic*) and non-organic (*abiotic*) components must be considered, and that interactions among the different components, including humans, have to be considered (see SGEAM 5/2/00). SGEAM came to the conclusion that the definition of ecosystem from the Convention of Biological Diversity (below) should be adopted for the purposes of ecosystem management, although it should be noted that, in principle, this definition is very similar to many others.

Ecosystem: "*a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.*" *(Article 2, Convention of Biological Diversity)*

This definition does not specify any particular spatial unit or scale, which allows the flexibility to refer to any functioning unit at any scale. Indeed, the scale of analysis and action should be determined by the problem being addressed. It could, for example, be a particle of soil, a pond, a forest, a biome or the entire biosphere, and it should be recognized that ecosystems exist at all scales and within any chosen boundaries. The choice of ecosystem boundaries has important implications on management because many important species have distributions which cross ecosystem boundaries, thus making management difficult. It can be useful from a management perspective to work at the scale of Large Marine Ecosystems (LMEs; see below) as this scale will often encompass commercial fish stocks.

(2) Large marine ecosystems (LMEs)

Large marine ecosystems are extensive regions, typically greater than 200 000 km^2, having unique hydrographic regimes, submarine topography, productivity, and trophically dependent populations. The underlying strategic approach to the assessment, monitoring, and management of LMEs is based on a five-module framework that includes consideration of (1) productivity, (2) fish and fisheries, (3) pollution and ecosystem health, (4) socioeconomics, and (5) governance.

(3) Ecosystem management, ecosystem approach or ecosystem-based management

Ecosystem management, ecosystem-based management, and ecosystem approach are synonymous terms. An ecosystem approach is usually a synonym for an integrated or holistic approach to ecosystem management. It recognizes the complexity of ecosystems and the interconnections among component parts. Ecosystem-based management does not imply an attempt to manage ecosystems by humans, but rather to manage human impacts on ecosystems. It recognizes that humans are an integral part of ecosystems and that human social and economic systems constantly interact with other physical and biological parts of the system.

The following twelve principles, taken from the *Convention of Biological Diversity*, are complementary and interlinked, and need to be applied as a whole when adopting an ecosystem approach:

1) *The objectives of management of land, water and living resources are a matter of societal choice.*
2) *Management should be decentralized to the lowest appropriate level.*

3) *Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.*
4) *Recognizing potential gains from management, there is a need to understand the ecosystem in an economic context.*
5) *A key feature of the ecosystem approach includes conservation of ecosystem structure and functioning.*
6) *Ecosystems must be managed within the limits of their functioning.*
7) *The ecosystem approach should be undertaken at the appropriate scales.*
8) *Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.*
9) *Management must recognize that change is inevitable.*
10) *The ecosystem approach should seek the appropriate balance between conservation and use of biological diversity.*
11) *The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices*
12) *The ecosystem approach should involve all relevant sectors of society and scientific disciplines.*

The following definition for Ecosystem Management is proposed by SGEAM:

"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."

This definition points to the need for a comprehensive and holistic approach to understanding and anticipating ecological change, assessing the full range of consequences, and developing appropriate responses. Principles 5, 6, and 10 from the *Convention of Biological Diversity* (listed above) are very relevant to understanding ecosystem management. Healthy ecosystems perform a diverse array of functions that provide both goods and services to humanity. The term "goods" refers to items given monetary value in the market place, whereas "services" from ecosystems are valued, but rarely bought or sold. Examples of ecosystem goods and services are provided in Table 5.1.1 as well as examples of the paradigm shift which comes along with ecosystem management (Table 5.1.2) (Lubchenco, 1994).

Table 5.1.1. Some examples of goods and services provided by ecosystems to humans (after Lubchenco, 1994).

HEALTHY ECOSYSTEMS PROVIDE:
Goods
Food
Medicinal Materials
Raw Materials
Wild Genes
Services
Absorbing and Detoxifying Pollutants
Cleansing Water and Air
Generating and Maintaining Soils and Reefs
Maintaining Hydrological Cycles
Maintaining the Composition of the Atmosphere
Pollinating Crops and Other Important Plants
Providing Sites for Tourism, Recreation, and Research
Regulating Climate
Storing and Cycling Essential Nutrients

Table 5.1.2. Some of the substantive changes between traditional resource management and ecosystem management (after Lubchenco, 1994).

ECOSYSTEM MANAGEMENT: A PARADIGM SHIFT	
From	**To**
Individual Species	Ecosystems
Small Spatial Scale	Multiple Scales
Short-term Perspective	Long-term Perspective
Humans: Independent of Ecosystems	Humans: Integral Parts of Ecosystems
Management Divorced from Research	Adaptive Management
Managing Commodities	Sustaining Production Potential for Goods and Services

(4) Ecological Quality (EcoQ)

"An overall expression of the structure and function of the marine ecosystem taking into account the biological community and natural physiographic, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities" (TemaNord, 1999:591)

The use of the words "surface water", instead of "ecosystem", were discussed during the Scheveningen Workshop. The conclusion reached was that the original wording of the North Sea Task Force, "ecosystem", is more appropriate for marine ecosystems. This conclusion was also reached by SGEAM.

(5) Ecological quality reference level

A reference level is defined as the level of ecological quality, based on scientific evidence, where the anthropocentric influence on the ecological system is minimal. The reference level has to take into consideration natural variability and trends. For example, the historic level for certain environmental conditions may not be an appropriate reference level for the contemporary ecosystem if this ecosystem evolved, through natural trends, towards different characteristics. It should be emphasized that the reference level should not be confused with the ecological quality objective.

(6) Ecological Quality Objectives (EcoQOs)

An ecological quality objective should reflect an ecosystem approach and integrate objectives for various ecosystem components, for example, within a multidimensional framework. It should be a political decision based on scientific advice to identify:

"the desired level of ecological quality relative to a reference level".

Within the OSPAR framework for Ecological Quality Objectives for the North Sea (EcoQOs), a set of ten issues was identified. These issues divide the ecosystem into manageable units, under which EcoQOs can be developed. Following discussion, SGEAM came to the conclusion that in order to implement an ecosystem approach, all ten issues should be considered together in an integrated manner. Measuring individual EcoQOs would not necessarily comply with an ecosystem approach. SGEAM also found that further work is required to review the ten issues proposed to ensure that all aspects of the ecosystem are accounted for. This would establish a framework through which EcoQOs could be proposed.

(7) Indicator

An indicator is a variable, or an index combining different variables, which provides information on the status of the ecosystem. Indicators are usually used to reflect trends in the state of the ecosystem and are used to monitor the success towards achieving management objectives. Indicators can provide information on the biological, physical, social or economic conditions. A simple classification for indicators includes pressure indicators, which reflect human influence on the natural environment (e.g., nutrient discharge), and condition indicators that address environmental conditions (e.g., nutrient concentration in a certain area).

(8) Sustainability

Sustainability is often used in the context of sustainable development, which has been defined in general terms as "development that meets the need of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission). In the context of ecological resources management, the sustainability concept carries two different aspects: sustainability of use (sustainable use) and sustainability of ecological resources/ecosystems. The two are tightly linked since sustainable use of ecological resources can only be achieved if these resources are themselves sustainable.

5.2 A Framework for an Ecosystem Approach

5.2.1 General approach

The task assigned to SGEAM is to discuss the framework for an ecosystem approach. In the follow up of the North Sea Intermediate Ministerial Meeting (IMM), a Workshop on the Ecosystem Approach to the Management and Protection of the North Sea was held in Oslo, Norway, in 1998. A mixture of scientists, policy makers, user groups and NGOs attended this workshop. Although some or even most of them were somewhat unfamiliar with the concept of an ecosystem approach, the meeting was constructive, resulting in clear recommendations for future work. The Oslo Workshop conclusions can be considered as the first European attempt to define a general framework for ecosystem management.

The ecosystem approach or ecosystem management originates from the United States where it was first introduced in forestry policies. Later it became an important approach in U.S. federal environmental policies and was strongly supported through the Clinton Administration (Lubchenko, 1994; Morressy, 1995; Eickemeyer, 1998). In the United States, NOAA's Northeast Fisheries Science Center in Woods Hole developed and implemented an ecosystem-based assessment and monitoring system that was integrated into marine fishery management advice in the early 1980s. More recently NOAA has been collaborating with the Global Environment Facility (GEF) in Washington, D.C., in assisting developing countries in the planning and implementation of an ecosystems approach to marine resource development and sustainability in international waters of Asia, Africa, Latin America, and eastern Europe (Sherman and Duda, 1999).

In order to get hold of the different views on an ecosystem approach, the results of the Workshop on the Ecosystem Approach (TemaNord, 1998) were compared with recommendations given by other fora and literature available on this concept. In this section, SGEAM will attempt to evaluate the results of the Oslo Workshop and try to adapt or construct a general (scientific) framework to be used in further work by ICES. SGEAM is of the opinion that there is no need to call it a scientific framework since the ecosystem approach is also oriented on a political decision-making process.

5.2.2 Ecosystem approach and North Sea management

The North Sea countries have a long history in promoting an ecosystem approach to fisheries assessment and management. The earliest discussions by ICES on the need for a more formal ecosystem approach to marine fisheries issues were held during the 1975 Symposium on the Long-Term Changes in Fish and Fisheries of the North Sea (Hempel, 1975). Countries in the ICES region were also instrumental in the development and implementation of an ecosystem approach to the assessment and management of Antarctic marine resources (Scully *et al.*, 1986).

Finally, in 1997 at the Intermediate Ministerial Meeting (IMM) on the Integration of Fisheries and Environmental Issues in the North Sea, the ecosystem approach found a definitive spot on the European political agenda. The ecosystem approach was especially seen as a concept which could stimulate the integration of fisheries and environmental issues. In the Statement of Conclusions of the IMM conclusion 2.6 refers to the ecosystem approach as follows:

"Further integration of fisheries and environmental protection, conservation and management measures, drawing upon the development and application of an ecosystem approach which, as far as the best available scientific understanding and information permit, is based on, in particular:

- *the identification of processes in, and influences on, the ecosystems which are critical for maintaining their characteristic structure and functioning, productivity and biological diversity;*
- *taking into account the interaction among the different components in the food-webs of the ecosystems (multi-species approach) and other important ecosystem interactions; and*

- *providing for a chemical, physical and biological environment in these ecosystems consistent with a high level of protection of those critical ecosystem processes."*

The objective of the North Sea states is to develop a management regime of the North Sea that is based on an ecosystem approach. This approach is considered to be fundamental to achieve sustainable use and protection of the marine environment. The general meaning is that management decisions consider all consequences of human activities for the marine environment in an integrated way. The Oslo Workshop was the follow up of Conclusion 2.6 of the IMM in 1997.

5.2.3 Results of the Oslo Workshop

The Oslo Workshop on the Ecosystem Approach resulted in eight conclusions (TemaNord, 1998). A complete description and interpretation of these conclusions can be found in Annex 4. One conclusion urges the need for "agreed upon definitions of terms" such as "ecosystems" and "ecosystem approach" which is treated in Section 5.1 and will not be further debated here. The remaining conclusions are (interpreted according to TemaNord, 1998):

1) integrated management of human activities in accordance with the principles of sustainable use and protection of the North Sea ecosystem;
2) clear objectives to the management and protection of the North Sea must be formulated. There is a need for both general objectives and specific, operational objectives;
3) best use of scientific knowledge;
4) research on climatic, biological and human driving forces of ecosystem variability;
5) adopted integrated monitoring to reveal the human impacts on the ecosystem;
6) need for integrated assessments on environment, socioeconomics and ecology;
7) stakeholders, along with scientists, managers and politicians should be involved at different stages of the decision process.

SGEAM considers the conclusions of the Oslo Workshop to be valuable and useful as a basis for the construction of a framework for the development of an ecosystem approach. In other fora, similar progress is being made on the development and implementation of an ecosystem approach (Lubchenko, 1994). In the U.S. several reports have been produced which address the developing paradigm of ecosystem management based on strengthening the linkage between science-based assessments of the changing states of marine ecosystems and the economic valuation of ecosystems goods and services. Interesting material is found in the findings of an expert panel of the Ecological Society of America (Christensen *et al*., 1996), reports by Zinn and Corn (1994) and NOAA publications (Baker, 1996; Griffis and Kimball, 1996).

Lanters (1999) compared the results of the Oslo Workshop (TemaNord, 1998) with the reports of the Ecological Society of America, ESA, (Christensen *et al*., 1996) and of the U.S. Interagency Ecosystem Management Task Force (Anon., 1995) to identify some general "rules" for ecosystem management. The U.S. Interagency Ecosystem Management Task Force is responsible for the implementation of the ecosystem approach in day-to-day management. Their major cases are land-based but some management regimes concern coastal areas or inland waters. Their operational task is reflected in their definitions of their major elements of an ecosystem approach (Lanters, 1999). ESA is a professional society of ecologists. ESA seeks to promote the responsible application of ecological principles to the solution of environmental problems through ESA reports, journals, research and expert testimony to Congress. The results of the comparison are presented in Table 5.2.3.1.

These common elements are considered by SGEAM to identify the basic elements for ecosystem management and to construct a framework for the implementation of an ecosystem approach in marine management. The similarity in the issues addressed by the different documents is remarkable. This shows that there is, to some extent, a general view on how an ecosystem approach can be achieved in theory. More recently, ecosystem-based management of marine fisheries has been endorsed in an evaluation report of the U.S. National Research Council (NRC, 1999). SGEAM took all this information to construct a general framework for an ecosystem approach with special reference to the role of science and ICES.

Table 5.2.3.1. A comparison of the basic elements for ecosystem management mentioned by the Oslo Workshop (TemaNord, 1998), ESA (Christensen *et al*., 1996), and the U.S. Interagency Ecosystem Management Task Force (Anon., 1995) (from Lanters, 1999).

Oslo Workshop	ESA	U.S. Task Force	Common element
Sustainable use and protection of the ecosystem	Sustainability as a precondition before "deliverables"	Sustaining or restoring natural systems and their functions and values (objective)	*Objectives cover sustainability*
Clear objectives, general and operational	Measurable goals	Short- and long-term consequences	*Clear, measurable objectives*
Best use of scientific knowledge	Sound ecological models and understanding	Using the best science	*Optimal scientific input*
Research on climatic, biological and human driving forces on ecosystem variability	The dynamic character of ecosystems. Ecosystem management avoids attempts to "freeze" ecosystems in a particular state or configuration		*Taking into account natural dynamics*
Integrated monitoring to reveal human impact	Management approaches must be viewed as hypotheses to be tested by research and monitoring programmes	Improving information and data management	*Evaluation of measures through monitoring*
Integrated assessments on environment, socioeconomics and ecology	Humans as ecosystem components. Ecosystem management values the active role of humans in achieving sustainable management goals		*Integrated assessment on environment, socioeconomics and ecology*
Stakeholders, along with scientists, managers and politicians are involved in the decision process		Forming partnerships between federal, state, and local governments, Indian tribes, landowners, and other stakeholders	*Involvement of stakeholders, scientists and politicians*
	Context and scale. There is no single appropriate scale or time frame for management	Adjusting management direction as new information becomes available	*Adaptive management*
		Communication with general public	
		Coordination among federal agencies	

5.2.4 A framework for an ecosystem approach

The following framework (Figure 5.2.4.1) was prepared as the result of discussions within SGEAM on former frameworks, as in the report of the Oslo Workshop (TemaNord, 1998) and Lanters (1999). The framework is constructed on the assumption that specific and operational objectives for the marine environment are already available.

Figure 5.2.4.1. A simplified framework for an ecosystem approach to the management of marine ecosystems to achieve sustainable use of ecosystem goods and services and conservation of ecosystem integrity.

Figure 5.2.4.DOC

In essence, the framework presented is nothing new. It starts with the action to generate information from the ecosystem and interacting human activities. This is achieved by monitoring to assess the state of the system and through research, giving insight into relationships, interactions, and processes guiding the ecosystem. Together this information feeds the central line and dominating part of the framework, the integrated assessment. The integrated assessment is subject to the objectives that are stated for the marine ecosystem at stake. Comparison of the outcome of the integrated assessment with the objectives will result in (scientific) advice to the management regarding what measures should be considered to achieve the objectives set. This advice is used by managers and policymakers to set up a management regime for the upcoming period. The effect of this new management regime is measured through monitoring. And the process continues over and over again. In the real world there are many interactions between the parties involved and this communication forms an important aspect of the ecosystem approach. Each element in the framework will be discussed in further detail in the next section.

The integrated assessment is a major issue which forces other elements of the framework to deal with integrated issues. For research and monitoring, this can be interpreted as multidisciplinary research and integrated monitoring where, at least, data exchange between different fields of work is common practice. SGEAM recognizes that the process to define operationally specific objectives for the management of marine ecosystems is a major challenge before an ecosystem approach can come into action. This developing process involves the interaction between scientific knowledge, socioeconomic forces, and national and international agreements ending up in a political decision-making process.

5.2.5 Reflections on the framework presented by SGEAM

The application of the framework to North Sea fisheries shows that the elements of the framework are indeed basic. Each of the basic elements hides a complex world underneath. Ecosystem management needs the right building blocks (e.g., scientific knowledge, objectives), but it is also a process that concerns everyone involved. SGEAM is of the opinion that the concept of an ecosystem approach should be applied to all management regimes in a marine ecosystem before it is successfully applied. This does not mean that implementation of ecosystem considerations in the management of human activities should be delayed until all possible actions are undertaken.

The attention for socioeconomics and the strong urge to involve stakeholders in the decision process express that humans and human activities form an inherent component of ecosystem management. Ecosystem management in the North Sea can, in fact, only be done by the regulation of human activities, which is a good reason to include the users in the ecosystem management concept. This choice can possibly have fundamental consequences for environmental management. For many marine activities, the effects are usually less clear than the profits. Therefore, communication and cooperation between scientists and user groups, including NGOs, is essential to reach any new objective.

5.3 Scientific Elements in the Ecosystem Approach Framework

5.3.1 Marine ecosystem dynamics

Large marine ecosystems are characterized by a high degree of natural variability, which is a primary driving force for ecosystem dynamics. In addition, there are also strong biological interactions between organisms at various trophic levels in ecosystems. The climatic driving forces can act either directly on species and populations or indirectly by providing conditions for different biological interactions. The climatic forcing and the biological interactions add up to more or less complex patterns of ecosystem dynamics.

Fish stocks are particularly prone to show large variability due to their mode of reproduction and large recruitment variability. Since many commercial fish stocks are large and constitute major components of marine ecosystems, their variability is influencing (reflected in) the variability characteristics of the ecosystems. Also, plankton and benthos may show variation in relation to climatic forcing.

The natural variability in fish stocks, plankton, and benthos is a shifting baseline for the state of the ecosystem which must be taken into account both when conducting environmental assessments and when setting EcoQOs. This means that one must acknowledge the variability and not set fixed objectives, for instance, for populations which may be in contradiction to the natural dynamics. The lack of specific knowledge may, however, make this difficult in many cases.

5.3.2 Integrated assessment

Production of integrated assessments is an important scientific element of an ecosystem approach. There is a need to move from the present assessments of fish stocks and environmental conditions to more holistic and integrated ecosystem assessments. There are at least three steps or levels of integration in this development:

1) integration of environmental information into the assessment of fish stocks;
2) integration of information on fish stocks and fisheries into environmental assessments;
3) integration of socioeconomic considerations into environmental or ecosystem assessments.

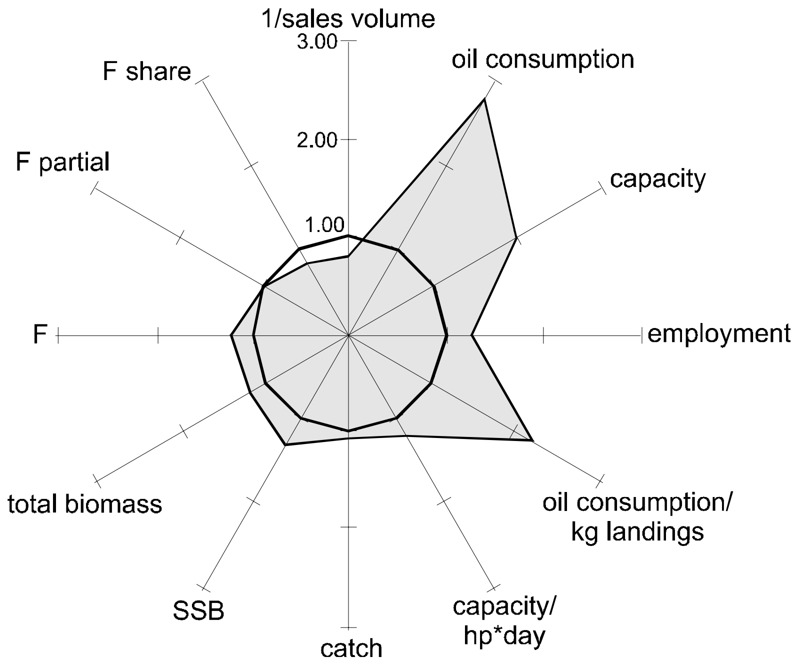
Integration of environmental information into assessments of fish stocks offers the promise of better assessments of current status and trends. This is because of the strong influence of climatic variability on the dynamics of many fish stocks. Such use of environmental information is a major focus for operational fisheries oceanography as described earlier by ACME. The implication for ICES is a need to speed up the reporting, compilation and assessment of environmental data from contributing national laboratories to match the time frame for assessing data on the fish stocks.

Integration of information on fish stocks and fisheries into environmental assessments is currently done in the preparation of Environmental Quality Status Reports (QSRs). There is considerable scope for improving the involvement and information of fisheries experts and expertise in collaboration with environmental experts. The scientific challenges are to better assess the indirect effects of fisheries through trophic interactions and habitat deterioration, and to assess and separate the impact of fisheries from the impacts of other human influences such as eutrophication and pollution.

The third step or element of integration involves the consideration of socioeconomics in ecosystem assessments. Fisheries management is, on the one hand, confronted with the multidimensional problem of effects on individual species, communities, and ecosystems and, on the other hand, with sustaining an economically viable fishery. Socioeconomic considerations are the main driving force for fishing and are of major importance in designing and developing a sustainable fisheries. An integrated ecological and economic approach is expected to facilitate the communication between the fisheries sector, and research and management, and to give insight into the strategies used by the fishing industry to achieve maximal economic profit. In the Northwest Atlantic, NOAA's National Marine Fisheries Service has introduced the use of the five-module framework in fishery assessments that includes consideration of (1) ecosystem productivity, (2) fish and fisheries, (3) pollution and ecosystem health, (4) socioeconomics, and (5) governance (Sherman, 1994).

Integrated indicators such as the Catch per Unit of Effort (CPUE) have the potential to integrate economic and ecological issues. Another approach is to construct assessment methods that provide insight into the multidimensional aspects of fishing activities. An example for the Dutch beam trawl fleet is shown in Figure 5.3.1. Recently the FAO published a report on indicators for sustainable development of marine capture fisheries where the use of integrated assessment tools is supported as well (FAO, 1999).

Figure 5.3.1. AMOEBA showing an example of an integrated assessment of economic and ecological indicators for the beam trawl fleet. The reference period is 1970–1972, prior to the introduction of heavy beam trawls. (Source: Lanters *et al.*, 1999.)



5.3.3 Monitoring

To support integrated assessments, monitoring programmes provide updated information on status and trends. There is a need to move towards integrated monitoring in an ecosystem context. Thus, all elements in existing national and international monitoring programmes in a given ecosystem should be reviewed with the aim to incorporate them into an integrated ecosystem monitoring programme following appropriate adjustments. There is a considerable potential for a more comprehensive and efficient utilisation of monitoring results in integrated assessments.

Many commercial fish stocks are monitored regularly through research vessel surveys. In many instances, environmental data are collected during fish stock surveys. An example is provided by the ICES-coordinated IBTS (International Bottom Trawl Survey) in the North Sea. During this cruise, hydrographical data are collected which provide semi-synoptic descriptions of the distribution of water masses and density fields. This has been accepted as a component in the international GOOS programme. Many laboratories also monitor nutrients during the winter IBTS. This has provided some of the most comprehensive data on winter nutrient distribution in the North Sea and was used in the 1993 North Sea QSR; with low additional costs it would be possible to extend this nutrient monitoring as a component of a systemic nutrient budget, productivity and eutrophication monitoring programme.

+ Benthos (?)	BEWG
Ocean climate monitoring and modelling	WGOH
Zooplankton monitoring	WGZE
HAB monitoring	WGHAB

5.4 Conclusions

SGEAM proposes that ICES establish Regional Ecosystem Groups (REGs) to provide for the preparation of integrated assessment by experts on fisheries and environmental conditions. The work in the REGs should focus on the following tasks:

1) consider the general issue of integration of pertinent assessment information on the changing states of large marine ecosystems in the region, based on regional expertise;
2) prepare periodic assessments of the status and trends in fish stocks and environmental conditions of the LMEs in the region with emphasis on:
    a) climatic/physical driving forces, and
    b) biological (e.g., multispecies) interactions;
3) contribute to environmental assessments and preparation of Quality Status Reports (QSRs) in cooperation with stakeholders, academic institutions, the public, and other organizations (e.g., EEA, OSPAR, AMAP, HELCOM).

The results and products of the REGs would be reviewed and translated into advice by the JASC and, as appropriate, by ACFM and ACME.

The REGs would receive input to their work from thematic WGs such as status of fish stocks from stock assessment WGs, climate status from Oceanic Hydrography, pollution status from Marine Chemistry and Biological Effects, etc. The output from the REGs would in reverse be used as input to stock assessment WGs and WGs dealing with specific environmental issues such as harmful algal blooms or fish diseases. It is furthermore likely that the number of thematic WGs could be reduced as some of the tasks would be taken over by the REGs.

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6 REVIEW THE METHODOLOGY AND PROPOSALS FOR ECOLOGICAL QUALITY OBJECTIVES FOR THE NORTH SEA

Ronald Lanters and Hein Rune Skjoldal gave an introduction to the two reports from the Scheveningen and the Oslo Workshops, published in the TemaNord series of the Nordic Council of Ministers as TemaNord 1999:591 and TemaNord 1998:579, respectively. The two reports covered a wide spectrum of topics and were based on intensive work of scientists as well as of managers, both in the preparation for and during the workshops. SGEAM briefly discussed the two reports and concluded that they are a most valuable contribution to the process of preparing Ecological Quality Objectives for the North Sea. The formation of EcoQOs is an integral part of the ecosystem management framework put forward in Section 5 of this report.

SGEAM felt it appropriate to point out the fact that, while some Ecological Quality Objectives may be specific to a particular ecosystem, the basic principles for establishing EcoQOs are of a general nature.

The report from the Scheveningen Workshop proposes a set of ten issues for Ecological Quality Objectives for the North Sea, namely:

1) reference points for commercial fish species;
2) threatened or declining species;
3) sea mammals;
4) seabirds;
5) fish communities;
6) benthic communities;
7) plankton communities;
8) habitats;
9) nutrient budget and production;
10) oxygen consumption.

The Scheveningen report states that the proposal of these ten issues should be the basis for further work. The ten issues were used in a paper presented by the OSPAR Secretariat to the meeting of the Environmental Assessment and Monitoring Committee (ASMO) in Hamburg, 27–31 March 2000.

SGEAM felt that the ASMO proposal had brought EcoQOs for the North Sea a step further to being implemented by management. SGEAM recognized the importance of scientific input based on insight into basic ecological principles in the further work. ICES should therefore take an active role in the development of EcoQOs. A suggested work programme with indicated involvement of ICES WGs needs to be developed. However, it should be noted that the ASMO document lacks the details contained in the Scheveningen report, which are important to consider when further developing EcoQOs. This should be taken into account when proposing the next stage in the development of specific EcoQOs and, by referring back to the original workshop report, duplication of effort by repeating discussions conducted at the workshop will be avoided.

When adopting an ecosystem approach to management, SGEAM noted that the ten issues listed from the Scheveningen Workshop should be considered together in an integrated manner. Measurement of single EcoQOs in isolation is <u>not</u> in line with an ecosystem approach, and it should be emphasised that a holistic assessment of the ecosystem requires the measurements of EcoQOs from all ten issues.

The development of EcoQOs is seen as an important component in the implementation of an ecosystem assessment (EA) for the management of the North Sea. SGEAM wants to stress the importance of taking full account of the interactions between biotic and abiotic components in the integrated assessment and management of marine ecosystems. The final development and application of EcoQOs up against integrated assessments should be done by a group of experts with broad knowledge of the North Sea ecosystem and the human activities affecting it.

By adopting an ecosystem approach to assessment and management, all management decisions have to be based on an analysis of consequences considering effects on the ecosystem. The purpose of ecosystem management is not to have a stable unchanged ecosystem, but to secure a plan for management that avoids unexpected and undesirable changes within the system.

SGEAM felt that only specially designed working groups with a broad knowledge of the actual ecosystem would be able to consider both biotic and abiotic effects on ecosystems and give advice on the management of these ecosystems.

7 EVALUATE THE USE OF RESULTS FROM MONITORING PROGRAMMES AND THEIR EFFECTIVENESS TO SUPPORT INTEGRATED (ECOSYSTEM) ASSESSMENTS IN THE ICES AREA

This discussion was primarily based on the OSPAR regional and 2000 Quality Status Reports for the Northeast Atlantic and the HELCOM Third Periodic Assessment of the Baltic Sea.

Monitoring of the various components of the marine environment and its living marine resources forms the necessary basis for carrying out assessments of the status of ecological quality and resultant progress towards achieving ecological quality objectives (e.g., reduced levels of pollutants, more viable fisheries within sustainable ecosystems).

In order to monitor the status of the environment and its living marine resources, a programme of measurements and information gathering must be conducted in time and space. As national networks of collaborating laboratories and other institutions in many countries collect the data, it is necessary that data be collected according to agreed protocols involving their intercomparison and quality assurance. On the basis of quality-assured data, periodic assessments are then carried out—often involving peer review and necessary consensus—in order to provide the best available scientific information and advice for the political decision-making process for management (e.g., regulatory) purposes. Thus, it is vital that the underpinning process starting with monitoring provides both the appropriate quantity and quality of data so that those involved in the scientific and political processes can agree on the status and trends concerning the ecosystem and its components.

Due to the limited time and number of participants at the SGEAM meeting, only some of the OSPAR regional reports were reviewed. SGEAM's impressions of these reports are summarized below.

As Table 7.1 shows, the sources of information for the Region I QSR are a mixture of time series data, monitoring data, fisheries statistics, case studies, and general opinion. This is also the case for OSPAR Region II (Table 7.2). The sources of high impact are in general better documented through regional monitoring or time series data compared with sources of lower impact, but to be able to secure the scientific basis which was demanded from the OSPAR Convention, there is need for a coordination of data input from the different countries that are responsible for data collection in the OSPAR regions.

Table 7.1. OSPAR Region I QSR.

Impact source	Observed effects	Source of concern	Source of information
Fisheries	Large	Stock size reference points	Monitoring. Fisheries statistics
	Large	Population composition	Monitoring. Scientific data. Time series.
	Large	Trophic interactions	Monitoring. Scientific data.
	Large	Discards and non-target species	General opinions.
	Large	Habitat destruction	Scientific data. General opinions.
	Large	Fisheries vs. Seabirds	Monitoring. Time series. Scientific data.
Sea mammals	Large	Population size reference points	Monitoring. Scientific data. Time series.
PCBs	Medium	Level of PCBs in the system	Studies? General opinions
	Medium	Biological effects of PCBs	Scientific data.
Other persistent organic compounds	Medium	Level and biological effects	Scientific data. Time series.
Mariculture	Medium	Genetic “pollution” of wild stocks	Studies. General opinion.
	Medium	Increased infections of parasites and diseases on wild stocks	Studies. General opinion.
Oil and gas	Medium	General environmental risk	Scientific data. General opinion.
PAHs	Small	Level and biological effects	General opinions
Metals	Small	Level and biological effects	Scientific data Time series General opinions
Radionuclides	Small	Levels	Time series
Introduced species	Small	Biological effects	General opinions

Table 7.2. OSPAR Region II QSR.

Classification	Source of concern	Area covered	Type of data
High impact	Removal of target species by fisheries	Regional	Monitoring
	Inputs of trace organic contamination	Regional	Monitoring
	Seabed disturbance by fisheries	Local	Studies
	Inputs from nutrients from land	Regional	Monitoring
	Effects of discards and mortality of non-target species	Local	Studies
	Input of TBT and other antifouling substances by shipping	Regional	Monitoring
Upper intermediate impact	Input of oil and PAHs from oil industry	Regional	Monitoring
	Input of oil and PAHs from shipping	Local	Monitoring
	Input of other hazardous substances from oil and gas industry	Regional	Monitoring
	Input of other hazardous substances from shipping	Local	Studies
	Input of heavy metals from land	Regional	Monitoring
	Input of oil and PAHs from land	Regional	Monitoring
	Introduction of non-indigenous species from shipping	Regional	Studies
	Introduction of cultured specimens, non-indigenous species and diseases from mariculture	Local	Studies
	Inputs of microbiological pollution and organic material from land	Regional	Monitoring
Lower intermediate impact	Physical disturbance by offshore industry	Local	Studies
	Input of litter from shipping	Local	Studies
	Dispersion of substances by dredging and dumping of dredged material	Local	Monitoring
	Dumping of ammunition by military activities	Local	Studies
	Constructions in the costal zone by engineering	Local	Studies
	Input of chemicals by mariculture	Local	Studies
	Mineral extraction	Local	Studies
	Input of nutrients and organic material from mariculture	Local	Studies
	Physical disturbance by dredging and dumping of material	Local	Monitoring
	Inputs from radionuclides from land	Local	
Lowest impact	Physical disturbance by shipping		
	Input of litter by recreation		
	Physical disturbance by military activities		
	Physical disturbance by recreation		
	Power cables by engineering operations		
	Dumping of inert material		

The overall general impression is that the conclusions in the reports are not as precise as wished. In many cases it seems that the conclusions are not made on the basis of adequate monitoring. However, there are examples where time series from monitoring programmes have proved effective for drawing conclusions. In particular, this is the case where monitoring of contaminants has been undertaken over a period of time long enough to establish trends. This type of monitoring is, however, seldomly seen in the context of an ecosystem approach but rather as single measurements of specific contaminants in different matrices.

SGEAM is of the opinion that monitoring programmes should be required to include measurements of parameters that can explain the development of both the biotic and abiotic driving forces of the actual ecosystem. In the process of assessing an ecosystem, weight should also be placed in describing the goods and services of that particular ecosystem; this aspect should also be reflected in the monitoring programmes.

NOAA's National Marine Fisheries Service has developed and implemented a multi-decadal programme for the monitoring and assessment of changing states of the Northeast Shelf Large Marine Ecosystem. Key components of the programme include measurements of ecosystem productivity, fish and fisheries, and pollution and ecosystem health, derived from NOAA's National Status and Trends Measurements. A general description of the strategy and methodologies used is given in Annex 5.

8 OUTLINE A PROGRAMME OF WORK FOR THE NEXT FIVE YEARS

The time available at the meeting did not allow for a particular discussion of this agenda item. It was, however, indicated that the items in the TOR already given to SGEAM (see Section 1.1) and not dealt with at this meeting (agenda items 8 and 9) in themselves included sufficient work for the next meeting. In addition to these two items SGEAM should be given the task of considering terms of reference for the proposed Regional Ecosystem Groups (REGs) and, as a consequence of a possible creation of REGs, also to propose a set of regional ecosystems within the ICES area and to propose the requested scientific composition of membership in the proposed REGs.

9 ANY OTHER BUSINESS

No issues were raised under this agenda item at the meeting.

10 CONSIDERATION AND APPROVAL OF RECOMMENDATIONS

SGEAM concluded that the main effort of the meeting was put into agenda item 5, where a proposal for establishing Regional Ecosystem Groups (REGs) within the ICES area was presented (Section 5.4), and that this proposal should be introduced for discussion in the ICES system. The proposal is given in Annex 6.

11 PROPOSAL FOR A FURTHER MEETING

SGEAM was of the opinion that the next meeting should take place in the ICES Headquarters in late spring 2001, but allowing for sufficient time for preparation of a draft report of the meeting to be presented to the June 2001 meeting of the ACME. By having a late meeting it was believed that relevant working groups of ICES could have considered the proposal for establishing REGs, and in particular commented on regional divisions and scientific composition of the REGs.

12 CONSIDERATION AND APPROVAL OF THE MEETING REPORT

The draft bits of the text were approved and it was agreed that the Chair should prepare a final draft report to the ACME June meeting after having circulated the draft to the participants for comments via e-mail. It was further agreed that the Chair should, in cooperation with the ICES Secretariat, prepare the final report of the SGEAM 2000 meeting to be submitted to the ICES Annual Science Conference.

13 CLOSURE OF THE MEETING

The Chair thanked the participants for a most interesting and intense meeting, which in his opinion had reached some very important goals due to the effort laid down by the participants and the valuable knowledge they possessed. The Chair also made a comment of the fact that he had feared for the outcome of the meeting given the rather moderate interest from the ICES scientific community prior to the meeting. The Chair took the liberty once more to point to the great efforts laid down in attracting attendants to the meeting and repeated his remarks from the introductory section of this report. However, in spite of not having managed to deal with the whole set of TORs given to the Study Group it was felt that the report from the meeting would be an important document and also a most needed document for the discussion of the future of ICES.

On behalf of SGEAM, the Chair thanked the staff of ICES for their friendly help and hospitality, and closed the meeting at 16.00 hrs on Friday 12 May 2000.

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ANNEX 2: AGENDA

1) Opening of the meeting.
2) Adoption of the agenda.
3) Arrangements for the preparation of the report.
4) Reports of activities in other fora of interest to the meeting.
5) Discussion of the scientific framework for an ecosystem approach for sustainable use and protection of the marine environment, including living marine resources. The discussion will be based on the reports of the North Sea conference's Oslo and Scheveningen workshops and the ICES discussion document on ecosystem management of the Baltic Sea.
6) Review the methodology and proposals for Ecological Quality Objectives for the North Sea.
7) Evaluate the use of results from monitoring programmes and their effectiveness to support integrated (ecosystem) assessments in the ICES area. Discussion based primarily on the OSPAR regional and 2000 Quality Status Reports for the Northeast Atlantic and the HELCOM Third Periodic Assessment of the Baltic Sea.
8) Review existing regional monitoring programmes in order to:
   a) identify management questions/objectives and environmental issues,
   b) identify ecological quality objectives,
   c) identify indicators
   d) identify methods for integrating indicator results into a regional assessment.
9) Review existing regional and international monitoring programmes in order to:
   a) synthesise management questions/objectives, ecological quality objectives, and environmental issues,
   b) synthesise indicators for each management question/objective, and for each ecological quality objective,
   c) identify best or most promising methods for integrating indicator results into regional assessments for the ICES area.
10) Outline a programme of work for the next five years.
11) Any other business.
12) Consideration and approval of recommendations.
13) Proposals for a further meeting.
14) Consideration and approval of the meeting report.
15) Closure of the meeting.

ANNEX 3: REFERENCE DOCUMENTS

SGEAM 5/1/00	Glossary of ecological terms used in the Oceans Act and its implementation programs. Discussion Paper, Department of Fisheries and Oceans, Canada, February 2000.
SGEAM 5/2/00	Review of terms and definitions relevant to ocean and marine resource management under the Oceans Act. Report to the Department of Fisheries and Oceans, Canada, 1999.
SGEAM 5/3/00	Contextual framework for Marine Environmental Quality under the Oceans Act. Department of Fisheries and Oceans, Canada, April 2000.
SGEAM 5/4/00	Workshop on Ecological Quality Objectives (EcoQOs) for the North Sea, Scheveningen, the Netherlands, 1–3 Sept. 1999, TemaNord, 1999:591.
SGEAM 5/5/00	Workshop on the Ecosystem Approach to the Management and Protection of the North Sea, Oslo, Norway, 15–17 June 1998, TemaNord, 1998:579.
SGEAM 5/6/00	Developing ICES ecosystem advice. Test Case—Baltic and North Seas. ACME, June 1999.
SGEAM 5/7/00	Ecological quality objectives for the North Sea. Basic document for the Workshop on Ecological Quality Objectives for the North Sea, 1–3 September 1999, Scheveningen, Netherlands. Ed. by R.L.P. Lanters, H.R. Skjoldal, and T.T. Noji. RIKZ Report 99.015, June 1999.
SGEAM 5/8/00	Overview report on ecological quality (EcoQ) and ecological qualtity objectives (EcoQOs). Report prepared within the framework of the OSPAR Commission. H.R. Skjoldal.
SGEAM 5/9/00	Ecosystem-based fishery management. A report to Congress by the Ecosystem Principles Advisory Panel. As mandated by the Sustainable Fisheries Act amendments to the Magnuson-Stevens Fishery Conservation and Management Act 1996. USA.
SGEAM 5/10/00	Integration of information on Europe's marine environment. European Environment Agency, Technical Report No. 17.
SGEAM 5/11/00	Environmental indicators: Typology and overview. European Environment Agency, Technical Report No. 25.
SGEAM 5/13/00	Ecosystem approach—the principles and practicalities of incorporating it in management advice. A presentation by H.R. Skjoldal to the Follow-up of the 11th Dialogue Meeting, 8 February 2000, London.
SGEAM 5/14/00	Lanters, R.L.P. 1999. Basic elements for the implementation of an ecosystem approach in marine management. ICES CM 1999/Z:10.
SGEAM 5/15/00	Sherman, K., and Duda, A.M. 1999. An ecosystem approach to global assessment and management of coastal waters. Marine Ecology Progress Series, 190: 217–287.

ANNEX 4: SUMMARY AND CONCLUSIONS FROM THE WORKSHOP ON THE ECOSYSTEM APPROACH TO THE MANAGEMENT AND PROTECTION OF THE NORTH SEA

The workshop was arranged in the framework of the North Sea Conference. Invited speakers presented relevant topics in plenary sessions (abstracts in Annex VI). Parallel group discussions were arranged in session II and II. In the final summary session IV, the discussion was structured according to a suggested framework for an Ecosystem Approach as illustrated by the flow chart in Figure A4.1. The following conclusions were drawn from the plenary discussions:

1) It may be difficult or impossible to manage the North Sea towards a desired ecosystem state. We may, however, manage the human activities in an integrated manner to achieve sustainable use and protection of the North Sea.

The North Sea is an open ecosystem with complex interactions and considerable natural variability. This, along with our limited understanding of these interactions and variability, set limits to our ability to manage the North Sea as an ecosystem. It is, however, clear that some human activities result in changes to the North Sea ecosystem. These human activities may be managed in order to keep the impacts and changes within acceptable limits, in accordance with the principle of sustainable use and protection of the North Sea ecosystem.

2) There is a need for agreed upon definitions of terms such as “ecosystem” and “ecosystem approach”.

The definition of “Ecosystem Approach” was discussed, but the workshop did not draw a conclusion. Some definitions and explanations of the concept are given in Annex III. A clear and agreed upon terminology is required to avoid misunderstandings based on semantic rather than substantial differences of opinion. Important elements of a definition are the interlinked nature of organisms as components of ecosystems.

3) Clear objectives for an Ecosystem Approach to the management and protection of the North Sea must be formulated. There is a need for objectives both at the general level, as overall or integrated objectives, and at the specific level, as more detailed and operational objectives.

It is a political responsibility to establish objectives for both ecosystem function, as well as human use, based on advice from scientists, managers, and stakeholders. General objectives have been formulated in the Statement of Conclusions from the IMM 97 in Bergen. The development of Ecological Quality Objectives in the Oslo-Paris Convention (OSPAR) may provide more clearly defined general objectives as a framework for more specific operational objectives related to fish stocks and the marine environment. It would be useful if these and any new scientific fishery related objectives were developed in time to be included as part of the new EU Common Fishery Policy.

4) The management of the North Sea should be based on the best use of the present scientific knowledge. In particular, there is a potential for more extensive use of existing ecological knowledge.

Management decisions have to be taken continuously even if the scientific basis is limited. The current monitoring of fish stocks and environmental conditions provide information for management decisions. This information may be integrated more extensively as a basis for management advice. Ongoing work in the International Council for the Exploration of the Sea (ICES) may provide advice on how to achieve this.

5) The present knowledge of the North Sea as an ecosystem does not provide a sufficiently good basis for full implementation of an Ecosystem Approach to the North Sea management. There is, therefore, a need for focused research on the North Sea ecosystem, including climatic, biological and human driving forces of ecosystem variability.

Despite a long history of research and monitoring, the knowledge of the North Sea as an ecosystem is still insufficient, and a systematic and holistic Ecosystem Approach to the study of the North Sea is insufficiently developed. Ecosystem research can provide a systematic framework for identifying important gaps in knowledge and for filling those gaps. In this process it is important that managers and politicians specify and communicate their needs for information and advice.

6) 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.

While research provides basic knowledge and insight into the functioning of the North Sea ecosystem, monitoring provides updated information about the state of components of the ecosystem. Important features of the ecosystem dynamics are long-term and large-scale variability related to fluctuations or changes in climatic driving forces. Monitoring can provide data on such variability which is used in research to reveal the underlying mechanisms. It is important that monitoring activities are linked to objectives. Monitoring programmes for collection of ecological and socioeconomic information must, therefore, be adjusted as new objectives are being developed as part of an ecosystem approach. There is at present a considerable amount of monitoring being carried out for various purposes, most of it as national programmes. However, there is a considerable potential for improved collection and utilisation of data through coordination and harmonisation of ongoing national and international monitoring activities. There is also a need to implement new and better methods and technologies in monitoring programmes. ICES, OSPAR, and the Global Ocean Observing System (GOOS) are international bodies which are already contributing and may contribute in future to the harmonisation and further development of monitoring in the North Sea.

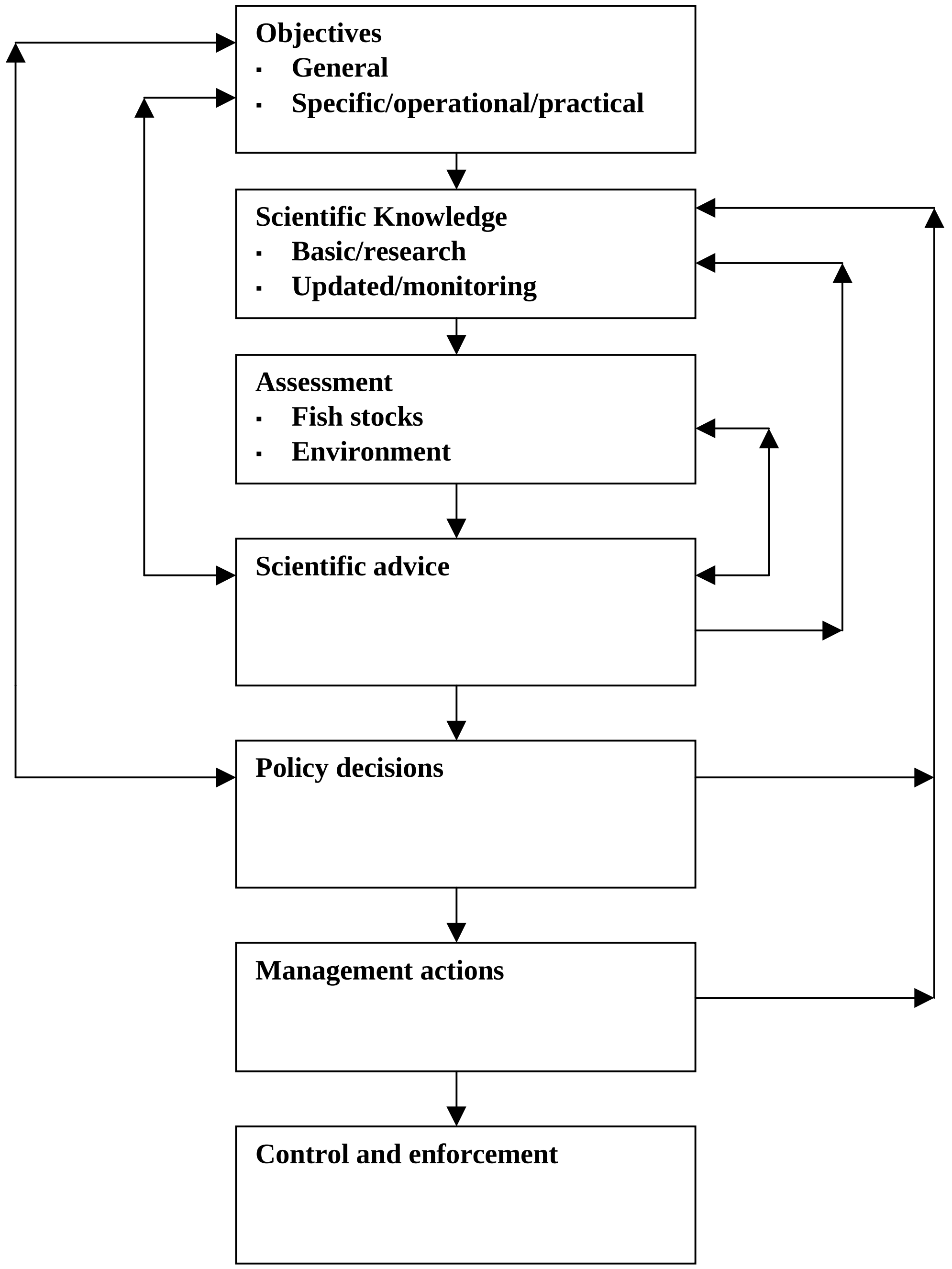
7) There is a need for integrated assessments prepared by experts on North Sea fish stocks, environment and socioeconomics.

Assessments of available information from monitoring and research provide the basis for scientific advice and management decisions. Integration of fisheries, environmental and socioeconomic issues require integrated scientific advice and assessments. The integrated assessments should be prepared by experts on North Sea fish stocks and the North Sea environment in close collaboration To avoid duplication of work and to secure cost-effectiveness, this could be carried out as coordinated or joint activities between the relevant international bodies (i.e., ICES, OSPAR, European Environment Agency (EEA)). One possible approach to assessment is the development of indicators of change based on socioeconomic and ecological research. These indicators should be linked to objectives and they should be practical in management use (measurable yardsticks).

8) Stakeholders, along with scientists, managers, and politicians, should be involved at different stages of the decision process to promote openness, transparency and responsibility.

Involvement of stakeholders in the management process is important to achieve sustainable utilisation of marine ecosystems. Stakeholders should be involved in the various steps including the setting of objectives, assessment of scientific information and utilisation of scientific advice for management decisions. The scientific basis should be clearly outlined and the advice should be clearly stated. Scientific and political considerations, although interlinked, should be kept separate. This will improve the transparency in the decision-making process and will clarify the different roles and responsibilities of stakeholders, scientists, managers, and politicians. However, to achieve common objectives for an Ecosystem Approach, adequate communication between stakeholders, scientists, managers, and politicians within an already existing institutional framework is of major importance.

Figure A4.1. A conceptual framework for an Ecosystem Approach to the management and protection of the North Sea. The flowchart shows elements in a stepwise and scientifically based management process.



ANNEX 5: WHY REGIONAL COASTAL MONITORING FOR ASSESSMENT OF ECOSYSTEM HEALTH?

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Public Concerns and Responses

During recent years, the public and the scientific communities have signaled concern over growing degradation of ecosystem health, depleted fisheries, pollution, and habitat loss. Public concern has been registered in newspapers, electronic media, and congressional actions. Scientific concern has moved from the pages of journals to the actions of professional societies, as for example the *Sustainable Biosphere Initiative* of the Ecological Society of America (Lubchenco *et al.,* 1991). Responsive actions at the national and international levels have resulted in Conventions and Protocols on Climate Change, Biodiversity, Ozone, and internationally recognized declarations for sustaining marine fisheries.

Recovery of ecosystem health, depleted marine resources, and environments are vital to coastal countries and their economies. Published commentary on how best to improve the degraded state of resources and coastal environments are not without controversy. While some scientists are concerned with the lack of consistent success in the management of marine resources (Ludwig *et al*., 1993), others stress the utility of science-based assessments as a key component of marine resource management practices (Rosenberg *et al*., 1993). Given the growing stress from the expanding human population on coastal ecosystems, stewardship institutions cannot wait for science to achieve a full understanding of ecosystem structure and function. The best presently available science is needed to monitor and assess changing ecosystem conditions and implement mitigating actions. In the northeast and northwest Atlantic scientists have been collecting information for the past forty years describing the declines in marine fisheries, habitats, and water quality. But it was not until the later half of the 1990s that government policies were coupled with actions to accelerate a reversal of overexploitation and environmental degradation. In the United States, among the more forward-looking legislative acts mandating improvements in coastal environments and promoting fisheries sustainability can be found in recent amendments to the Magnuson-Stevens Fishery Conservation and Management Act, and the National Environmental Policy Act.

In the late 1970s, in response to public concerns resulting in Congressional mandates for improving coastal water quality and fisheries sustainability, NOAA's National Marine Fisheries Service initiated systematic bottom-trawl surveys of the fish inhabiting the Northeast continental shelf. Oceanographic, plankton, and water quality surveys followed, and the transition from a sector-by-sector approach to resource and environmental monitoring, assessment, and management actions advanced toward an ecosystem-based strategy for improving the health of coastal waters.

Ecosystem Monitoring and Assessments

The Ecological Society of America Committee on the Scientific Basis for Ecosystem Management concluded that the overarching principle for guiding ecosystem management is to ensure the intergenerational sustainability of ecosystem goods (e.g., fish, trees, petroleum) and ecosystem services or processes including productivity cycles and hydrological cycles (Christensen *et al*., 1996). This approach represents a paradigm shift from the highly focused short-term sector-by-sector resource assessment and management approach in general practice today by natural resource stewardship agencies, to the broader more encompassing ecosystem approach that moves spatially from smaller to larger scales, and from short-term to longer-term management practice (Lubchenco, 1994). Included in the new paradigm is a movement from the management of commodities to the sustainability of the productive potential for ecosystem goods and services (Table A5.1).

This approach builds on an earlier application of “an ecosystem approach” to management of the Great Lakes Basin Ecosystem (Great Lakes SAB, 1978; Duda, 1990), and more recent efforts in developing an ecosystem assessment approach for the management of the North Sea (OSPAR, 1993; Reid, 1999; TemaNord, 1999), the Northeast Shelf of the USA (Sherman *et al*.,1996), the Baltic Sea (ECOPS *et al*., 1995), and the Yellow Sea (Lee and Sutinen, 1999). The ecosystem approach recognizes humankind and economic/social systems as being integral parts of the ecosystem. The Great Lakes approach led to agreements between the USA and Canada to follow longer-term pathways for sustainable use of ecological resources. The two decades of experience in struggling to operationalize this ecosystem approach has resulted in management programs to reverse the trend in coastal degradation. Ecosystem-based management of fisheries has recently been endorsed by the National Research Council (1999).

The ecosystem-based approach has relevance to the management of large marine ecosystems (Figure A5.1). On a global scale, fifty Large Marine Ecosystems (LMEs) produce 95 percent of the world's annual marine fishery yields and within their waters most of the global ocean pollution, overexploitation, and coastal habitat alteration occurs (AAAS 1986, 1989, 1990, 1991, 1993; Sherman *et al*., 1996; Kumpf *et al*., 1999; Sherman and Tang, 1999). The LMEs are regions of ocean space encompassing coastal areas from river basins and estuaries out to the seaward boundary of continental shelves and the outer margins of coastal current systems. They are relatively large, on the order of 200,000 km^2 or greater, characterized by distinct bathymetry, hydrography, productivity, and trophically-dependent populations. The theory, measurement, and modelling relevant to monitoring the changing states of LMEs are imbedded in reports on ecosystems with changing ecological states, and on the pattern formation and spatial diffusion within ecosystems (Holling, 1973; Pimm, 1984; AAAS, 1990; Mangel, 1991; Levin, 1993; Sherman, 1994). In relation to the studies needed to improve the state of knowledge, it should be noted that for thirty-three of the fifty LMEs, retrospective analyses have been conducted on the principal driving forces affecting changes in biomass yields (Table A5.2).

Assessment Modules

Based on information obtained from the 33 LME case studies, a modular strategy has been developed to provide information for the monitoring, assessment, and management of LMEs.

The modules are focused on ecosystem (1) productivity, (2) fish and fisheries, (3) pollution and health, (4) socioeconomic conditions, and (5) governance protocols.

Productivity Module

Productivity can be related to the carrying capacity of an ecosystem for supporting fish resources (Pauly and Christensen, 1995). Recently, scientists have reported that the maximum global level of primary productivity for supporting the average annual world catch of fisheries has been reached, and further large-scale “unmanaged” increases in fisheries yields from marine ecosystems are likely to be at trophic levels below fish in the marine food chain (Beddington, 1995). Evidence of this effect appears to be corroborated by recent changes in the species composition of the fisheries catches from the East China Sea LME (Chen and Shen, 1999). Measuring ecosystem productivity also can serve as a useful indication of the growing problem of coastal eutrophication (OSPAR, 1993). In several LMEs, excessive nutrient loadings of coastal waters have been related to algal blooms implicated in mass mortalities of living resources, emergence of pathogens (e.g., cholera, vibrios, red tides, paralytic shellfish toxins), and explosive growth of nonindigenous species (Epstein, 1993).

The ecosystem parameters measured in the productivity module are zooplankton biodiversity and information on species composition, zooplankton biomass, water column structure, photosynthetically active radiation (PAR), transparency, chlorophyll *a*, $N0_2$, NO_3, and primary production. Plankton of LMEs have been measured by deploying Continuous Plankton Recorder (CPR) systems monthly across ecosystems from commercial vessels of opportunity over decadal time scales (Jossi and Goulet, 1993; Planque and Taylor, 1998). Advanced plankton recorders can be fitted with sensors for temperature, salinity, chlorophyll, nitrate/nitrite, petroleum hydrocarbons, light, bioluminescence, and primary productivity (Aiken *et al*., 1999), providing the means to monitor changes in phytoplankton, zooplankton, primary productivity, species composition and dominance, and long-term changes in the physical and nutrient characteristics of the LME and in the biofeedback of plankton to the stress of environmental change.

The Fish and Fisheries Module

Changes in biodiversity among the dominant species within fish communities of LMEs have resulted from excessive exploitation (Sissenwine and Cohen, 1991), naturally occurring environmental shifts in climate regime (Bakun, 1993), or coastal pollution (Mee, 1992). Changes in the biodiversity of a fish community can generate cascading effects up the food chain to apex predators and down the food chain to plankton components of the ecosystem (Payne *et al.,* 1990). These three sources of variability in fisheries yield are operable in most LMEs. However, they can be described as primary, secondary, and tertiary driving forces in fisheries yields, contingent on the ecosystem under investigation. For example, in the Humboldt Current, Benguela Current, and California Current LMEs, the primary driving force influencing variability in fisheries yield is the influence of changes in upwelling strength (Crawford *et al*., 1989; Alheit and Bernal, 1993; Bakun, 1999); fishing and pollution effects are secondary and tertiary effects on fisheries yields. In continental shelf LMEs, including the Yellow Sea and Northeast United States Shelf, excessive fisheries effort has caused large-scale declines in catch and changes in the biodiversity and dominance in the fish community (Sissenwine, 1986; Tang, 1993). In these ecosystems, pollution and environmental perturbation are of secondary and tertiary influence.

In contrast, significant coastal pollution and eutrophication have been the principal factors driving changes in fisheries yields of the Northwest Adriafic (Bombace, 1993), Black Sea (Mee, 1992), and near-coastal areas of the Baltic Sea (Kullenberg, 1986). Overexploitation and natural environmental changes are of secondary and tertiary importance. Consideration of the driving forces of change in biomass yield based on multi-year time-series data is important when developing options for management of living marine resources for long-term sustainability.

The Fish and Fisheries Module includes fisheries-independent bottom-trawl surveys and acoustic surveys for pelagic species to obtain time-series information about changes in fish biodiversity and abundance levels. Standardized sampling procedures, when deployed from small calibrated trawlers, can provide important information on diverse changes in fish species. Fish catch provides biological samples for stock assessments, stomach analyses, age, growth, fecundity, and size comparisons (ICES, 1991); data for clarifying and quantifying multispecies trophic relationships; and the collection of samples for monitoring coastal pollution. Samples of trawl-caught fish can be used to monitor pathological conditions that may be associated with coastal pollution. Trawlers also can be used as platforms for obtaining water, sediment and benthic samples for monitoring harmful algal blooms, virus vectors of disease, eutrophication, anoxia, and changes in benthic communities.

Pollution and Ecosystem Health Module

In several LMEs, pollution has been a principal driving force in changes of biomass yields. Assessing the changing status of pollution and health of the entire LME is scientifically challenging. Ecosystem "health" is a concept of wide interest for which a single precise scientific definition is problematical. Methods to assess the health of LMEs are being developed from modifications to a series of indicators and indices described by several investigators (Costanza and Mageau, 1999). The overriding objective is to monitor changes in health from an ecosystem perspective as a measure of the overall performance of a complex system (Costanza, 1992). The health paradigm is based on multiple-state comparisons of ecosystem resilience and stability (Pimm, 1984; Holling, 1986; Costanza, 1992) and is an evolving concept.

Following the definition of Costanza and Mageau (1999), to be healthy and sustainable, an ecosystem must maintain its metabolic activity level and its internal structure and organization, and must resist external stress over time and space scales relevant to the ecosystem These concepts were discussed by panels of experts at two NOAA workshops convened in 1992 (NOAA, 1993) and at a series of workshops convened by the Nordic Council of Environmental Ministers (Lanters *et al*., 1999). Five of the indices discussed by the participants in both series of workshops are being considered as experimental measures of changing ecosystem states and health: (1) biodiversity; (2) stability; (3) yields; (4) productivity; and (5) resilience (Sherman and Solow, 1992; TemaNord, 1999). Data from which to derive the experimental indices are obtained from time-series monitoring of key ecosystem parameters. The ecosystem sampling strategy is focused on parameters relating to resources at risk of overexploitation, species protected by legislative authority (marine mammals), and other key biological and physical components at the lower end of the food chain (plankton, nutrients, hydrography). The parameters of interest are described in Sherman (1994).

Fish, benthic invertebrates, and other biological indicator species are used in the Pollution and Ecosystem Health Module to measure pollution effects on the ecosystem, including the bivalve monitoring strategy of "Mussel-Watch"; the pathobiological examination of fish; and the estuarine and nearshore monitoring of contaminants and contaminant effects in the water column, substrate, and in selected groups of organisms (NOAA, 1998; Wade *et al*., 1998). The routes of bioaccumulation and trophic transfer of contaminants are assessed, and critical life history stages and selected food chain organisms are examined for parameters that indicate exposure to, and effects of, contaminants. Effects of impaired reproductive capacity, organ disease, and impaired growth from contaminants are measured (Myers *et al*., 1998). Assessments are made of contaminant impacts at the individual species and population levels. Implementation of protocols to assess the frequency and effect of harmful algal blooms (Smayda, 1991) and emergent diseases (Epstein, 1993) are included in the pollution module.

The Socioeconomic Module

This module is characterized by its emphasis on practical applications of its scientific findings in managing an LME and on the explicit integration of economic analysis with science-based assessments to assure that prospective management measures are cost-effective. Economists and policy analysts will need to work closely with ecologists and other scientists to identify and evaluate management options that are both scientifically credible and economically practical with regard to the use of ecosystem goods and services (Hanna, 1998).

Designed to respond adaptively to enhanced scientific information, socioeconomic considerations and management approaches must be closely integrated with the science. This component of the LME approach to marine resources management, developed by the late James Broadus, former Director of the Marine Policy Center, Woods Hole Oceanographic Institute, consists of six interrelated elements:

1) Human Forcing Functions

The natural starting point is a generalized characterization of ways in which human activities affect the natural marine system and the expected “sensitivity” of these forcing functions to various types and levels of human activity. Population dynamics, coastal development, and land use practices in the system's drainage basin are clear examples. Work integrating the efforts of natural and social scientists should concentrate further on resolving apparent effects (such as eutrophication-associated red tide events or changing fish population structures) that are confounded by cycles or complex dynamics in the natural system itself Progress is possible, too, in achieving better characterizations of the way in which human activities affecting ecosystems are mediated by alternate management options. Emphasis should be on isolating and quantifying those forcing activities (sewage discharge, agricultural runoff, fishing effort) likely to be expressed most prominently in effects on the natural system.

2) Assessing Impacts

Another natural element in the systemic approach is to estimate and even predict the economic impacts of unmanaged degradation in a natural system and, obversely, the expected benefits of management measures. Such assessment is a form of standard benefit-cost analysis, but it requires scientific information to describe the effects of human forcing so they can be quantified in economic terms. Initial analysis should focus on the social and economic sectors likely to experience the largest impacts: fishing, aquaculture, public health, recreation, and tourism.

3) Feedbacks

Collaborative efforts between resource management agencies and stakeholders also should be devoted to reviewing the results of analyses used in identifying and estimating the feedbacks of economic impacts into the human forcing function. For example, extensive coastal eutrophication associated with coastal development and runoff might reduce the suitability of coastal areas for aquaculture production and increase their exposure to red tide damage, thereby putting a premium on capture fishery and increasing pressure on wild stocks. Similar feedback, both negative and positive, should be addressed and expressed in economic terms for all the major sectors.

4) Ecosystem Service/The Value of Biodiversity

Special consideration should be given to improved knowledge of how the natural system generates economic values. Many valuable services provided by natural systems are not traded in markets or included in planning evaluations, so extra care must be taken to assure they are not sacrificed through ignorance. The services provided by coastal wetlands as nurseries for fisheries, natural pollution filters, and storm buffers are well-known examples particularly relevant to coastal reclamation activities now underway by NOAA and other federal and state agencies. Other examples are more subtle, including the importance of predator-prey relationships and the possibility of losing unrecognized “keystone” species in a valuable ecosystem. Experience indicates that growing economic values of aesthetic and recreational or tourism amenities are to be expected in LMEs. Various sources of economic value arising from the natural diversity of the LME should be identified and assessed in regard to existing uses and potential management innovations.

5) Environmental Economics

Many of the elements described in this section comprise topics in Environmental Economics. Specialists in that field attempt to estimate the economic values (both use and non-use) associated with environmental resources and to identify conditions associated with their optimal management (to derive the greatest net benefits for society). An important element is the collaboration between scholars from developing and developed nations to transfer and adapt to the needs and techniques of Environmental Economics.

6) Integrated Assessment

The ultimate objective is integration of all the results achieved above, with scientific characterizations of the LME, into a comprehensive analytic framework (decision support environment) that will permit integrated assessment of human practices, effects, and management options in the region. Such work is at the forefront of recent research on the human dimensions of global environmental change as well as research on human interactions with natural marine systems.

Governance Module

The Governance Module is evolving based on case studies now underway among ecosystems to be managed from a more holistic perspective than generally practiced in the past In projects supported by the Global Environmental Facility (GEF)—for the Yellow Sea ecosystem, the Gulf of Guinea LME, and the Benguela LME—agreements have been reached among the environmental ministers of the countries bordering these LMEs to enter into joint resource assessment and management activities. Among other LMES, the Great Barrier Reef ecosystem is being managed from an holistic ecosystems perspective (Kelleher, 1993), along with the Northwest Australian Continental Shelf ecosystem (Sainsbury, 1988) being managed by the state and federal governments of Australia. The Antarctic marine ecosystem is being managed from an ecosystem perspective under the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and its 21-nation membership (Scully, 1993). Movement toward ecosystems management is emerging for the North Sea (OSPAR, 1993), Barents Sea (Eikeland, 1992), Black Sea (Hey and Mee, 1993) and Baltic Sea. Recent reports have examined options for improving linkages between the science-based Fish and Fisheries and Ecosystem Health Modules to the Socioeconomic (Sutinen *et al*., 1998) and Governance Modules (Juda, 1999).

Ecosystem Health and the "Why" Paradigm for Monitoring and Assessment

Before the 1992 Earth Summit in Brazil, the Global Environment Facility (GEF) was established within the World Bank as a pilot programme to test new approaches and innovative ways to respond to global environmental challenges in four focal areas: climate change, biodiversity conservation, ozone depletion, and international waters. In March 1994, after 18 months of intergovernmental negotiations, agreement was reached in Geneva to transform the GEF from its pilot phase into a permanent financial mechanism. The restructured facility, which has so far committed more than $2.5 billion in grant funding, is open to universal participation (currently 165 countries) and builds upon the partnership between the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank—which are its implementing agencies. In addition to the four focal areas, activities to address land degradation are also eligible for funding insofar as they relate to one or more of the four focal areas.

According to its Operational Strategy (GEF, 1996), the GEF will fund projects and programmes that are country-driven and based on national priorities designed to support sustainable development. In the international waters area, GEF's objective is to contribute primarily as a catalyst to the implementation of a more comprehensive, ecosystem-based approach to managing international waters and their drainage basins as a means of achieving global environmental benefits (Sherman and Duda, 1999). The GEF implementing agencies assist countries to find means of collaborating with neighboring countries in international waters projects. The GEF addresses priority transboundary concerns consistent with Chapters 17 and 18 of Agenda 21 made at the 1992 Earth Summit (Duda and Cruz, 1998). Scientists and natural resource managers from 59 countries representing environmental and fisheries ministries recognize the usefulness of LME geographic designation as an ecologically based assessment and management unit for coastal and marine resources, and have developed or are in the process of developing proposals for implementing LME projects under the Operational Strategy of the Global Environment Facility (Table A5.3).

From this growing LME activity a paradigm is emerging that is moving forward monitoring and assessment and management practices from single species to multispecies, from small spatial scales to larger spatial scales, from short-term management perspectives to long-term perspectives, and from managing single commodities to sustaining the production potential for a wider array of marine ecosystem goods and services.

Ecosystem management necessitates intergovernmental and intersectoral governance accommodation. This is *why* governmental stewardship agencies will have to identify barriers to interagency coordination and *why* they must develop alliances and partnerships with non-federal agencies and private sector stakeholders. Ecosystem management must be able to cope with the uncertainty associated with the complexity of ecosystems as natural systems, and the organizational and institutional complexity of the implementation environment (Acheson, 1994). The fit between the spatial and temporal scales of government jurisdictions on the one hand and ecosystems on the other requires investigation of ways to connect ecosystems through "networked institutions" at federal state, local, and NGO levels. How these institutions must adapt to deal with the complexity of the ecosystem and the complexity of the governance system in order to achieve an optimal mix of benefits and costs is a fundamental issue (Creed and McCay, 1996).

The complex interplay of socioeconomic, ecological, political and legislative processes underscores the need for an integrated approach to the governance and management of drainage basins, coastal areas and linked continental shelves and dominant current systems.

The LME monitoring and assessment approach is designed to be integrative. It provides a framework for linking the governance aspects of modular monitoring and assessment with the management of drainage basins and coastal areas with continental shelves and dominant coastal currents. The approach (i) addresses the many-faceted problem of sustainable development of marine resources; (ii) provides a framework for research monitoring, assessment and modelling to allow prediction and better management decisions; and (iii) aids in focusing marine assessments and management on sustaining productivity and conserving the integrity of ecosystems. The World Bank and the Global Environment Facility (GEF) have adopted the LME approach to marine ecosystem research and management, viewing it as "an effective way to manage and organize scientific research on natural processes occurring within marine ecosystems to study how pollutants travel within these marine systems".

According to Sutinen *et al*. (1998) one of the most challenging aspects of ecosystem management, especially for LMEs, is "[t]he mismatch between the spatial and temporal scales at which people make resource management decisions and the scales at which ecosystem processes operate" (Christensen *et al*., 1996). Christensen and his co-authors, writing for the Ecological Society of America, went on to lament that "we have identified few mechanisms to translate the actions occurring within individual forest ownership or local fishing communities into strategies to reconcile competing demands for resources or promote a regional vision for sustainability." Property rights establish the incentives and time-horizons for resource use and investment (Libecap, 1989). From a governance perspective the property rights paradigm coupled with the science-based monitoring and assessment modules can serve as the framework necessary to implement LME resource governance and management policies for long-term economic growth and resource sustainabillity.

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Table A5.1. Some of the substantive changes between traditional resource management and ecosystem management (from Lubchenco, 1996).

ECOSYSTEM MANAGEMENT: A PARADIGM SHIFT	
From	**To**
Individual Species	Ecosystems
Small Spatial Scale	Multiple Scales
Short-term Perspective	Long-term Perspective
Humans: Independent of Ecosystems	Humans: Integral Parts of Ecosystems
Management Divorced from Research	Adaptive Management
Managing Commodities	Sustaining Production Potential for Goods and Services

Table A5.2. List of 33 LMEs and subsystems for which syntheses relating to primary, secondary, or tertiary driving forces controlling variability in biomass yields have been completed for inclusion in LME volumes.

Large Marine Ecosystem	Volume No.	Authors
U.S. Northeast Continental Shelf	1 4 6	M. Sissenwine P. Falkowski S. Murawski
U.S. Southeast Continental Shelf Gulf of Mexico	4 2 4 9	Y. Yoder W. Richards and M. McGowan B. Brown *et al.* R. Shipp
California Current	1 4 5	A. MacCall M. Mullin D. Bottom
Eastern Bering Shelf	1 8	L. Inze and J. Schumacher P. Livingstone *et al.*
West Greenland Shelf	3	H. Hovgård and E. Buch
Norwegian Sea	3	B. Ellersten *et al*.
Barents Sea	2 4	H. Skjoldal and F. Rey V. Borisov
North Sea	1	N. Daan
Baltic Sea	1	G. Kullenberg
Iberian Coastal	2	T. Wyatt and G. Perez-Gandaras
Mediterranean-Adriatic Sea	5	G. Bombace
Canary Current	5	C. Bas
Gulf of Guinea	5	D. Binet and E. Marchal
Benguela Current	2	R. Crawford *et al*.
Patagonian Shelf	5	A. Bakun
Caribbean Sea	3	W. Richards and J. Bohnsack
South China Sea - Gulf of Thailand	2	T. Piyakarnchana
East China Sea	8	Y.-Q. Chen and X.-Q. Shen
Sea of Japan	8	M. Terazaki
Yellow Sea	2	Q. Tang
Sea of Okhotsk	5	V. Kusnetsov *et al*.
Humboldt Current	5	J. Alheit and P. Bernal
Pacific Central American	8	A. Bakun *et al*.
Indonesia Seas - Banda Sea	3	J. Zijlstra and M. Baars
Bay of Bengal	5 7	S. Dwivedi A. Hazizi *et al*.
Antarctic Marine	1 and 5	R. Scully *et al*.
Weddell Sea	3	G. Hempel
Kuroshio Current	2	M. Terazaki
Oyashio Current	2	T. Minoda
Great Barrier Reef	2 5 8	R. Bradbury and C. Mundy G. Kelleher J. Brodie
Somali Current	7	E. Okemwa
South China Sea	5	D. Pauly and V. Christensen

Vol. 1 Variability and Management of Large Marine Ecosystems. 1986. Ed. by K. Sherman and L.M. Alexander. AAAS Selected Symposium 99. Westview Press, , Boulder, CO. 319 pp.

Vol. 2 Biomass Yields and Geography of Large Marine Ecosystems. 1989. Ed. by K. Sherman and L.M. Alexander. AAAS Selected Symposium 111. Westview Press, , Boulder, CO. 493 pp.

Vol. 3 Large Marine Ecosystems: Patterns, Processes, and Yields. 1990. Ed. by K. Sherman, L.M. Alexander, and B.D. Gold. AAAS Symposium. AAAS, Wahsington, D.C. 242 pp.

Vol. 4 Food Chains, Yields, Models, and Management of Large Marine Ecosystems. 1991. Ed. by K. Sherman, L.M. Alexander, and B.D. Gold. AAAS Symposium. Westview Press, , Boulder, CO. 320 pp.

Vol. 5 Large Marine Ecosystems: Stress, Mitigation, and Sustainability. 1992. Ed. by K. Sherman, L.M. Alexander, and B.D. Gold. AAAS Press, Washington, D.C. 376 pp.

Vol. 6 The Northeast Shelf Ecosystem: Assessment, Sustainability, and Management. 1996. Ed. by K. Sherman, N.A. Jaworski, and T.J. Smayda. Blackwell Science, , Cambridge, MA. 564 pp.

Vol. 7 Large Marine Ecosystems of the Indian Ocean: Assessment, Sustainability, and Management. 1998. Ed. by K. Sherman, E.N. Okemwa, and M.J. Ntiba. Blackwell Science, , Malden, MA. 394 pp.

Vol. 8 Large Marine Ecosystems of the Pacific Rim: Assessment, Sustainability, and Management. 1999. Ed. by K. Sherman and Q. Tang. Blackwell Science, , Malden, MA. 455 pp.

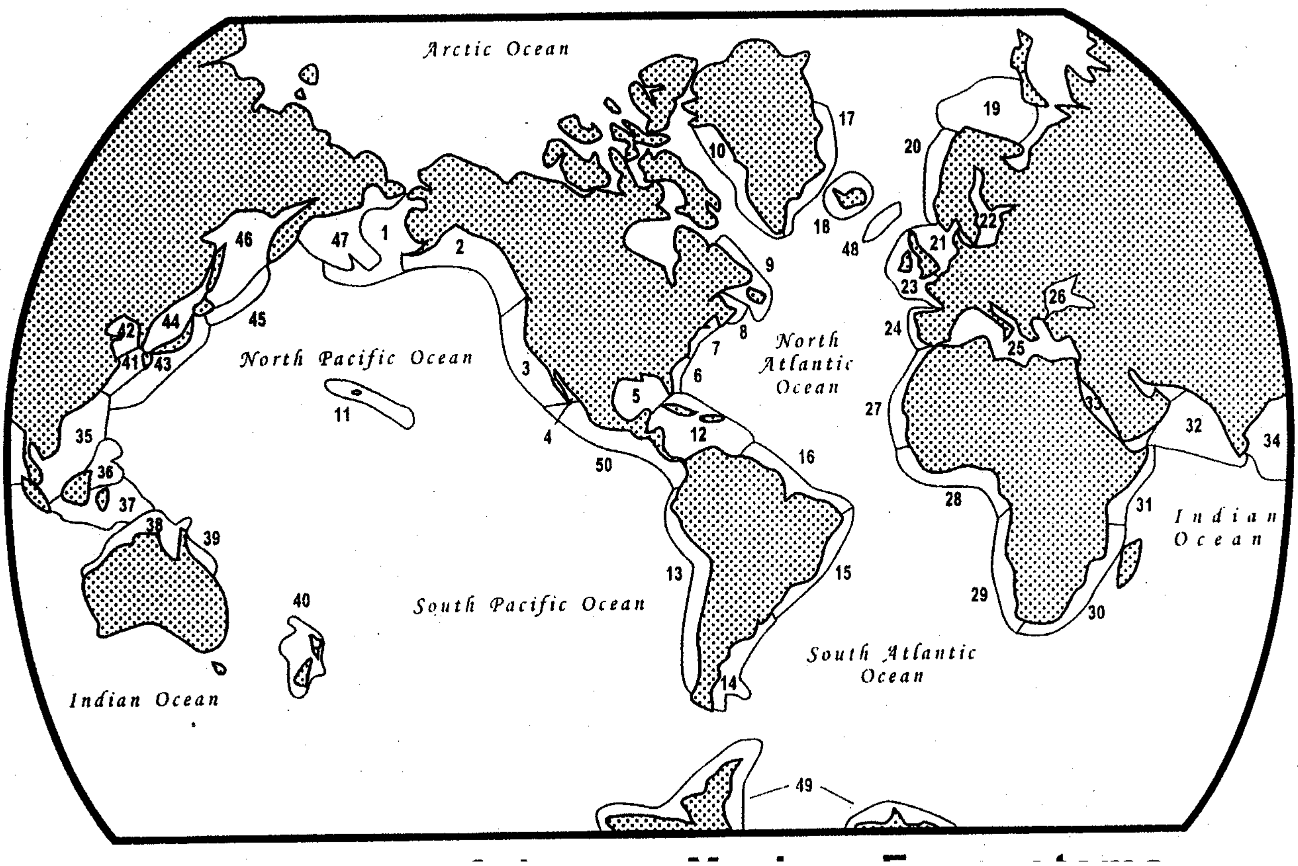
Vol. 9 The Gulf of Mexico Large Marine Ecosystem: Assessment, Sustainability, and Management. 1999. Ed. by H. Kumpf, K. Stiedinger, and K. Sherman. Blackwell Science, , Malden, MA. 736 pp.

Table A5.3. Countries where Marine Resource Ministries (fisheries, environment, finance) are supportive of resource assessment and management from an ecosystems perspective.

Continent	LME	Participating countries	Status
Asia	Bay of Bengal	Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka, Thailand	PDF Block B funding approved. UN Executing Agency is FAO.
	South China Sea	Sumatra, Malaysia, Cambodia, Thailand, Vietnam, China, Philippines, Borneo	PDF Block B funding approved. UN Implementing Agency is UNEP.
	Yellow Sea	Korea, China	PDF Block B funding approved. UN Implementing Agency is UNDP.
Africa	Gulf of Guinea	Nigeria, Chana, Ivory Coast, Benin, Cameroon, Togo	$6 mil. Approved. Project in year 2. UN Executing Agency is UNIDO.
	Benguela Current	South Africa, Namibia, Angola	PDF Block B funding approved. UN Implementing Agency is UNDP.
	Somali Current	Tanzania, Kenya	PDF Block B funding approved. UN Implementing Agency is UNEP.
	Agulhas Current	Mozambique, South Africa, Madagascar	Initial funding pending. UN Implementing Agency is UNEP.
	Canary Current	Guinea, Guinea Bissau, Gambia, Cape Verde, Mauritania, Morocco, Senegal	PDF Block B funding approved. UN Implementing Agency is UNEP, IUCN a partner.
South America	Humboldt Current	Chile, Peru	In planning phase.
	Caribbean Sea	Bahamas, Barbados, Belize, Brazil, Colombia, Costa Rica, Cuba, Jamaica, Mexico, Panama, St. Lucia, Trinidad and Tobago, Venezuela (IOCARIBE members)	In planning phase with UNESCO/IOC. PDF Block A approved.
Eastern Europe	Baltic Sea	Poland, Estonia, Latvia, Lithuania, Russia, Finland, Sweden, Germany, Denmark	PDF Block B approved. Implementing Agency is the World Bank.

FAO = United Nations Food and Agricultural Organization, Rome.
UNEP = United Nations Environmental Programme, Nairobi.
UNDP = United Nations Development Programme, New York.
UNIDO = United Nations Industrial Development Organization, Vienna.
IUCN = The World Conservation Union, Gland.
UNESCO/IOC = United Nations Educational and Scientific Organization/Intergovernmental Oceanographic Commission, Paris.

Figure A5.1. World map of large marine ecosystems.



1)	Eastern Bering Sea	26)	Black Sea
2)	Gulf of Alaska	27)	Canary Current
3)	California Current	28)	Gulf of Guinea
4)	Gulf of California	29)	Benguela Current
5)	Gulf of Mexico	30)	Agulhas Current
6)	Southeast U.S. Continental Shelf	31)	Somali Coastal Current
7)	Northeast L.J.S. Continental Shelf	32)	Arabia Sea
8)	Scotian Shelf	33)	Red Sea
9)	Newfoundland Shelf	34)	Bay of Bengal
10)	West Greenland Shelf	35)	South China Sea
11)	Insular Pacific-Hawaiian	36)	Sulu-Celebes Seas
12)	Caribbean Sea	37)	Indonesian Seas
13)	Humboldt Current	38)	Northern Australia
14)	Patagonian Shelf	39)	Great Barrier Reef
15)	Brazil Current	40)	New Zealand Shelf
16)	Northeast Brazil Shelf	41)	East China Sea
17)	East Greenland Shelf	42)	Yellow Sea
18)	Iceland Shelf	43)	Kuroshio Current
19)	Barents Sea	44)	Sea of Japan
20)	Norwegian Shelf	45)	Oyashio Current
21)	Baltic Sea	46)	Sea of Okhotsk
22)	Celtic-Biscay Shelf	47)	West Bering Sea
23)	Iberian Coastal	48)	Faroe Plateau
24)	Mediterranean Sea	49)	Antarctic
25)	Mediterranean Sea	50)	Pacific Central American Coastal

ANNEX 6: RECOMMENDATIONS

SGEAM proposes that ICES establish Regional Ecosystem Groups (REGs) to provide for the preparation of integrated assessment by experts on fisheries and environmental conditions. The work in the REGs should focus on the following tasks:

- consider the general issue of integration of pertinent assessment information on the changing states of large marine ecosystems in the region, based on regional expertise;
- prepare periodic assessments of the status and trends in fish stocks and environmental conditions of the LMEs in the region with emphasis on:
  - a) climatic/physical driving forces, and
  - b) biological (e.g., multispecies) interactions;
- contribute to environmental assessments and preparation of Quality Status Reports (QSRs) in cooperation with stakeholders, academic institutions, the public, and other organisations (e.g., EEA, OSPAR, AMAP, HELCOM).

SGEAM further proposes that, at its next meeting, SGEAM is given the task of making a proposal for a division into regional ecosystems and also work out a proposal for a required scientific membership composition for the proposed REGs.