Ecosystem Approach to Management - what is it and what does it imply?

A concept paper prepared for use in the Arctic Council

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Background

The Ecosystem Approach to management (EA) was adopted as an overarching principle and approach by Arctic Council Ministers in 2004 as part of the Arctic Marine Strategic Plan (AMSP). In the strategic plan the EA was described in the following manner:

"An integrated ecosystem-based management approach requires that development activities be coordinated in a way that minimizes their impact on the environment and integrates thinking across environmental, socioeconomic, political and sectoral realms. The management of resource activities needs to be focused on realistic, practical steps that are directed toward reducing environmental damage, protecting biodiversity and promoting the health and prosperity of local communities. For such an approach to be successful, the relevant ecosystems need to be better understood, monitored and reported on. Actions must be based on clear objectives and a sound management structure, employing best available knowledge and practices, integrated decision-making and, where appropriate, a coordinated, regional approach."

This is a good description and a good starting point for this brief tour and summary of the history and development of the concept of the *Ecosystem Approach to management*, or for short, the *Ecosystem Approach*.

The follow-up work on the EA in the Arctic Council was taken on board by the PAME working group. PAME developed a working map with a break-down of the marine Arctic into 17 Arctic Large Marine Ecosystems (LMEs) that was adopted by Ministers in 2006. PAME established an expert group (EG) on the EA in 2007 that was broadened to become a joint group with AMAP and CAFF in 2011. As part of the work of the EG, Norway (as one of the co-leads for this topic along with the USA) agreed to produce a 'concept paper' on the EA that summarizes previous discussions and agreements on concepts and terminology related to ecosystem approach to management for discussion within the Ecosystem Approach Expert Group.

The Arctic Council Ministers enabled an Experts Group on Arctic ecosystem-based management (EBM) as a follow-on to the Nuuk Declaration of 2011. The Experts Group on Arctic EBM is developing a common understanding of EBM and EBM principles for the Arctic Council and it is also providing recommendations for advancing EBM on land and sea in the Arctic. The report of the Experts Group is to be delivered in advance of the 2013 Arctic Council Ministerial meeting.

History of an evolving concept

The concept of the EA is not new. It has been around for at least 30 years and it has been extensively discussed, elaborated and developed.

The concept has matured to the point where it is now past the time to dwell on the definitions and purposes of the EA. Accordingly the task before us is to gather the available definitions and management contexts to move on to the next stage. The conclusion of our work is to address how EA is to be implemented in practice, in the real world of the Arctic.

The concepts of ecosystems and of the EA are at the same time well understood and vaguely defined. The paradox is created by the difficulty of precisely measuring the time-varying complex mix of attributes of hydrography, bathymetry, topography, food web structure and productivity that together are well understood to characterize the ecosystem.. Ecosystems are made up of the space of land or water together with the species that occupy and use that space during their lives. The space itself may be a mosaic of different biotopes or habitats. An ecosystem is defined as the sum of the living space (or habitats) and the species, acting as a 'functional unit'. Defining the ecosystem is further complicated by the fact that nature is continuous and ecosystems as functional units may not be conspicuous and easily recognized as such, as units. This vagueness about the definition of ecosystems is in part responsible for the difficulty in gaining acceptance for the ecosystem approach to their management, which still has a cloud of skepticism around it for many people.

The EA is embedded in the core of the concept of Large Marine Ecosystems (LMEs) which has been around for about 30 years. The LME process was launched in the early 1980s and has proceeded with a number of symposia and books about the concept, approach, methodological aspects, and conditions in a wide range of LMEs around the globe (Sherman 1994, 2008, Sherman et al. 2004). A number of LME projects have been launched with implementation of the EA to the management of specific LMEs such as the Benguela Current, Yellow Sea, and others (Sherman et al. 2009).

Scientists have discussed the EA concept at length both within and outside the LME context. Gene Likens wrote in 1992 the book 'The ecosystem approach: its use and abuse'. In a landmark attempt to move the discussion toward a common understanding, more than two hundred US-based science and policy experts released in 2005 a scientific consensus statement on marine ecosystem-based management (McLeod et al. 2005). In another attempt to find common ground, among many such possible examples, a wide range of scientists contributed to two theme sections on the EA in the journal Marine Ecology progress Series in 2004-05 (Browman et al. 2004, 2005). Nonetheless, the extensive writing by scientists has not always helped to clarify the concept because of the complexity created by the polyglot nature of the perspectives from so many different scientific and policy disciplines. Developing a common understanding of the EA is a painstaking process of distilling the many different disciplinary perspectives, economic and policy aspects and examples from terrestrial and marine case studies into a common language.

In parallel with the intellectual development of the LME and allied EA concepts described above, governments all over the world have been in process of adopting the principles of EA into legislation prescribing regulatory practices for management of natural resources for at least two decades.

The United Nations Convention on Biological Diversity (CBD) uses EA as an overarching framework for the work of the Convention in implementing its objectives (CBD 2004). The 12 so-called 'Malawi principles' were developed in 1998 and adopted in 2000 as part of a description of the EA including 5 points of operational guidance to implementation (COP Decision V/6; http://www.cbd.int/decision/cop/?id=7148). CBD carried out an 'in-depth review' of the EA in 2010 (CBD 2010). A general conclusion from the review was that there was no need to revise the concept but that experiences from application should be collected and shared (Ref.).

In Europe, North Sea Ministers and EU Commissioners asked in 1997 that an EA should be developed and implemented as a guiding principle for the further integration of fisheries and environmental management measures for the North Sea ecosystem (IMM 1997). This was done and the North Sea Ministers agreed to a framework for the EA at the 5th North Sea Conference in Bergen in 2002 (NSC 2002). The EA framework in the Bergen Declaration has been used as a basis for development of integrated management plans for the Barents Sea and Norwegian Sea ecosystems in Norway (Olsen et al. 2007, Olsen and Hoel 2011). It has also influenced the ocean policy development in the European Union with the Marine Strategy Framework Directive (MSFD) as the sustainability pillar of an integrated maritime policy (Skjoldal and Misund 2008, refs.).

During the same time period as the developments in the EU, the United States was moving toward implementation of EA principles. In 1996 the revised Magnuson Stevens Fishery Conservation and Management Act (MSFCMA) required a broad approach to fishery management that included characterizing the environment on which the fish species depended. As of 2009 the concept now known as Ecosystem-Based Fishery Management, or EBM, has been largely adopted in the Fishery Management Plans of the United States (NMFS 2009). The Arctic Fishery Management Plan issued in 2009 is a notable application of EA in that it closes all U.S. Arctic waters to commercial fishing until such time as information on the potential impacts of fishing may be produced (http://www.fakr.noaa.gov/npfmc/PDFdocuments/fmp/Arctic/ArcticFMP.pdf).

In the United Nations the EA concept was a main topic for the meeting of the Informal Consultative Process (on Oceans and the Law of the Sea) at its seventh meeting in July 2006. The meeting agreed a number of consensual elements as to what the EA should include and how it could be achieved in practical implementation (ICP 2006). Later in the same year a

Conference in Bergen (organized by Norway and Iceland with support from FAO) considered, as one of the topics, the EA concept, both in general and when applied in fisheries (Bianchi and Skjoldal 2008).

As mentioned in the background section above, the AC adopted the EA as a general principle and approach in 2004 and work has been followed up by PAME. One follow-on activity was the project BePOMAR (Best Practices in Ecosystem-Based Oceans Management in the Arctic) (run in collaboration with SDWG) where best practices from planning and implementation of the EA in national ocean management policies were reviewed. BePOMAR identified several core elements that are essential when applying the EA and drew 6 general conclusions from the review of practices (Hoel 2009).

Definition of EA

One would like to believe that since the EA is an old concept that has been extensively elaborated and discussed over several decades, it would now be crystal clear. It is not, but still we know what it means.

There is broad agreement on why we need the EA and what it represents in terms of integrated management of human activities with due regard to the well-being and sustainability of the marine ecosystems. There is also agreement on core elements and principles. So based on this we know what the EA is and we know what to do to implement it, in general terms.

There are several reasons why the concept still remains somewhat clouded. One is the inherent vagueness about ecosystems and the related scale issue. It is clear that you need defined ecosystems to apply the EA. But how do we deal with the fact that ecology and human uses and activities happen at a wide range of different scales? And how do we deal with the open boundaries of ecosystems and the nesting of scales both within and across those boundaries? There are many scientific and practical challenges associated with this, not the least of which is the difficulty of precisely measuring on biologically meaningful time and space scales the attributes that characterize the ecosystem (such as hydrography, bathymetry, topography, food web structure and productivity). Another factor (related to the scale issue) is the hierarchical nature of things. EA is an overarching principle and approach supported by a number of principles, tools and practices at more detailed levels. Mixing practical details of implementation into the consideration of the general principles has tended to confuse and cloud the debate on the EA concept. A diverse terminology (EA, ecosystem-based management, etc.) has not helped in clarifying the debate, rather the contrary.

Management of ecosystems

The EA is about management of ecosystems. It relies on the recognition that ecosystems are functional units where species are connected in predator-prey relationships as part of food-webs, and where the species depend on habitats that are defined by hydrography, bathymetry, topography, and the productivity of their fellow species. In our management we therefore must take into account the many interdependencies between and among species and habitats.

The EA represents a shift in emphasis towards the well-being of the natural ecosystems and maintenance of their integrity. This means that we should be attentive to the status of species and habitats, which are the components of ecosystems, and maintain them in good or acceptable status. We should also pay attention to the functional aspects of the interactions between and among species and habitats in order to safeguard the functional integrity of the ecosystems.

The functional aspects of ecosystems, where species and habitats interact to constitute functional units, dictate that we must identify the ecosystems as a prerequisite for applying the EA. It is nearly impossible to take into account functional aspects such as integrity, resilience, variability and stability properties without the frame of reference provided by a defined system. So in order to take a systems approach implicit in the EA we must work with defined ecosystems.

There are a number of challenges in defining ecosystems. We can be out in Nature and see the ecosystem around us with the land or the water that are the living space or habitats for the living things, the many species of plants and animals (and also invisible microorganisms) that occupy the space and use the habitats for different purposes (food, shelter etc.) during their life. However, the functional units may be difficult to recognize and to see. What size do the functional units have, and do they really have boundaries? Can we 'see' where one ecosystem ends and another starts? These are tough questions that we must confront.

There has been a growing awareness of the importance of identifying ecosystems for applying the EA to their management. This was recognized in the 2004 AMSP of the Arctic Council and it was also one of the consensus elements from the ICP in 2006. The Large Marine Ecosystem (LME) concept rests solidly on the basis of identified ecosystems. The L signifies a choice: the marine ecosystems to be used as management units are large, typically 0.5-1 million km^2. The LMEs are identified through the use of four general ecological criteria: bathymetry, hydrography, productivity, and trophic interactions (Sherman 1994, 2008). In applying the ecological criteria we are aided by the existence of discontinuities in the otherwise continuous marine environment. Capes, underwater ridges and other topographic features result in circulation cells, frontal structures and water mass boundaries that translate into biogeographical and ecological discontinuities or boundaries.

The scale issue

The LMEs represent a deliberate choice regarding the scale issue. We regard the scale of LMEs as the most appropriate and primary scale for applying the EA to management. The ecological criteria used when identifying the LMEs include trophic interactions and put emphasis on animal populations residing in and interacting with other species and habitats within the defined ecosystem. Such interacting populations contribute to the system characteristics of the defined LMEs. Commercial fish stocks in particular occur at the scale of LMEs and their distribution and interactions are an important part of the information basis when applying the ecological criteria for identifying LMEs (Skjoldal and Misund 2008).

With a decision to use LMEs as the primary units for applying the EA, the issues of scales within LMEs and how to nest the different scales will still be there. However, the LMEs offer a framework for dealing with the scale issue in a structured manner both from scientific and management perspectives.

Within the LMEs there is a mosaic of different biotopes or habitats that contribute to the overall functions of the larger ecosystem. The habitats should ideally by known and put on maps, their functional roles should be investigated, and their conditions should be monitored in the longer run. Identification of ecologically important areas such as EBSAs (Ecologically and Biologically Significant Areas) represents an important step in this direction. Management should be place-based where the conditions and functional roles of habitats are taken into account in management decisions and where the overall consequences of the many management decisions at local scales are assessed in terms of the well-being (integrity, resilience, etc) of the larger system, the LME. The latter aspect would be part of integrated assessments (including cumulative impact assessment and ecosystem status evaluation). Such integrated assessments at the larger scale would in turn be an important information basis for the management decisions at the local scale within an LME.

All marine ecosystems are open systems with water flowing through them like ocean currents, transporting plankton and other substances such as nutrients, organic matter, and pollutants. Many species of fish, birds and marine mammals migrate at larger scale and come into a particular LME to use habitats there for various purposes in their life cycles such as foraging, reproduction, and wintering (Skjoldal et al. 2013 - AMSA IIC). Climate variability and change are part of large scale patterns (global and hemispheric) that impact each and any of the identified LMEs (e.g. Sherman and co-workers). Persistent pollutants (POPs and others) are transported in large scale patterns into the Arctic region where they are distributed and pose a risk to wildlife and humans (AMAP 2010). As drivers for change, climate and pollution must be described, analyzed and managed at the appropriate large scale. However, the biological and ecological effects are on local populations and biodiversity (species and habitats) that are best analyzed at the scale of LMEs.

It is an approach to management

EA is an approach to management. This may sound trivial but it is worth emphasizing. EA is not an approach to science. For that we have another name: ecology or systems ecology in a more narrow sense. However, the EA is science-based and requires a strong scientific support. This represents a challenge to science which is typically fragmented and organized in traditional scientific disciplines. The science basis for EA is not only natural sciences but includes also social sciences in full measure (Rice et al. 2010). This is a further challenge to science where collaboration across natural and social sciences is usually weak and difficult to establish.

EA is an approach to management of ecosystems. However, many would say that it is not the same as management of ecosystems (e.g. the consensus statement from US science and policy experts; McLeod et al. 2005). There is a subtle nuance in this which is partly semantic but there is also an element of substance in it. Ecosystems are dynamic entities which we still are far from understanding well. We should therefore not attempt to manage them in an engineering manner towards any desired state, for instance by some optimization consideration. In contrast, what we can do is to manage the human uses and activities in the marine ecosystem with an aim to maintain it in a good status, allowing the ecosystem to operate and fluctuate within its natural boundaries.

Definitions and explanations of the EA therefore emphasize that it is about integrated management of human activities. The following is a definition used in European policy contexts (OSPAR/HELCOM Joint Ministerial Statement in 2003, and in work developing the thematic Marine Strategy within the EU; Skjoldal and Misund 2008):

'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.'

This definition has four parts; the first states that it is integrated management of human activities, the other three are about the ecosystem (best science, appropriate measures, and the dual objectives of sustainable use and conservation). While it is true that what we can manage are primarily the human activities that use and impact on the ecosystem, we do this by focusing our attention on the status of the ecosystem. It is the status of habitats, fish, birds, mammals and other ecosystem components that should form the basis for regulations and restrictions as part of an adaptive management system. In one sense we are therefore managing the ecosystem with the aim to keep it in good shape through regulations of the human activities. This is why the distinction that EA is not the same as ecosystem management is partly semantic.

One approach - many terms

There are many different terms used to describe an integrated approach to ocean management. In addition to EA and ecosystem management there are terms like: ecosystem-based management (EBM), ecosystem-based approach to management, integrated ecosystem-based approach, integrated ocean management, and other variants. These terms are often used without clear definitions and the variety of terms may cause some confusion as to whether they mean the same or not.

We have mentioned above the possible distinction one could make between ecosystem management and EA to management. We would argue that this distinction need not be implied and that the terms should therefore be taken to mean the same thing. Thus IUCN has a Commission on Ecosystem Management (CEM) that deals with the EA to management (Shepherd 2004).

In the AMSP from 2004 (PAME 2004) different terms are used under the heading 'An Ecosystem Approach': 'ecosystem-based management', 'integrated ecosystem-based management approach', 'ecosystem-based approach to managing the Arctic marine environment'. It is clear from the context that these different terms are used to describe the same general management approach, the EA.

While there may be nuances implied in the use of different terminology, unless those differences are clearly defined and explained, we should take the various terms to mean the same thing. Use of different terms contributes to confusion and lack of clarity regarding the EA (Bianchi et al. 2008). We should therefore make it clear that different terms such as EA, EBM, integrated ocean management etc. mean the same thing and should be regarded as synonyms. In order to reduce confusion we should move to a consistent international terminology where we use EA. If for some reason other terminology is used, it should be made clear whether a distinction from EA is implied or whether the term is taken to mean the same. If it is the same, please use EA.

A special issue is the use of the term EA in relation to a specific sector such as fisheries (EAF - ecosystem approach to fisheries; FAO 2003, Bianchi 2008). The Bergen Conference in 2006 helped to clarify the relationship between the EA in general as a broad sector-integrating concept, and its implementation within a sector like fisheries (Bianchi et al. 2008). What is implied in EAF is really to take ecosystem considerations into account in fisheries management as is clear from the Reykjavik Declaration from 2001 (FAO 2002). A clearer terminology would be to speak about ecosystem considerations in fisheries, or use of the EA in fisheries rather than to fisheries. This is a small nuance in language but it helps to clarify that EAF must be an integral component of the broader EA.

One approach - many ways to implement

The EA is described as 'a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way' by CBD. As a strategy and general principle and approach to management, there is only one EA - the EA. The EA is supported by some high-level or general principles, e.g. the 'Malawi principles' of CBD (COP Decision V/6). However, when it comes to practical implementation, the EA can be done in different ways that are consistent with the general strategy, approach and principles. In implementation it is necessary to take into account the specific ecological conditions as well as differences in social, cultural and political conditions. This may make it desirable to implement the EA in different ways.

Going from the general strategy and principles to the practical details of implementation there is therefore a diversification. This has several implications. One is that while there is only one EA as a management strategy or principle, there can be several different approaches to implementation. Another implication is that when attempting to illustrate key elements and features of the EA, this needs to be kept at the general level. There should be a clear distinction between a general scheme and more specific schemes that illustrate how the EA is implemented in specific cases. There is a border area where the general scheme (applicable in all cases) stops and where more specific schemes (adapted to the specific ecological, social and other conditions) begin. It is important that a general scheme do not become too detailed and too prescriptive in relation to the different ways that the EA can be implemented in practice.

A small 'jungle' of principles and common elements

We have mentioned CBD COP Decision V/6 where the EA is described along with 12 principles (Malawi) and 5 points of operational guidance for practical implementation. These 5 points are:

1. Focus on the functional relationships and processes within ecosystems
2. Enhance benefit-sharing
3. Use adaptive management practices
4. Carry out management actions at the scale appropriate for the issue being addressed, with decentralization to lowest level, as appropriate
5. Ensure intersectoral cooperation

IUCN CEM has considered the 12 Malawi principles and turned them into five steps to the implementation of the EA (Shephard 2004):

Step A - Determining the main stakeholders, defining the ecosystem area, and developing the relationship between them
Step B - Characterizing the structure and function of the ecosystem, and setting in place mechanisms to manage and monitor it
Step C - Identifying the important economic issues that will affect the ecosystem and its inhabitants
Step D - Determining the likely impact of the ecosystem on adjacent ecosystems
Step E - Deciding on long-term goals, and flexible ways of reaching them

The outcome from the ICP on the EA to ocean management in 2006 was included in the UN General Assembly Resolution on the Oceans and Law of the Sea later that year. This was based on agreed consensual elements of what an EA should include and how it could be achieved. The agreed consensual elements for what the EA should include were:

> (a) Emphasize conservation of ecosystem structures and their functioning and key processes in order to maintain ecosystem goods and services;
>
> (b) Be applied within geographically specific areas based on ecological criteria;
>
> (c) Emphasize the interactions between human activities and the ecosystem and among the components of the ecosystem and among ecosystems;
>
> (d) Take into account factors originating outside the boundaries of the defined management area that may influence marine ecosystems in the management area;
>
> (e) Strive to balance diverse societal objectives;
>
> (f) Be inclusive, with stakeholder and local communities' participation in planning, implementation and management;
>
> (g) Be based on best available knowledge, including traditional, indigenous and scientific information and be adaptable to new knowledge and experience;
>
> (h) Assess risks and apply the precautionary approach;
>
> (i) Use integrated decision-making processes and management related to multiple activities and sectors;
>
> (j) Seek to restore degraded marine ecosystems where possible;
>
> (k) Assess the cumulative impacts of multiple human activities on marine ecosystems;
>
> (l) Take into account ecological, social, cultural, economic, legal and technical perspectives;
>
> (m) Seek the appropriate balance between, and integration of, conservation and sustainable use of marine biological diversity; and
>
> (n) Seek to minimize adverse impacts of human activities on marine ecosystems and biodiversity, in particular rare and fragile marine ecosystems.

These 14 consensus elements of what an EA should include can be rearranged to better illustrate their relationship to the 5 steps of operational guidance of CBD or the 5 steps to practical implementation by IUCN listed above.

<u>Define the ecosystem</u>

- Geographically specific areas based on ecological criteria (b)

Ecosystem function

- Ecosystem structures, functioning and key process (a)
- Interactions including human activities (c)
- Influence of factors outside the boundaries (d)

Objectives

- Conservation in order to maintain ecosystem goods and services (a)
- Balance diverse societal objectives (e)
- Balance conservation and sustainable use (m)
- Minimize adverse impacts (n)
- Restore degraded ecosystems (j)

Science-based

- Based on best available knowledge

Assessment

- Assess cumulative impacts (k)
- Assess risks (h)

Management

- Integrated decision-making processes and management (i)
- Inclusive with stakeholder participation (f)
- Apply the precautionary approach (h)
- Take into account different perspectives (l)
- Adapt to new knowledge and experience (g)

The BePOMAR project identified 8 core elements that were considered 'essential to ecosystems based oceans management':

- The geographical scope of ecosystems defined by ecological criteria.
- The development of scientific understanding of systems and of the relationship between human actions and changes in other system components.
- The application of the best available scientific and other knowledge to understand ecosystem interactions and manage human activities accordingly.
- An integrated and multidisciplinary approach to management that takes into account the entire ecosystem, including humans.
- Area-based management and use of scientific and other information on ecosystem changes to continually adapt management of human activities.

- The assessment of cumulative impacts of different sectors on the ecosystem, instead of single species, sectoral approaches.
- A comprehensive framework with explicit conservation standards, targets and indicators in order to facilitate responses to changes in the ecosystem.
- Transboundary arrangements for resolution and handling of transboundary ecosystems and issues.

These 8 core elements are broadly similar to the 14 UN 'consensual elements' although the wording and arrangements are different. The first core element is about defining the ecosystems based on ecological criteria. The next two elements are about the development and use of the best available scientific and other knowledge about the ecosystem components and interactions, including human activities. The 4th and 5th elements state that the management is integrated, area-based, science-based, and adaptive. The 6th element emphasizes assessment of cumulative impacts, while the 7th addresses operational aspects of ecological objectives. The 8th element recognizes the transboundary nature of ecosystems and issues.

The LME approach operates with a system of 5 modules each with a suite of indicators to facilitate integrated ecosystem assessments in support of management (Sherman 1994, 2008). The 5 modules are:

- Productivity
- Fish and fisheries
- Pollution and ecosystem health
- Socio-economics
- Governance

This system of 5 modules is somewhat different from the consensual or core elements listed above in that it is more operational and partly thematic according to ecosystem features and human activities like fishing or human developments leading to pollution. The LME approach emphasizes the importance of socioeconomics and governance as separate modules along with the more natural sciences modules.

The Ministerial North Sea Conference in Bergen in 2002 agreed to a framework for the EA with 5 main components (NSC 2002, Skjoldal and Misund 2008):

- *objectives*, set for the overall condition in the ecosystem and translated into operational objectives or targets;
- *monitoring* and *research*, to provide updated information on the status and trends and insight into the relationships and mechanisms in the ecosystem;
- *assessment*, building on new information from monitoring and research, of the current situation, including the degree of impacts from human activities;

- *advice*, translating the complexities of nature into a clear and transparent basis for decision makers and the public;
- *adaptive management*, where measures are tailored to the current situation in order to achieve the agreed objectives.

The NSC framework is illustrated in Fig. x which emphasizes the way the elements are linked in an iterative management decision cycle. This operational EA framework includes many if not all the consensual or core elements listed above. It is a framework to be applied in defined ecosystems like the North Sea LME and it implicitly focuses on ecosystem functions. It is science-based and emphasizes the important role of integrated assessments (including ecosystem status and trends, cumulative impacts from human activities, and socioeconomic aspects) as a basis for informed adaptive management.

Getting out of the 'loop'

There have been many processes and meetings over the last decades where the concept and framework for EA have been discussed and elaborated. As is evident from the above summary, there is broad agreement in the outcomes from the various processes and meetings in terms of key features and elements. We have in one way exhausted the discussion on the EA concept and there is no need for further discussion on what it means. However, we are in various stages of implementing the EA and there are valuable experiences and lessons learned to be shared when it comes to practical arrangements and details. This relates to the transition from general principle to practical implementation.

We need to break out of the loop where we keep on discussing what an EA is. Rather we should consolidate the concept with its main elements as a strategy and general principle. We then need to remember that there is no single way to implement the EA, which should be done differently according to the specific ecological, social, cultural and other conditions. The specific implementation must however be consistent with the general purpose and principle of the EA.

EbM outcome

Main elements of an EA framework

Based on the overview of elements and steps in the preceding section, we offer the following 6 elements as the main components of the EA framework:

- Identify the ecosystem
- Describe the ecosystem
- Set ecological objectives
- Assess the ecosystem
- Value the ecosystem

- Manage human activities

These elements can be seen as 6 steps in an iterative management cycle. They do not need to be seen as sequential and the practical arrangements of how and where the various elements are dealt with in a management system can vary in practical implementation.

The EA is a science-based, place-based and adaptive approach to management of ecosystems (in this case marine ecosystems). It regulates human activities with due attention to the state of the ecosystem translated into ecological objectives for what is a good or acceptable state of the ecosystem. The focus on ecosystem functions is one reason why ecosystems need to be defined geographically based on ecological criteria. It is also a reason for why we need to describe the defined ecosystems with their main structural elements and functional features, including fluxes (of water, plankton, migrating fish, whales, etc) across the open boundaries. Based on results from monitoring and best use of available scientific and other knowledge, the status of the ecosystem and degree of impacts from human activities need to be assessed to inform adaptive management through a scientific advisory process. The value of ecosystem goods and services need also to be assessed in order to take those values more fully into account in the mainstream socioeconomics ('greening of the economy'). Socioeconomics in broad sense (including cultural, political and other aspects) come into play in all elements of the EA. Setting ecological objectives is in the end a societal choice where the balances between sustainable use and conservation and between diverse societal needs are considered.

Defining the ecosystem

This is probably the single most important step or element when applying and implementing the ecosystem approach. Defining the ecosystem based on ecological criteria should be done up front in an EA implementation process. Defining the ecosystem allows one to describe it and use a systems approach to understand the functional aspects of the ecosystem (including fluxes and processes at the open boundaries). It also defines the management system including agencies and jurisdictional aspects and the legitimate stakeholders for that defined geographical area.

As we have explained in previous sections, identified ecosystems are explicitly used in the LME approach. LMEs are recognized in the USA (ref.) and are also used as the basis for implementing the EA through integrated management plans in Norway (Winsnes and Skjoldal 2008, Olsen and Hoel 2011). Canada has been using the equivalent of LMEs although they are named differently as Large Ocean Management Areas (LOMAs) (Siron et al. 2008). Canada has recently redefined their marine areas as 'bioregions' using a biogeographic classification system (DFO 2009). In the policies of the European Union, geographical regions or subregions used as units for implementing the EA through the MSFD are also largely equivalent to LMEs (Skjoldal and Misund 2008).

There is a growing appreciation of the need to define geographical ecosystems as reflected in one of the UN consensual elements (b) and also in one of the core elements from BePOMAR. However, this is a critical element where there is still a need to develop a clearer common understanding. The scale issue is embedded in the core of this matter. It is clear that ecology and human activities occur at a number of different scales and that we need to nest and integrate across those scales both in our science and in management. One of the 5 points of guidance in the CBD context is to 'carry out management actions at the scale appropriate for the issue being addressed'. In the BePOMAR summary it was stated: "Issues of scale can be addressed viewing ecosystems as nested systems".

As we have described in a previous section ('Scale issue') the recognition of LMEs as the primary scale for applying the EA offers a structured framework for dealing with the nesting of scales, both smaller and larger.

The LMEs of the Arctic area have been identified as the working map adopted in 2006 with the current revision that is expected to be finalized in early 2013. We have therefore a basis to move forward in implementing the EA for identified ecosystems based on ecological criteria. The Arctic LMEs are in some cases located within the area of jurisdiction of one country such as Canada or Russia, or they span the EEZs of two countries such as Norway and Russia for the Barents Sea LME, Canada and USA for the Beaufort Sea LME, and Russia and USA for the Bering and Chukchi LMEs.

Describing the ecosystem

The first point of operational guidance from CBD is to 'focus on the functional relationships and processes within ecosystems'. The second step in the IUCN framework is 'Characterizing the structure and function of the ecosystem'. This requires a basic description of the ecosystem once it is defined based on ecological criteria.

An ecosystem description would include all elements of the system including the seafloor, currents and water masses, plankton, benthos, fish stocks, marine mammals and birds. The description could be extensive with long lists of species and their Latin names, the biology and ecology of the dominant species, accounts of food webs, trophic interactions, animal migrations, and several other aspects of ecosystems. Such basic descriptions may remain valid for an extended time period although there may be a need for periodic updates to reflect new knowledge and/or changes in the ecosystem.

Examples of such basic ecosystem descriptions are summarized in Table ? (Table to be developed, e.g. the Norwegian Sea Ecosystem (Skjoldal 2004), the Barents Sea (Sakshaug et al. 2009, Jakobsen and Ozhigin 2011), Beaufort Sea (Cobb et al. 2008), Hudson Bay (Stewart and Lockhart 2005), Bering Sea (Laughlin et al. 1999?, ??)). Another source of detailed information on marine ecosystems is EIAs (Environmental Impact Assessments) or EISs (Environmental Impact Statements) prepared in response to planned activities such as oil and gas development. Examples of such reports are a 2007 EIS for the Chukchi Sea prepared for an oil and gas lease sale (MMS 2007) and a 2009 EIA for Greenland waters in Baffin Bay in relation to petroleum activities (Boertmann et al. 2009). These ecosystem descriptions are often comprehensive and rich in details regarding ecosystem components such as fish stocks and marine mammals, but they are commonly less elaborate when it comes to properties at the ecosystem level. This reflects at least partly the inherent limitation in our present knowledge of ecosystem properties.

It may be useful to prepare a short summary or statement of what the key features of a defined ecosystem are. This may include a brief synopsis of the main topographic and oceanographic features, the key or dominant species in terms of biomass and energy flow, and key features of habitats and food web dynamics. A brief ecosystem synopsis should highlight the key defining features of the identified area as an ecosystem.

An important part of an ecosystem description is an account of the open boundaries. There are always fluxes of water and organisms across these boundaries that should be characterized and if possible quantified. For instance, the residence time or turn-over (flushing) time of water in a given ecosystem may be an important system characteristic (e.g. the residence time of water in the shallow Chukchi Sea is about 1 year while it is about 5 years for the deeper Barents Sea LME). Since boundary conditions are common between neighbor LMEs, there is a strong rational for management collaboration between Arctic States across various Arctic LMEs. This is not least the case since there are often migratory stocks of marine mammals that use two or more LMEs in their seasonal cycle between wintering and summering areas.

Many features of an ecosystem are spatial information that can be shown on maps. An important part of this is the collection of information on habitats and production of habitat maps. The habitats can be broadly grouped into ‘stationary’ habitats on the seafloor and ‘dynamic’ habitats in the moving water masses. Some of the oceanographic features and habitats may be quasi-stationary such as topographically determined physical fronts or polynyas and flawleads. Other map information is the distributions and migratory pathways or patterns for species such as fish, birds and mammals. There is a need to move systematically towards more extensive mapping of habitats and species in identified LMEs.

The current emphasis on identifying EBSAs (Ecologically and Biologically Significant Areas) or areas of heightened ecological significance (such as in the AMSA IIC project; Skjoldal et al. 2012) is an important step in relation to LMEs and the EA. Ecologically important areas are identified because they need management attention. Many or most of the areas are identified because they are important for wildlife in their life cycles or in the annual seasonal cycle. This may be as spawning areas for fish, migration corridors for marine mammals, breeding colonies for seabirds, or spring and fall staging areas for migratory birds. The areas represent links between habitats and species in a functional ecological sense. We should give more attention in general to such linkages to help us focus on functional aspects of marine ecosystems that are important for their integrity and sustainability in the long run.

Setting ecological objectives - drawing the line of sustainability

The first Malawi principle (CBD) is: 'The objectives of management of land, water and living resources are a matter of societal choice'. Several of the UN ICP consensual elements are about objectives: to balance diverse societal objectives (element *e*), and to balance conservation and sustainable use (*m*). Setting objectives for the acceptable or wanted state of the ecosystem is one of the key features of the EA that distinguishes it from previous sector-based and more fragmented approaches. The issue of setting ecological objectives goes to the core of the EA approach and is related to the nuance between 'management of the ecosystem' and 'management of human activities that impact the ecosystem'.

The balance between conservation and sustainable use is what determines ecological sustainability as the main pillar of the concept of sustainable development. Sustainable use is (almost) by definition the same as conservation. True sustainable use should not lead to depletion and degradation but conserve all components and functional features of the ecosystem so that the ecosystem goods and services can benefit future generations. There is obviously somewhere along the axis of use (from no use to heavy use) where the transition lies between use that are within the bounds of what the ecosystem can withstand (due to the regenerative properties of nature) and excessive use that leads to degradation.

Setting ecological objectives for ecosystem components (species and habitats) and for the overall state of the ecosystem is equivalent to defining the line of sustainability through the ecosystem (or rather the envelope of conditions for ecosystem state that is compatible with sustainable use). The ecological objectives need to be translated into management objectives and regulations of human activities that will ensure ecosystem conservation and sustainable use.

This is nice in principle and extremely important in relation to sustainability. However, it is also very challenging and demanding from both scientific and practical perspectives. This is for (at least) two main reasons. One is that our basic understanding of how ecosystems work (as systems) is still lacking. Another is that the ecosystems are dynamic and changing and it is intrinsically hard to set objectives for highly dynamic systems. What is the acceptable state for a changing system, and how do we translate this into management decisions for regulating human activities? Part of the answer of how we address this lies in the issue of ecosystem assessments, which is addressed in the next section.

The ecosystem is composed of species and habitats, and ecological objectives should reflect the status of species and conditions of habitats. At a very general level, no species should be assessed as being threatened, and commercially exploited species should be maintained at high and safe levels. Habitats should be maintained in sufficient amount and quality so that they serve the various ecological functions for wildlife species dependent upon them in their life or annual cycles.

The OSPAR Commission for the Northeast Atlantic has worked for 20 years with the issue of setting Ecological Quality Objectives (EcoQOs) for the North Sea as part of the EA (NSC 2002, OSPAR 2005, Skjoldal and Misund 2008). The work has taken long time because it is genuinely difficult, and it has at the same time generated a large body of experiences. The International Council for Exploration of the Sea (ICES) is a scientific organization that has been advising OSPAR in the EcoQO process.

The Marine Strategy Framework Directive (MSFD) of the European Commission is a legal and practical implementation of the EA. MSFD is all about ecological (or environmental) objectives. The core of the Directive is the concept of 'Good Environmental Status' (GES) which is an overall goal. GES is defined and characterized by 11 statements or qualitative descriptors (basically saying that everything should be fine: species, habitats, and foodwebs should be in ok status, and there should be no adverse effects from pollution, eutrophication, introduced species, noise, and hydrological changes). The 11 GES descriptors are to be implemented and made operational by a large number of descriptors and indicators for various ecosystem components or features and also for several human pressures (EC 2010). The EU Member States are now working to implement the MSFD for defined marine regions or subregions (to some extent equivalent to LMEs) with delivery to EC in summer 2012 of an 'intital assessment', a plan for how GES will be operationalized with descriptors and indicators, and a suggested monitoring program.

One of the core elements of EA from BePOMAR was: 'A comprehensive framework with explicit conservation standards, targets and indicators in order to facilitate responses to changes in the ecosystem'. This is about setting ecological objectives to help us define and achieve sustainability. The experiences from OSPAR, EU and other places should be drawn upon when elaborating the issue of setting ecological objectives for the Arctic LMEs.

Assessing the ecosystem

Assessment of ecosystem status is another core element of the EA which sets it apart from previous sector-based management approaches. The focus is on the state of the ecosystem which needs to be assessed with due regard to its dynamic nature. Integrated assessment is a buzz-word for what is needed to underpin the EA (Rice et al. 2010). An integrated assessment is an assessment of the status and trends in all relevant ecosystem components and thereby of the overall state of the ecosystem as such. It includes assessments of the impacts by various human activities such as fishing, pollution, coastal development, etc., as well as the overall or cumulative impacts by those activities. Integrated assessments include also socioeconomic factors and conditions, e.g. as driving forces for use and impacts, and as consequences back on society from altered provision of ecosystem goods and services.

Marine ecosystems are inherently dynamic and ever changing. Physical forcing, expressed by variability in ocean climate (currents, watermasses etc.), has large influences on marine populations of fish and other organisms and on ecological processes. These processes include trophic interactions (predator-prey relationships and foodweb dynamics). There is therefore an intricate relationship between physical forcing and biological interactions in marine ecosystems with simultaneous and linked bottom-up and top-down regulations. The strengths of these regulations may fluctuate, reflecting time delays by mechanisms such as strong year-classes of fish caused by climatic conditions in one period and manifested as ecological interactions some years later when the fish grow up.

The large natural variability of marine ecosystems poses a challenge when it comes to assessing the impact of human activities, both individually and cumulatively. The impacts or effects e.g. from fishing or pollution, come in addition to the natural fluctuations in ecosystem components and may be difficult to distinguish from the natural variations. Assessments need therefore to be careful and detailed in order to allow effects to be distinguished from the natural ups and downs of ecosystem components such as fish stocks. This is challenging but not impossible. However, it requires the best use of the best available scientific and other knowledge.

The physical forcing can be characterized and described by a combination of oceanographic observations, remote sensing from satellites, and mathematical modeling (3-D circulation models). Important features of the physical environment are the seasonal ice conditions, currents and fluxes of water, distribution and properties of water masses, and the vertical layering and stratification of waters. The physical regime sets the stage for phytoplankton development, transport of plankton including fish larvae, and distributions and migrations of fish stocks, marine mammals, and birds. These features determine again the overlap and trophic interactions between predators and prey including herbivorous zooplankton in food webs. The defined ecosystem (LME) allows a detailed examination of the biological and ecological interactions among the species in food-webs and their dependence and interactions with habitats (e.g. walrus modify the bottom habitats by depleting stocks of large clams and disturbing the sediments).

The detailed ecosystem descriptions and analyses provide a basis for examining the effects of climate variability (as a regular physical driver for ecosystem change) and climate change on the defined ecosystems (LMEs). Fish, birds and mammals occur with more or less clearly defined populations and they are the primary biological units that respond to the physical drivers. The populations are linked in food webs which allow indirect effects (e.g. cascades) to be examined in an assessment. The biological system that responds to physical forcing in defined ecosystems is also impacted directly and indirectly by harvesting in commercial fisheries and subsistence hunting. Knowledge about defined ecosystems allows impacts from fishing and hunting to be addressed and quantified in integrated assessments.

Assessments of pollution must take into account both the physical and biological parts of ecosystems. Contaminants are transported by the atmosphere, in ice, and in water, often associated with fine particulates which are resuspended from the bottom sediments. Contaminants are taken up in organisms and can be amplified and concentrated in trophic transfer up the food chains (which are typically embedded in food webs). Assessment of the pathways and pollution effects of contaminants need to take into account both the physical and the biological compartments of marine ecosystems (Macdonald et al. 2003). Again the context of defined ecosystems allows a careful and detailed examination of pollution as part of an integrated assessment.

Integrated assessments may be carried out in a modular fashion with detailed accounts as separate thematic assessments of ocean climate conditions, plankton production, fish stocks impacted by fisheries, habitat conditions, pollution effects, conservation status of birds and mammals, and others. Assessment of climate conditions (including variability and trends) and biological impacts of climate may help in distinguishing between natural variability and impacts from single sectors or factors such as fishing or pollution. Finally it also allows the overall situation including cumulative impacts to be addressed and assessed.

The role of indicators and ecological modeling as tools for carrying out integrated assessments are being explored in many contexts. In general, use of indicators will have strong limitations in their usefulness in assessments because of the complex and dynamic nature of marine ecosystems. The causal relationships between an impact factor and the resulting effects in the ecosystem are seldom simple and linear but are typically embedded in networks reflecting the connections among species in food-webs. Examining the many direct and indirect effects from fishing, pollution and other human pressures requires the best and full use of scientific and other knowledge, which is typically not the case with a system of selected indicators. However, it should be noted that some indicators may be useful for some purposes. For instance, there may be sensitive species (e.g. corals) that may be used to indicate impacts from bottom trawling on fragile habitats. The strength of indicator systems is in general on the communication side, communicating information on the environmental status once that has been assessed through careful scientific analysis.

Integrated assessments (including thematic components such as assessment of status of fish stocks, etc) are carried out in order to be used as a basis for management decisions. As such they need to be translated into management advice through a careful and robust scientific advisory process. This represents in a way translation of the complexity of nature into a clear basis for management decisions. Again this is challenging but not impossible. It requires the best use of scientific and other knowledge in a process where the integrity of the scientific advisory system is protected from undue political influence. The advice and the management decisions should be so that the ecological objectives that have been set for a given ecosystem are achieved.

Valuing the ecosystem

Ecosystem goods and services in terms of food, transportation, recreation, tourism etc contribute to the economies at local and wider scales. While socioeconomic aspects play dominant roles in most policy contexts, the environmental dimension is usually treated very fragmentary and incomplete in most socioeconomic calculations. This aspect, where the full value of ecosystem goods and services, also in a long-term (generational) perspective, is brought into play, remains largely to be developed as an active component of the EA.

Determining the values of ecosystem goods and services is a challenging task. Some aspects of this such as values of fish catches in commercial fisheries are fairly straightforward as it is a commodity in the regular economy. Other aspects, such as the sense of joy and belonging in Nature, are much more difficult if not impossible to give a value in economic terms. The valuing is related to the objectives for the ecosystem. They should reflect societal choices and balance various interests including non-economic parameters such as ‘human dignity’ and ‘respect for nature’.

Mangaging human activities

Management of human activities needs to be adaptive, meaning that actions are regularly tailored to the shifting ecological and social conditions to achieve and maintain the agreed ecological objectives. The Arctic marine ecosystems are dynamic, always fluctuating and changing, and human activities need to be regulated in accordance with the natural dynamics. For example, fish stocks in boreal and sub-arctic LMEs typically fluctuate with large amplitudes, and quotas and catches must be adjusted so that they do not exacerbate the situation, leading in the worst case to stock collapses. A fish stock is generally more vigorous and robust when it is naturally increasing due to favorable environmental conditions compared to when it is naturally declining and more sensitive and prone to overfishing.

Spatial management is an important part of the EA to management. The space of an ecosystem, made up of the seafloor and water masses, is the mosaic of habitats that serve a variety of ecological functions for all the species that inhabit or visit the ecosystem. Management must aim to keep a sufficient amount of the natural habitats in a sufficiently good condition to secure the functional integrity of the larger ecosystem. This is part of the task of setting ecological objectives. Ecologically important and sensitive areas (e.g. EBSAs) should be given special management attention due to the functions these areas play in the ecosystem. Giving higher degree of protection to some of them, e.g. by designating Marine Protected Areas (MPAs), is one of the management tools available. Closure of areas to fisheries is another tool that is commonly used in resource management.

Marine Spatial Planning (MSP) is currently receiving much attention, and general MSP guidelines have been developed in the form of a step-by-step approach by UNESCO and partners (Ehler and Douvere 2009). MSP is an important tool contributing to effective implementation of the EA to management. However, MSP is not the same as the EA since the latter also involves other management measures than the strict spatial ones, such as many fisheries and hunting regulations.

The EA to management is science-based, and management of human activities needs to be supported by a solid base of scientific advice. The advice should be based on integrated assessments where the overall conditions of the ecosystem and its components (species and habitats) and the cumulative impacts from all activities are taken into consideration. There is broad agreement that the EA should be supported by the best use of the best available scientific and other knowledge.

It is obvious that by focusing on the functional integrity of the ecosystem, including food web dynamics and species-habitat interactions, we are faced with a more demanding task than the conventional 'sector in isolation' approach. The scientific complexity is clearly greater in that a broader range of information needs to be brought together in an integrated analysis and assessment. This is sometimes characterized as leading to greater uncertainty. However, this is a perceived and false impression. The alternative of not taking information into account but instead ignoring it can hardly lead to greater certainty but quite the contrary.

The issue related to uncertainty is about how the information is used. There exist a large body of information and knowledge about species and habitats and their interactions in marine ecosystems in general and also in the Arctic. This information is contained in hundreds if not thousands of scientific publications and summarized in scientific reviews and books. The knowledge, and particularly the evolving knowledge, is also contained in the heads of the many hundreds if not thousands of active scientists from academia, government laboratories and private sector that work on Arctic scientific issues. This knowledge forms the basis for integrated assessments to be used to inform an adaptive management system for Arctic LMEs.

One issue related to knowledge is what roles mathematical ecosystem models can and should play in a scientific advisory context. Such models require that linkages and processes between species and habitats are represented by equations and coefficients in a mathematical language. This can only be done by making many (more or less correct) assumptions and it filters away much of the knowledge we have that is difficult to represent in a strict mathematical sense. Models therefore represent a constraint on the use of knowledge, and complex models may indeed increase uncertainty due to the increasing number of assumptions that have to be made to construct them. Mathematical ecosystem models can be powerful analytical tools to help us get insight into the dynamics of complex systems. At the same time their limitations need to be recognized and the output of such models must be used with care as one information source along with all our other knowledge in the broader context of integrated assessments and provision of scientific advice for management decisions.

The large body of existing knowledge, and the great number of experts holding the evolving knowledge, represent a challenge in terms of providing management advice. This requires a clearly defined and transparent advisory process that is institutionalized as part of the EA management system. The advisory process must be tasked with providing clear and documented advice on management options and actions based on integrated ecosystem analyses and assessments and the best use of scientific and other knowledge. The managers in turn should follow the advice to achieve the ecological objectives set for the ecosystem.

Concluding remarks

The work on the EA under the Arctic Council has progressed in recent years. The EbM Experts group established by the Ministers in 2011 has delivered their report in 2013, suggestion a common definition of EbM or the EA (the one given on page x in this document) and a number of principles of elements applicable to the Arctic region. One of the issues here has been to have a common understanding and approach for marine and terrestrial ecosystems.

PAME has followed-up the 2004 AMSP and has now (nearly) completed a revised map of Arctic LMEs that can be used as units for management and management cooperation. As we have addressed in previous sections, the LMEs do not sit in isolation but there are many links and interactions between them. They are open ecosystems where exchanges between them are important system characteristics. While management within LMEs is primarily a national responsibility within national boundaries, the open and connected nature of the Arctic LMEs provide a case for coordination and cooperation between Arctic states with jurisdiction in shared and neighboring LMEs.

The coastal zone is a special area linking land and freshwater ecosystems with the marine ecosystems. The delineation of Arctic LMEs is in broad agreement with the watersheds on land, where the estuaries of the major Arctic rivers are contained inside LMEs and generally not close to ecosystem boundaries. This facilitate the treatment of ecological connectivity between the estuaries and coastal zone on the marine side with the freshwater systems on the other, e.g. through seasonal migrations of anadromous or amphidromous fish species.

There is strong ecological connectivity between the land and the sea for many Arctic birds. Most shorebirds and many ducks, geese and seabirds (e.g. Arctic tern, skuas or jaegers, and gulls) breed inland on Arctic tundra or in freshwater wetlands, but move to the coast after breeding for feeding and staging prior to the autumn migration out of the Arctic. This connectivity needs to be taken into account in the management on both the marine and land sides. Many of the ‘areas of heightened ecological significance’ (identified in the AMSA

IIc project) located in the coastal zone are areas that are used by birds and represent this type of ecological connectivity.

Despite the strong ecological connections, the land and freshwater systems and the marine systems are distinct and quite different in their ecological properties in terms of species and habitats and human activities. Therefore, to keep focus on the functional aspects and integrity of land and sea, it makes sense to delineate marine ecosystems as separate from the land and freshwater systems for management purposes. The marine ecosystems (the LMEs) include the nearshore coastal waters and estuaries.

There are many issues in the coastal zone that require more detailed and local attention, where the scale is clearly much smaller than the scale of the LME. Such issues should be dealt with in an integrated coastal zone management (ICZM) framework that integrates across the land-sea interface. From a marine perspective, the ecological functions that coastal habitats play for fish, birds and mammals are of central importance and need to be included in the set of ecological objectives and integrated assessments for the wider LME. From an ICZM perspective, information on the wider ecosystem including migratory fish stock, birds and mammals may in turn be an important basis for local management decisions.

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