Implementing the ecosystem approach: experiences from the North Sea, ICES, and the Institute of Marine Research, Norway

Ole Arve Misund*, Hein Rune Skjoldal

Institute of Marine Research, PO Box 1870, 5817 Bergen, Norway

**Email: ole.arve.misund@imr.no*

The ecosystem approach. The ecosystem approach is a management principle which builds on the recognition that nature is an integrated entity and that we must take a holistic approach to nature management. The science to support ecosystem approach to management must also be integrated and holistic. A core element of this science is ecology, with a focus upon the properties and dynamics of ecosystems (Fenchel 1987). Many scientists and managers have recognised the need for an ecosystem approach for a long time (Likens 1992), although it is only during the last 10 to 15 yr that a broader awareness of this has developed.

The increased awareness and formalisation of the ecosystem approach have emerged as a result of international environmental agreements within the framework of the United Nations, and a fundamental description of the basis of an 'ecosystem approach' was first formalised in the Stockholm Declaration in 1972 (Turrell 2004). The most authoritative account of the ecosystem approach is probably in Decision V/6 from the meeting of the Conference of the Parties to the UN Convention on Biological Diversity in Nairobi, Kenya, in 2000. This decision has an annex with a description, principles and operational guidance for application of the ecosystem approach (www.biodiv.org/decisions/?m=cop-05).

The Large Marine Ecosystem (LME) concept has been the basis for a practical development of the ecosystem approach to the management of marine resources and environment (Sherman 1995, Duda & Sherman 2002). Currently, 64 LMEs have been identified, dividing mainly the shelf regions of the globe into management units. Scientific and management issues concerning these LMEs have been the subject of a large number of symposia and books (see www.edc.uri.edu/lme).

In many fisheries science institutions, advisory communities and management bodies, practical implementation of the ecosystem approach has been a central issue for the last years. There is no unified understanding or protocol on how to deliver scientific advice for management of fish stocks under the broad scope of the ecosystem implications of fishing, as compared to the traditionally narrow consideration of the population dynamics of single fish stocks. The FAO Expert Consultation on Ecosystem-based Fisheries Management in Reykjavik in 2001 (FAO 2003, Garcia et al. 2003) produced an overall, pragmatic solution for implementing the ecosystem approach to fisheries (EAF) by merging ecosystem management and fisheries management. The EAF principles are yet to be implemented by most of the fisheries scientific and advisory bodies around the world.

The ecosystem approach has been a central issue in political processes such as the Fifth International Conference on the Protection of the North Sea held in Bergen in 2002 (NSC 2002), and the development of a governmental white paper on integrated marine management in Norway in 2002 (Anonymous 2002). Similarly, the ecosystem approach was a basis for the development of the strategic plan of the International Council for the Exploration of the Sea (ICES 2002), and in the reorganisation of the Institute of Marine Research (IMR), Norway (Anonymous 2001, Misund et al. 2005). We reflect here on our experiences from the political processes for the North Sea and in Norway on developing the ecosystem approach to management. We go on to give our views on the development of the ecosystem approach within 2 scientific organizations that must deliver scientific advice according to the ecosystem approach, ICES and our home institute (IMR) in Norway.

Development of the ecosystem approach for the North Sea. The first International Conference on the Protection of the North Sea was held in Bremen in Germany in 1987, followed by the 2nd and 3rd Conferences in London in 1988 and The Hague in 1990. The Ministers at the 3rd Conference in The Hague requested that OSPAR (the Convention for the Protection of the Marine Environment of the North-East Atlantic) and ICES should establish a North Sea Task Force (NSTF), for producing a Quality Status Report (QSR) for the North Sea. This QSR was completed in 1993 (NSTF 1993) and identified fisheries as having major impacts on the North Sea ecosystem. At the 4th Conference in Esbjerg in 1995, these fisheries impacts were discussed by the Ministers responsible for the environment.

As host for the 5th Conference, Norway arranged an Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues in Bergen in March 1997. In their Statement of Conclusions (IMM 1997), the Ministers responsible for fisheries and the environment in the countries bordering on the North Sea agreed that an ecosystem approach should be developed and implemented as a guiding principle for the further integration of fisheries and environmental management measures. This was followed by a workshop in Oslo in 1998 where a framework for an eco-

system approach was drawn up (Anonymous 1998). This framework was adopted with slight modifications by the Ministers at the 5th Conference in Bergen 2002 (NSC 2002).

The framework for an ecosystem approach to management consists basically of 5 major elements or modules in a management cycle (Fig. 1). Objectives should relate to the state of the ecosystem. Monitoring and research should be performed to provide updated information about status and trends (monitoring) and insight into mechanisms and causal relationships (research). Assessments should use information from monitoring and research to evaluate whether objectives are being met or whether progress is being made towards meeting them. Scientific advice should be formulated clearly to translate the natural complexity into a clear and transparent basis for decisions. Finally, management should respond to the advice and to the needs for actions to meet the agreed objectives.

The Ministers at the 3rd Conference in The Hague had requested that methodology for setting ecological objectives should be developed. This work was initiated by the NSTF and continued by OSPAR after 1993. Workshops were held at Bristol in 1992, Geilo in 1993, and Ulvik in 1995 to consider terminology, feasibility and selection criteria for formulating Ecological Quality Objectives (EcoQOs). This resulted in a general methodology or approach for setting EcoQOs (Skjoldal 1999). In 1997 OSPAR agreed to apply this methodology to the North Sea as a test case. This work was subsequently linked to development of the ecosystem approach, filling the need for ecological objectives in the latter. Based on the outcome of 2 workshops held at Scheveningen in 1999 and Schiphol in 2001, and considerable input from ICES (Advisory Committee on Ecosystems, ACE Reports for 2001, 2002, 2003; available at www.ices.dk/products/cooperative.asp), a set of 10 EcoQOs were agreed by the Ministers at the 5th North Sea Conference (NSC 2002, Annex 3).

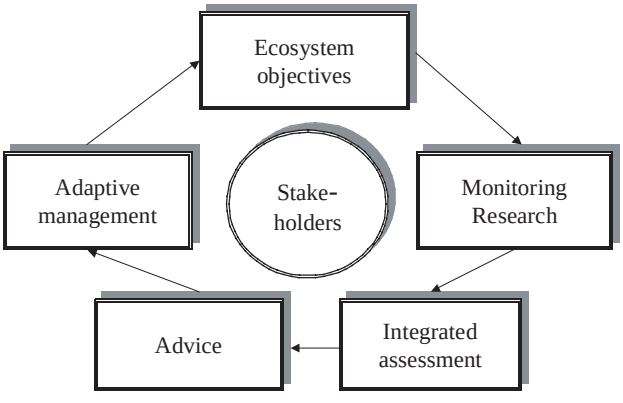

Fig. 1. Framework for the ecosystem approach to ocean management with main components or modules shown in an iterative management decision cycle. This is a simplified version of the framework in the Bergen Declaration (NSC 2002). Stakeholders should be included in the process, to promote openness and transparency

The ICES Study Group on Ecosystem Monitoring and Assessment proposed the following definition of the ecosystem approach (ICES 2000): '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 formed the basis for the technical definition of ecosystem approach used in a statement from the First Joint Ministerial Meeting of the Helsinki and OSPAR Commissions (JMM) in Bremen in June 2003 (www.ospar.org), and in the work on developing the thematic Marine Strategy within the EU (http://europa.eu.int/comm/environment/water/consult_marine.htm):

> The comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity.

It is worth stressing the emphasis on *integrated management of human activities* in this definition. Integration between different sectors of the society is a key element of the ecosystem approach, and this has scientific and institutional implications. Scientifically, we need the ability to assess the combined impacts from different sectors on the marine ecosystems, and institutionally the sectors need to work closely together. This means for instance that close collaboration between the fisheries and environmental conservation sectors is a prerequisite for an effective ecosystem approach to management.

In the Norwegian Government's White Paper 'Clean and Rich Sea', which shaped Norwegian marine policy (Anonymous 2002), the ecosystem approach is seen as the means of achieving better sector integration. The marine areas under Norway's jurisdiction constitute parts of the North Sea, the Norwegian Sea and the Barents Sea LMEs. The description of the ecosystem approach in the White Paper was modelled very much after the framework developed for the North Sea. In addition to continuing the international work in the North Sea, the Norwegian Government has started to develop a management plan for the Barents Sea. This includes development of EcoQOs and assessments of the key impacts on the Barents Sea ecosystem: fisheries, mariculture, offshore oil and gas production, shipping, long-range transport of pollutants, and climate change.

Developments within ICES. ICES is an independent scientific and advisory organisation that has existed for more than 100 yr (Rozwadowski 2002). It has traditionally provided governments of the North Atlantic region with advice on harvesting of fish stocks and on environmental issues such as pollution monitoring, aggregate extraction, algal blooms, or mariculture. Recognising the focus on ecosystems and the need for stronger integration, ICES initiated in 1999 a process to develop a functional strategic plan. This plan includes the ecosystem approach as a foundation for the work of ICES, and it was signed by delegates from the 19 participating countries in 2002 (ICES 2002). Since then, the 7 scientific committees of ICES have developed specific action plans to implement the new strategy.

Responding to the foreseen need for more integrated advice on ecosystems, ICES established in 2000 a new Advisory Committee on Ecosystems (ACE) in addition to its 2 existing advisory committees, ACFM (Advisory Committee on Fisheries Management) and ACME (Advisory Committee on the Marine Environment). ACE is the ICES body for providing scientific advice and information on the status of and outlook for marine ecosystems, and on the exploitation of living marine resources in an ecosystem context.

The fishery science and the environmental science within ICES represent 2 different scientific traditions and cultures. Bridging them has not been easy. The fishery science is very computational using models and sophisticated statistical tools to estimate the current and future sizes of fish stocks as a basis for advising on catch quotas. The environmental science covers a much broader spectrum of disciplines with stronger emphasis on processes and descriptions, and less on formalised and standardised computations. The fisheries scientists work on a tight annual schedule with data collection, stock assessments at working group meetings, and provision of advice on next year's quotas to fisheries management institutions. Environmental scientists usually have less time pressure from the management system, with environmental assessments carried out at more irregular and less frequent intervals. The difference between the 2 traditions materialises clearly, for example, in the difficult issue of integrating information about oceanographic variability into the regular fish stock assessment process (Ulltang & Blom 2003).

The ground layer of the ICES structure consists of >100 working or study groups that meet annually or work by correspondence to produce reports addressing specific terms of reference given to them by the ICES Council. These groups cover virtually every aspect of the marine environment. This structure has evolved over the decades in response to past needs, and it has been partly overhauled to meet the current and future needs for information on the status of and outlook for the marine ecosystems in the North Atlantic region.

Integrated assessments of the status and outlook of the marine ecosystems could provide a focus and incentive for ICES to become more operational. ICES activities in the Baltic Sea and the North Sea are serving as test cases. A Regional Ecosystem Study Group for the North Sea (REGNS) was established in 2003 and is now coordinating efforts to produce an assessment of the recent status and trends in the North Sea ecosystem, to be finalised in 2006 (ICES 2004).

There is an increasing awareness that ecosystems are not abstract concepts, but real entities in nature. They are open systems and their boundaries may be fuzzy and to some extent pragmatically determined, depending on the purpose of their delimitation. Nevertheless, there are more or less sharp discontinuities in physical features and distribution of organisms, and these are a help when drawing the boundaries of LMEs based on ecological criteria (Skjoldal 2004a,b).

Compiling and assessing information and advising on the status of and outlook for marine ecosystems requires a geographical focus consistent with the boundaries of the identified LMEs. This means in practice that experts on different aspects within each ecosystem, e.g. physical oceanography, plankton, benthos, fish, must work together to provide the integrated analyses and a synthesis of the information. Some rearrangement of the ICES working groups is required to account for regional aspects. Thematic groups to deal with general issues (e.g. methods, climatic driving forces) common to all or several specific ecosystems must be maintained. We therefore support development of a streamlined and ecosystem-oriented advisory function with regional working groups, much along the lines proposed by the ICES Study Group on the Advisory Committees and Working Group Protocols (ICES 2003), to enable ICES to deliver scientific advice according to the ecosystem approach.

Developments at IMR. The leaders of the Institute of Marine Research (IMR), Norway, considered that the organization of the institute was not strategically suited to deliver holistic ecosystem-based science and advice to support the ecosystem approach to management. The IMR had 4 science centres (for living resources, environment, aquaculture, and coastal studies) that acted to some extent as separate entities within the institute. The centres conducted their activities within advisory and science programmes that were specific to each centre. The centres were, furthermore, managed as separate economic units, each

with the responsibility to manage the budget with a positive balance in the long run. Cooperation between the centres was less than would be desirable, both scientifically and administratively, and it was difficult to achieve the level of cooperation between centres that is required for dealing with ecosystem issues.

Based on a recommendation from the directors of IMR, and its acceptance by the Ministry of Fisheries and Coastal Affairs, the IMR Board initiated in spring 2002 a process to develop a new organisation for the institute. The introduction of the ecosystem approach in the White Paper of the Norwegian Government, in the Bergen Declaration of the 5th North Sea Conference, and the new strategic plan for ICES were triggers of the reorganization of IMR. During a 1.5 yr internal process initiated by the leader group and extended with representatives from the major labour unions, a new organisation was developed (Misund et al. 2005). The classical, discipline-oriented structure with centres for marine environment, marine resources, coastal zone and aquaculture was abandoned. The former programme structure with 4 advisory programs following the centre structure, and up to 10 science programmes across the centre structure, was also abandoned.

The new organization has 3 ecosystem-based programmes and 1 thematic science and advisory programme, 19 research groups, a technical department divided into 9 research technical groups, an administrative department that includes the former centre administrations, and an unchanged research vessel department to operate the fleet of the institute (Fig. 2). These programmes provide a structure for the scientific and advisory activity of IMR by defining all activities into projects that are carried out by the research and technical groups.

The 3 ecosystem-based programmes are set up according to the division of LMEs in the North-Eastern Atlantic (Sherman 1995, Sherman & Skjoldal 2002). There is one programme that covers the Barents Sea LME and one that covers the Norwegian Sea and the North Sea LMEs together. A 3rd programme covers the coastal zone of Norway. The 4th programme is thematic and covers the aquaculture activities of the institute.

The ecosystem programmes build on a common, simplified understanding of the ecosystem approach to focus on 3 main operational goals: (1) a clean sea (monitoring and advice to secure the lowest possible level of contamination of anthropogenic pollutants in the marine environment and seafood); (2) better advice for sustainable harvest of marine resources (single species models are still applied, but multispecies considerations and ecosystem information will be taken more into account); (3) reduced ecosystem effects of fishing (improvement of the size and species selectivity of fishing gears and reduction of impacts on bottom fauna).

Parts of the Barents, Norwegian and North Seas LMEs are within Norwegian jurisdiction. Norway is only one of the countries that have the right to harvest the living marine resources within these ecosystems. International cooperation at the political, scientific and management levels is important for effective implementation of an ecosystem approach. The natural and anthropogenic drivers that influence the ecosystem

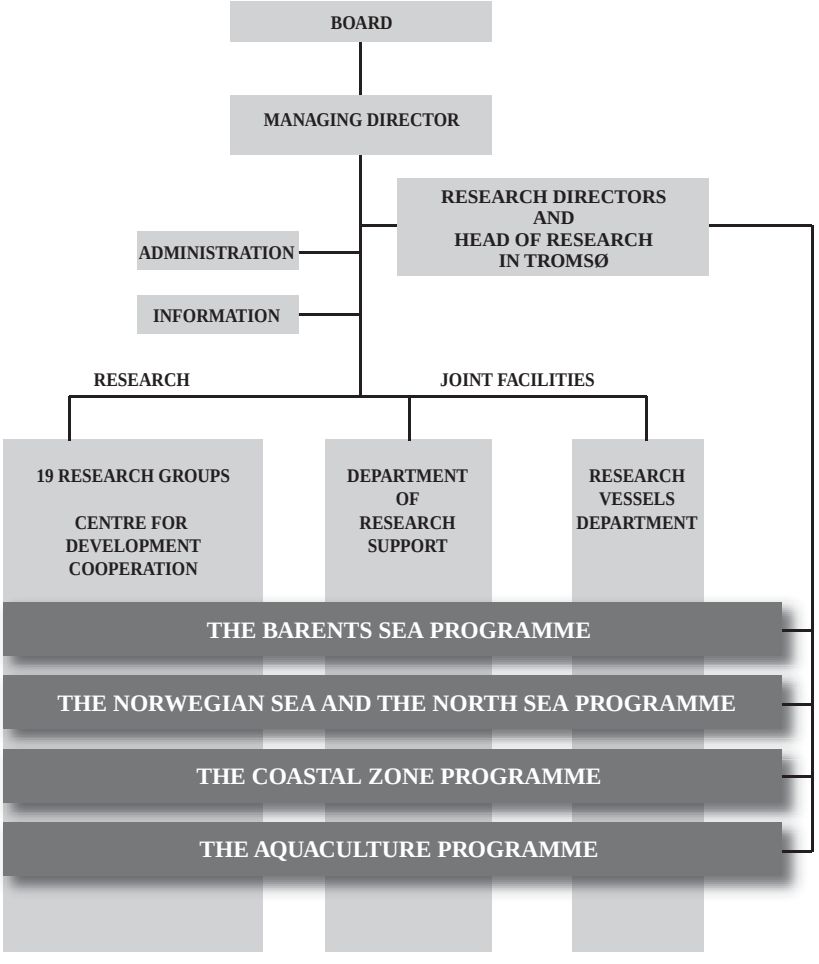

Fig. 2. Present organisational chart (tentative) of the Institute of Marine Research (IMR), following reorganisation in 2004 for adaptation to the ecosystem approach to ocean management.

structure, productivity and major living resources within these LMEs are different. The science and advisory programmes therefore have taken somewhat different approaches in building up their project portfolios.

Within the new organization of IMR, the science and advisory programmes are still in an early phase of development. In the years to come, attention will be given to further refine and develop the ecosystem approach as their central element. Surveys in the Barents Sea and the Norwegian Sea now have a clear ecosystem focus, including simultaneous monitoring of hydrographic conditions, plankton, fish stocks and marine mammals. The North Sea surveys, however, are still focused on single aspects such as demersal (IBTS surveys) or pelagic fish stocks (e.g. the herring surveys). These activities have a long tradition of ICES coordination, and it will take some time to adjust the various activities coordinated by ICES to support an effective ecosystem approach to North Sea management.

In developing the new organisation and structuring the scientific and advisory activities within IMR, we have chosen a pragmatic strategy. Our philosophy is that we will further develop the ecosystem approach within our scientific and advisory activities 'as we go along'. The choice of a new structure and way of functioning of the institute lowers the effect of the 'resistance to change' inherent in any organisation, and forces all persons involved to consider the new requirements by an ecosystem approach free from the constraints and empowerments from the previous structure. In the years to come, the objectives of the ecosystem approach to management of fisheries and marine ecosystems will be clarified and made more explicit, and we believe our new organization is well suited to deliver the scientific support for achieving those objectives.

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Implementation of the Ecosystem Approach to Fisheries Management — asynchronous co-evolution at the interface between science and policy

Jake C. Rice

Department of Fisheries and Oceans, Canadian Science Advisory Secretariat, 200 Kent Street, Ottawa, Ontario, Canada K1A 0E6

Email: ricej@dfo-mpo.gc.ca

Introduction. I write from the perspective of a scientist with a background in terrestrial post-MacArthur (1972) community ecology. I began to work on marine ecosystem research problems more than 20 yr ago, and was drawn into the web of problems of advising managers and policy developers first on fisheries, and then on a progressively much broader range of issues. For the past decade my advisory work for fisheries management and policy has been primarily through ICES — where since 1996 I have attended most meetings of their Advisory Committees on Fisheries Management (ACFM), Marine Environment (ACME) and Ecosystems (ACE) — and DFO (as director of the Science Advisory Secretariat). The change of the relationship between science and policy on ecosystem issues has been particularly apparent in these fairly formal advisory settings. Here is what I have seen.

The role of science in formulation of policy on the Ecosystem Approach to Fisheries (EAF) is fundamental — but primarily it has been a supporting role, not one of leadership. This is frustrating for both sides, but it is an inevitable consequence of the reality that science growth is incremental, whereas policy changes are saltatory. Few people in either science or policy understand why that is inevitable, and this lack of understanding frustrates communication and impedes progress, as each group may perceive the other as behaving irrationally. The different nature of change in science and change in policy also provides unlimited ammunition to those exercising hindsight, to the detriment of effective communication and true progress. Because of the importance of this difference in how change occurs in science and in policy, it is worthwhile to consider its origins.

Why policy changes are saltatory. There are pressures both outside and inside governments to maintain a stable policy environment. On the outside, resource users want stability to plan their operations rationally. It is hard enough for industries to keep up with changes in markets and operating conditions, without being uncertain about the regulatory framework in which they will have to work. On the inside, managers want stability to develop management plans for achieving a specified set of objectives, monitoring the effectiveness of the plans, and adapting management tactics to correct discrepancies. If the policy-based objectives change frequently, then effective management planning and implementation becomes impossible.

In a democracy, major change in policies and regulations requires at least consultation, if not legislation. Both take time and have significant inertia. As a result, major policy changes are not highly risk prone. For consultation to demand major change, a groundswell of support for a new approach already has to exist, or else a convincing case for change has to be made by the government promoting the change. Governments, in turn, want some confidence that they are making a change for the better, if they are shaking up a status quo to which many primary constituencies have adapted. Even when there is widespread perception that change is needed, consultation and political processes which follow democratic practices will be biased towards those options that the public wants, not the options recommended by the science community. Before the science can have a major impact on policy change, it has to be mature enough, so that the scientists can convince political decision makers that the associated costs and benefits are known and that the costs are justified.

Why science is out of synchrony with policy changes. The lack of synchrony factors is largely due to 2 factors: (1) Ideas gain influence in science slowly. Some ideas, although rarely disputed, are just hard to document fully enough to support management actions, and the science basis for changes to policy and management accumulate incrementally. For example, it has been acknowledged since the first years of fisheries science that predator–prey interactions are important to management (Smith 1994, Rozwadowski 2002). However, each time a science body made a serious effort to bring those relationships into the advisory process, it took a decade or more to collect the necessary information and develop the corresponding models (North Sea: Pope 1991; Barents Sea: Yndestad 2004; Antarctica: CCAMLR 2004), and even more time to convince the wider science community to accept the specific tools and the estimates of the interaction rates. It has been argued that really new ideas in science are revolutions not evolution (Kuhn 1970), but even in this case, acceptance of the revolutionary idea has to