THE CONCEPT OF ECOSYSTEM HEALTH AND ASSOCIATION WITH THE ECOSYSTEM APPROACH TO MANAGEMENT AND RELATED INITIATIVES

by
Christopher C.E. Hopkins[1]
AquaMarine Advisers, Granvägen 20, 265 32 Åstorp, Sweden. aquamarine@telia.com

Forward

The author has produced this paper concerning the concept of Ecosystem Health in response to a request from the November 2004 meeting (Vilnius, Lithuania) of the BSRP Study Group on Baltic Ecosystem Health Issues.

The concept of Ecosystem Health has many affinities with that of Human Health. It began to develop substantially from the initiatives arising in 1992 from the Rio Declaration of the United nations Conference on Environment and Development (UNCED) and the 1992 Convention on Biological Diversity, both of which are closely connected with the promotion of sustainable development. The concept of Ecosystem Health builds on the foundation of the precautionary principle and the application of the ecosystem approach by integrated management of the impacts of human activities on ecosystems in order to achieve sustainable use of *ecosystem goods and services* and maintenance of *ecosystem structure, function and integrity*. The ecosystem approach has become embedded in the policy and work of many international Conventions and regulatory instruments and bodies (e.g. CBD, European Commission, OSPAR, HELCOM, European Marine Strategy and EC Water Framework Directive). In order to monitor and assess changes in the status and trends of marine ecosystems and their components, and avoid problems related to 'shifting baselines', a coherent system of target and reference points needs to be established involving the use of indicators to aid the conservation and, where necessary, the restoration of ecological quality. A system of ecological quality issues and ecological quality objectives should be established that appropriately cover the components of the particular marine ecosystem that are impacted by human activities, thereby allowing the 'health' status of the ecosystem to be appropriately classified (e.g. good, satisfactory, poor) with regard to a reference condition. It is necessary to establish a closely linked 'cause-and-effect' relationship (based on a causal chain analysis) between the human activity causing serious impacts on one or more components in the ecosystem, so that regulatory measures aimed at the root cause of the problem will result in a substantial decrease in the detrimental ecosystem effects. To actively conserve and restore the health of marine ecosystems, it is necessary to establish a programme of appropriate actions including cost-effective research supporting scientific information and advice, monitoring and assessment tasks and regulation to redress the root causes of human induced problems (pressures and impacts).

1 WHAT IS HEALTH?

Health is defined as '***a state in which you are fit and well***', and regarding an organization or system a recognition of the extent to which it is '***working well***' (BBC 1993). Thus, the term **healthy** refers to the extent that a person or something is in **good condition**, or not. Good health, or deviation from good health, is measured against various reference levels. When one's condition has deviated substantially from a desirable **target level** of good health it is implicit that one has crossed a **limit level** beyond which **serious or irreversible harm** will result. Accordingly, to ensure that the serious or irreversible damage does not occur, we can take precautions ('action intended to prevent something dangerous or unpleasant from happening: BBC 1993) and establish **precautionary levels** beyond which we should not transgress. Keeping within the precautionary levels is desirable as it avoids the significant **socioeconomic costs** that arise from ill-health and its

[1] Citation: C.C.E. Hopkins 2005. *The concept of Ecosystem Health & association with the Ecosystem Approach to Management and related initiatives.* ICES BSRP/HELCOM/UNEP Regional Sea Workshop on Baltic Sea Ecosystem Health Indicators. 30 March – 1 April 2005. Sopot, Poland.

treatment. When our health condition has transgressed particular undesirable levels, it is necessary that **remedial actions** (treatment) be taken for restorative purposes. It is recognized that poor health is **unsustainable** in the long-term.

It is pertinent to note that the concept of human health is applied to our **whole body** but it is understood that health is dependent on the good functioning of all the organs, and supporting physiology, in the body. Thus, it is appreciated that one should have a **holistic and integrated view** of our body's health system.

There is a basic similarity in the concept of human health and ecosystem health, as will be elaborated below.

2 CONSERVING ECOSYSTEM HEALTH: THE ROLE OF THE PRECAUTIONARY PRINCIPLE, THE ECOSYSTEM APPROACH AND THE EUROPEAN MARINE STRATEGY

One can extend the above-mentioned human health considerations to talk of '**ecosystem health**', whereby an ecosystem can be considered as being healthy or not. By analogy, one can deduct that a healthy ecosystem is one that is in good condition and is functioning well: a healthy ecosystem is one that is sustainable – that is, it has the ability to maintain its structure (organization) and function (vigor) over time in the face of external stress (resilience) (Costanza & Magean 1999). A further elaboration of what exactly one means by this is provided in this section and section 3.

Focusing on the 'health' of the oceans and marine ecosystems is not new. For example, UNESCO's Intergovernmental Oceanographic Commission (IOC) has had activities examining the **Health of the Oceans** (HOTO) for several decades, including more recently the HOTO Panel that has been subsumed into the Global Ocean Observing System (GOOS) Coastal Oceans Observations Panel (COOP). The HOTO Module of GOOS provides a basis for the assessment of the state and trends in the marine environment regarding the effects of anthropogenic activities, including, *inter alia*, increased risk to human health, harm to marine resources, alterations of natural change and general ocean health. The term "Health of the Oceans" is operationally defined for the purposes of the HOTO Module of GOOS as a reflection of the condition of the marine environment from the perspective of adverse effects caused by anthropogenic activities, in particular the mobilization of contaminants and the release of human pathogens (IOC 2001). Such condition refers to the contemporary status of the ocean and the prognosis for improvement or deterioration in its quality. Thus, it is notable that ***the GOOS HOTO Module is relatively strongly focused on 'pollution' (e.g. contaminants and human pathogens) but relatively weak on the biodiversity monitoring and assessment aspects***. Further information is available from:
http://ioc.unesco.org/goos/docs/GOOS_099_HOTO_design_plan_3.pdf

2.2 The Precautionary Principle and the Polluter Pays Principle

In 1983 the United Nations (UN) appointed the World Commission on Environment and Development to propose strategies for '***sustainable development***': ways to improve human well-being in the short term without threatening the local and global environment in the long term. The Commission was chaired by Norwegian Prime Minister Gro Harlem Brundtland and it's 1987 report 'Our Common Future' was widely referred to as the Brundtland report (UN 1987).

Many international agreements promote the requirement for prudent and sustainable use of the marine environment, biodiversity (living marine resources) and ecosystems (e.g. UN Convention on the Law of the Sea, UNCLOS 1982; Rio Declaration, Principle 15 of UNCED 1992; Convention on Biological Diversity, CBD 1992; UN Agreement on Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, UN 1995; Code of Conduct on Responsible Fisheries, FAO 1995; HELCOM Convention 1992, OSPAR Convention 1992; EC Water Framework Directive 2000; European Marine Strategy 2002).

In order to achieve sustainability it is necessary to balance the effects of exploitation with the needs of conservation. Thus, the ***precautionary principle*** and the ***ecosystem approach*** to management have been promoted.

The **Precautionary Principle—**and the way to implement it (the precautionary approach)—have arisen from the Rio Declaration (UNCED 1992), which states that:

'*where there are **threats of serious or irreversible damage**, lack of full scientific certainty shall not be used as a reason for postponing **cost-effective measures to prevent environmental degradation***'.

This principle recognizes that changes in exploited systems are slowly reversible, difficult to control, not well understood, and calls for early action in the case of uncertainty and ignorance in order to prevent potential harm. Precaution places the ***burden of proof*** on the proponents of the activity, i.e. it is not appropriate to assume that environmental impacts are negligible until proved otherwise. This reversal of the burden of proof is fundamental to precautionary action, and creates incentives for the proponents of an activity to prove that their product or activity is safe or acceptable. This may be achieved, for example, through application of an environmental impact assessment (EIA) and strategic environmental impact assessment (SEA) in the European Union.

The principle that the costs of environmental damage or resource depletion should be borne by polluters or users – the **Polluter-Pays Principle** (PPP) - was elaborated as an economic principle in the 1970s and is embedded in the 1987 European Community (EC) Treaty. The principle requires producers or resource users to meet the cost of implementing environmental standards or technical regulations, or by introducing liability regimes making producers liable for causing environmental damage (Coffey & Newcombe 2000). In the EC, the PPP establishes a framework based on environmental liability covering damage to the biodiversity protected at EU and national levels, to waters regulated by Water Framework Directive 2000/60/EC (WFD, see below), as well as air and land contamination which cause serious harm to human and ecosystem health. The application of the precautionary principle and the PPP lie central to the 1992 HELCOM Convention on the Protection of the Marine Environment of the Baltic Sea Area as well as the 1992 OSPAR Convention on the Protection of the Marine Environment of the North-East Atlantic, with 1998 Annex V on 'The Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area'.

2.3 The ecosystem approach to management: An obligation in international agreements and other instruments

2.3.1. Ecosystem approach: Paradigm shift towards sustainability of ecosystem goods & services

Article 2 of the Convention on Biological Diversity (CBD 1992) defines an ***ecosystem*** as '*a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit*'. The ecosystem comprises a complex network of interactions , not only between species, but also between biota and the physical and chemical environment. Humans are recognized as an integral part of ecosystems, and socioeconomic systems constantly interact with other physical and biological parts of the system.

The ***ecosystem approach*** is the primary framework for action under the Convention on Biological Diversity (CBD 1992), in which the 12 'Malawi Principles' emphasize that humans are integral components of ecosystems and points out the consequences of this for sustainable use of biodiversity and related management (CBD 1998). The Jakarta Mandate (CBD 1995) focuses specifically on marine and coastal biodiversity, and calls for the adoption of the precautionary and ecosystem approaches for the conservation of biodiversity. Thus, the ecosystem approach is a holistic process, building on the precautionary principle, for integrating and delivering in a balanced way the three objectives of the CBD regarding biodiversity: 1) conservation, 2)

sustainable use, and 3) the equitable sharing of the benefits. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning.

Healthy ecosystems perform a diverse array of essential functions that provide both goods and services to humanity, in which '***goods***' refers to items given monetary value in the market place and '***services***' from ecosystems are valued but rarely bought and sold (Lubchenco 1994; Nilsen *et al.* 2002). For example, goods are food, medicinal materials, raw materials and wild genes, while services include maintaining the hydrological cycles and composition of the atmosphere, regulating climate, storing and cycling essential nutrients, and absorbing and detoxifying pollutants. The sustainability concept depends on two aspects: sustainability of use (sustainable use) and sustainability of ecological resources and their associated ecosystem. These aspects are tightly connected as sustainable use of ecological resources can only be achieved if these resources themselves are sustainable. Thus, the ecosystem approach to management involves, *inter alia*, a paradigm shift from managing commodities towards sustaining the production potential for both ecosystem goods and services ('natural capital') (Costanza *et al.* 1997).

The ***ecosystem approach*** is a synonym for an integrated or holistic approach to ecosystem management, recognizing the need to manage the impacts of human activities on ecosystems in order to achieve sustainable use of '*ecosystem goods and services*' and maintenance of *ecosystem integrity* (ICES 2000). This definition points to the need for a comprehensive and holistic approach to understanding and anticipating ecological change, assessing the full range of consequences and developing appropriate scientific and regulatory responses. It is important to emphasize that implementing an ecosystem approach is a process and should be considered as a **tool** to help comprehensively and systemically **redress the root causes human induced problems** (Hopkins 2004).

At the 1997 Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues in the North Sea, the desirability of an ***ecosystem approach*** was recognized (IMM97). The aim of the ecosystem approach is to ensure that fisheries and environmental protection, conservation and management measures are consistent with maintaining the characteristics, structure and functioning, productivity and biological diversity of ecosystems, and a higher level of protection—consistent with the needs of food production—of species and their habitats (Hopkins 1999; Nilsen *et al.* 2002). Developing and implementing an ecosystem approach has since become central to the protection of the North Sea, and the work of the OSPAR Commission and HELCOM (NSC 2002; JMM 2003) in the North-East Atlantic and the Baltic Sea, respectively. According to the 1998 Annex V to the OSPAR Convention and the OSPAR Strategy, for example, measures should be taken to conserve and protect the ecosystems and the biological diversity of the maritime area, and to restore, where practicable, marine areas which have been adversely affected by human activities.

2.3.2. Large Marine Ecosystem concept

The ***Large Marine Ecosystem*** (LME) concept for monitoring, assessment and management of international coastal waters was conceived in the 1980s, and has been developed and further refined as a complementary instrument for achieving an ecosystem approach to management (Sherman 1994; Sherman & Duda 1999; NOAA 2005). LMEs are regions of the ocean encompassing coastal areas from river basins and estuaries out to the seaward boundary of continental shelves, enclosed and semi-enclosed seas, and the outer margins of the major current systems. They are relatively large regions of the order of 200 thousand km^2 or more, characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations of plankton, benthos, fish, seabirds and marine mammals. Within a total of about 64 LMEs currently identified, about 95% of the usable annual global biomass yield of exploitable fish and shellfish is produced. However, within their waters most of the global marine pollution, overexploitation of living resources, and coastal habitat degradation occurs. Information for monitoring, assessing, and managing LMEs is organized according to five interrelated modules focused on: 1) ecosystem

productivity, related to carrying capacity; 2) fish and fisheries; 3) pollution and ecosystem health; 4) socioeconomic conditions; and 5) governance protocols. A major area of the operational application of LMEs is in international development cooperation aided by the Global Environment Facility (GEF). The Baltic Sea is currently designated as LME No. 23, and **GEF Baltic Sea Regional Project** (BSRP, implementation start March 2003) aims to introduce ecosystem-based assessments for strengthening the management of Baltic Sea coastal and marine environments through regional cooperation and targeted, transboundary marine and watershed activities, with a view to reducing impacts from non-point sources of pollution and to increasing sustainable biological production. The BSRP supports the HELCOM Joint Comprehensive Environment Action Programme (JCP) and provides linkages with country activities. It is consistent with GEF global environmental policy to contribute significantly to "reducing stress to [the] international waters environment" by integrating sound land and water resource management strategies through a more favourable political and regulatory climate and activities that promote sustainable development. The Project's long-term goal is for the three intergovernmental organizations —the Helsinki Commission (HELCOM), the International Baltic Sea Fishery Commission (IBSFC), and the International Council for Exploration of the Sea (ICES)—to utilize project-developed management tools for sustainable ecosystem management, and to contribute to the improvements in the social and economic benefits of the ecosystem to the coastal fishing and farming communities in the recipient countries of the eastern Baltic Sea area.

2.3.3. European Marine Strategy

The **European Marine Strategy**, EMS, '*towards a strategy to protect and conserve the marine environment*' (COM(2002) 539 final) recognizes that diverse human activities pose major threats that impact the marine environment and its associated ecosystems (EC 2002). The European Marine Strategy should *inter alia* cover all the actions needed to ensure that all human activities with an impact upon the oceans and seas are managed so that marine biological diversity and critical habitats are conserved and human use of them is sustainable. It is agreed that the development of the EMS should be focused on the concept of an integrated ***ecosystem approach to management*** (which it is emphasized should be kept simple) which is defined as:

'*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*' (JMM 2003).

A **suite of common principles** will underpin the effective implementation of the EMS, building on the ecosystem approach to management. These principles require *inter alia* that:

- A shared vision requiring stakeholder participation;
- Management objectives are consistent with sustainable development and reflect societal choice, and address the desired ecosystem quality status;
- Geographic management scales should reflect ecological characteristics enabling management of marine and coastal ecosystem components;
- Planning and management must be integrated, strategic, adaptive and be supported by explicit objectives, and have long-term perspectives;
- Management is based on the precautionary principle, the polluter-pays principle and the principle of prevention (i.e. that environmental damage should, as a priority, be rectified at source);
- Best Available Technologies (BAT) and Best Available Practices (BAP) should be applied;
- Management must be supported by coordinated programmes for monitoring, assessment, regulation and enforcement, and by the best available scientific information and advice.

The **EMS** recognizes that it is necessary to apply throughout the regional seas a more coordinated approach with overarching policy, strategy, goals/objectives, and actions/measures to achieve the

goals of ecosystem-based management. The **EMS** *inter alia* focuses on a common ***Vision*** and ***Strategic Goals*** that are Europe-wide. However, it is acknowledged that to be fully effective the EMS must be applied on an **ecoregion** basis (e.g. North Sea, Baltic Sea): in so doing there should be concordance between these regions and the divisions of the UNEP Global Marine Assessment (GMA). Thus, ***Ecological Objectives***, ***Operational Objectives,*** and use of ***Indicators*** encompassing ***Targets and Limits*** need to be developed and implemented at the ecoregion level. In order to be operationally applied at the regional level, the EMS will establish a ***work programme***, with a clear timetable and milestones, of actions/measures ('***delivery tools***'). Furthermore, cost effective ***periodic monitoring and assessment programmes*** need to be established to determine the ***changing status and trends*** of the marine ecosystem, i.e. to classify health status.

2.3.4. EC Water Framework Directive

The **Water Framework Directive**, WFD, (EC 2000) (2000/60/EC) is currently the most substantial piece of EC water legislation and is ***an essential instrument in implementing the EMS***. The WFD promotes the integrated management of all water-related operations in fresh and marine waters, including coastal waters extending to one nautical mile outside the baseline. The WFD aims to enhance protection and improvement, by establishing measures to terminate or phase out discharges, emissions and losses of pollutants including nutrients, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. ***It requires classification (five classes: High, Good, Moderate, Poor, Bad) of the quality status of all inland and coastal waters and for 'good status' to be achieved by 2015***. It will do this by ***establishing a river basin district structure within which demanding environmental objectives will be set, including ecological targets for surface waters***. By 2013, several of the components of EC water legislation (e.g. previous water-related Directives) will be streamlined and subsumed within the WFD.

3 DEVELOP A VISION AND OPERATIONAL STRATEGY FOR MAINTAINING ECOSYSTEM HEALTH

3.1 Tackling the Shifting Baseline Syndrome: Ecological quality and the use of indicators for conserving and restoring healthy ecosystems

Many **human activities**, on land and at sea, pose serious threats and result in substantial **impacts** on coastal and offshore ecosystems (OSPAR 2000; EEA 2002, 2003; ICES 2003; Christensen *et al.* 2003; HELCOM 2003; Huse *et al.* 2003; Nilsen *et al.* 2003; Hopkins 2004) (**Fig. 1**). They have caused the intensive exploitation of many living marine resources, pollution from hazardous substances (e.g. heavy metals, persistent organic pollutants, radioactivity), microbial pollution, inputs of nutrients and organic material, introductions of alien organisms, and diverse forms of disturbances. Climate change also poses a major threat to all levels in the ecosystem.

In particular, these impacts have resulted in:

- Marked declines and dangers of local extinctions of many vulnerable species. Especially in the case of fish, shellfish and benthos, this has reduced the abundance of larger individuals and species towards smaller sized ones;
- Degradation of the habitats that provide essential living areas (e.g. feeding, breeding, refuges) for species and communities;
- Distortions in the characteristic structure, function and integrity of ecosystems - which have traditionally made them valuable - thereby affecting their ability to provide important 'goods and services' and so reducing human food security, employment & income in many coastal communities.

There has been lengthy and substantial 'drift away' from the status and characteristics that are desirable for the living marine resources, habitats and ecosystems that form the natural basis for biological production and socioeconomic benefits. Pauly (1995) used the term ***shifting baseline syndrome*** to refer to trend in living resources management where each generation of scientists

'*accepts as a baseline the stock size and species composition that occurred at the beginning of their careers, and uses this baseline to evaluate changes'. When the next generation starts its career, the stocks have further declined, but it is the stock at that time that serves as the new baseline. The result obviously is a gradual accommodation of the creeping disappearance of resource species...*'. Thus, it is implicitly not sufficient only to attempt to prevent further decline and degradation: it is imperative that **proactive restoration plans** are implemented.

Fig. 1. Illustration of the main human activities that pose threats to coastal and offshore ecosystems. Ten potential EcoQ issues/elements are listed for which EcoQOs may be developed.

EcoQ Issue/Element
Reference points for commercial fish species
Threatened & declining species
Sea mammals
Seabirds
Fish communities
Benthic communities
Plankton communities
Habitats
Nutrient budgets & production
Oxygen consumption

3.2 The importance of habitats, their mapping and classification, and marine protected areas

There is major concern regarding human pressures on habitats, i.e. the locality where a plant or an animal lives, as characterized by the physical features (e.g. seabed). The many habitats in coastal and offshore areas have specific faunal and floral communities associated with them, and have been threatened over the past century by human activities and changes in climate (see references in section 3.1). Particular animal and plant species and communities depend on specific habitat characteristics and ecological quality criteria. Thus, the ***conservation of habitats is a precondition for conserving species*** that depend on characteristic habitats for their viability. Degradation, fragmentation and eventually complete loss of habitat caused by physical alteration (e.g. 'extractive activities') as well as water quality impairment (e.g. pollution including eutrophication) represent serious threats to marine biodiversity, especially if contiguous but different habitat forming landscape diversity is lost (GESAMP 1997).

The 1998 Annex V to the OSPAR Convention aims at identifying species and habitats for which protection measures need to be adopted, including species and habitats under threat or subject to rapid decline. In order to facilitate this, it has been proposed to establish an ecologically coherent ***network of marine protected areas*** (MPAs) and to agree on measures to ensure the sustainable use of the marine ecosystem. The selection and establishment of MPAs is related to the assessment of species and habitats in need of protection, habitat classification and identification of biogeographic regions, and to developing the ecosystem approach including setting ecological quality objectives.

OSPAR and HELCOM have agreed to establish an ecologically coherent network of well managed marine protected areas across the North-East Atlantic and the Baltic Sea area by 2010 in accordance with agreed guidelines on selection and management. In the European Union, Natura 2000 is designed to establish a network or a system of Special Areas of Conservation (SACs) under the Habitats Directive and Special Protection Areas (SPAs) under the Wild Birds Directive. The aim is to enable the habitats and the species to be maintained, or where appropriate, restored to a favourable conservation status in their natural range.

Networks of MPAs facilitate the area-based sustainable use, conservation and protection of marine biological diversity and its ecosystems. Networks should include all habitat types and have sufficient enforcement and monitoring. They may include where appropriate 'no-take /no-trawl zones', undisturbed areas (e.g. for protection of juvenile fish, spawning areas, and vulnerable species and habitats). Movement is occurring towards establishing effective ***habitat restoration/enhancement plans/programmes***.

To successfully manage coastal and marine ecosystems, it is essential to manage human activities at the appropriate spatial scale and identify what activity/use is appropriate for parts or the whole of the area, i.e. who is allowed or not allowed access to it and under what conditions. Thus, it is necessary to establish management policies and rules for the particular MPA defining its purpose and use. Many MPAs are multiple use conservation areas that permit both consumptive and non-consumptive activities (e.g. fishing, diving, boating and swimming). They include national marine sanctuaries, research reserves, national parks and wildlife refuges with marine components, and underwater parks. These multiple use MPAs function both to protect ecosystems and, at times, to support sustainable fisheries while allowing access for recreation and tourism.

A 'census' (i.e. mapping, classification and inventories) of coastal and marine areas provides an assessment of the distribution of habitat types and their associated communities. Thus, areas may be identified requiring particular conservation and protection measures due to their susceptibility (previous and future) to particular human activities. Some areas may be open to specific types of access under appropriate management conditions (e.g. fishing with precautionary total allowable catches using specific types of gear but not others). Some areas, based on their characteristics or

declining status may be protected as closed/no-take areas at least until a desired enhancement status (e.g. 'recovery') has been achieved.

3.3 The need for Vision, Policy and a Strategy to achieve Objectives, supported by Actions to Redress Root Causes

To achieve successful marine and coastal management, we must:

a) **Develop a Vision and implement integrated Policies, Strategies and Objectives, supported by Actions** at the appropriate spatial scales (e.g. regional, local) involving long-term perspectives – applying the precautionary principle and the ecosystem approach;
b) **Identify and rank the root causes** of the problems (harmful activities and practices) causing deterioration and degradation and **prioritize targeted management actions** (e.g. regulatory measures) aimed at **redressing the root causes** in a concerted manner for conservation and restoration purposes within the framework of the policy.

Starting with a wider definition of **vision and perspectives**, we need to ask:

1) What do we want to achieve and why? Unless we have a clear Vision for the Mission, we will not be able to agree on the specific details.

A convincing and coherent **policy** (e.g. the EMS) incorporating a clear overarching **vision** (e.g. from the EMS '*we and future generations can enjoy and benefit from biologically diverse and dynamic oceans and seas that are safe, clean, healthy and productive*') must elaborate in meaningful terms what it is we want to achieve and why (i.e. justification), which is translatable into tangible **goals/objectives** supported by agreed **actions/measures** (e.g. a workplan comprising a 'toolbox' of activities and regulatory measures) for implementation. An illustration of some of the components involved in such a process and their possible relationships is provided in **Fig. 2**.

Unless we are to continue to drift aimlessly regarding declining ecosystem status, one must be in a position to know:

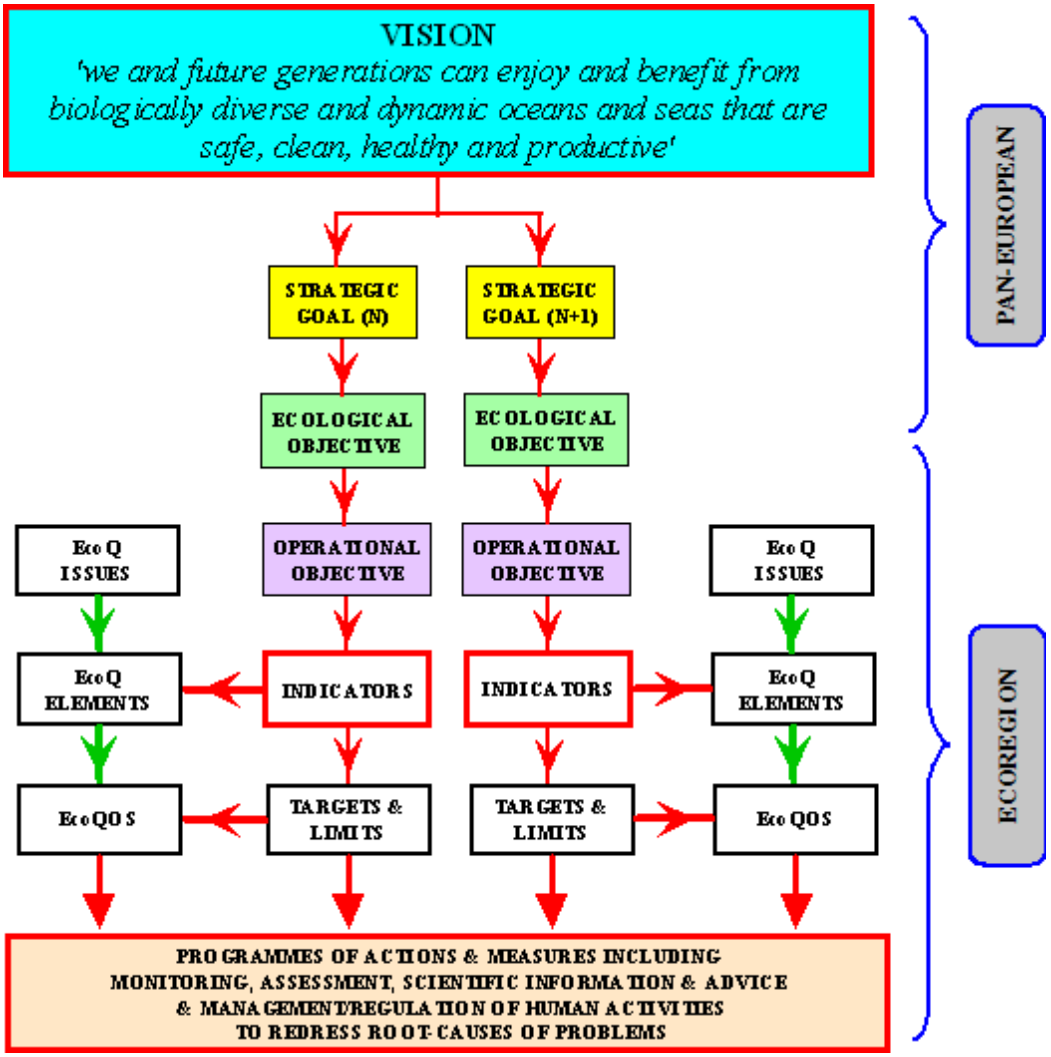
2) ***Where are we, where have we come from, and where do we wish to go?***

To answer this question, we must develop effective and relevant **targets and limits for environmental/ecological quality**, including the development of **indicators** that allow us to measure/track progress with respect to '**reference points**' (i.e. producing a map and knowing where we are on it and how we are approaching a 'destination').

The following **key explanations** (based on OSPAR and North Sea Conference usage) apply to determining our objectives:

- ***Ecological quality*** (EcoQ) is an expression of the ecosystem's status. It covers geographic, biological, chemical, physical and climatic aspects, including the results of human pressures/impacts.
- ***Ecological quality metrics*** are measurement scales or dimensions by which the EcoQ may be measured quantitatively or when appropriate qualitatively, and can at least be considered as a suitable way to measure the ecological property that the EcoQ is intended to capture. Various points on these metrics can be defined either by science or society.
- ***Ecological quality objectives*** (EcoQOs) for an ecosystem indicate the desired status of the system relative to a reference point (level).
- ***Reference points*** indicate the quality status in an ecological system where human-induced influence is minimal, i.e. an essentially undisturbed system.

Fig. 2. Organogram illustrating the process linking steps in the European Marine Strategy to indicators of ecological quality.



For delivering an ecosystem approach it is necessary to develop **a coherent and integrated, and easily understandable set of EcoQOs (targets) covering an appropriate set of ecological quality components**. Within the OSPAR framework for ecological quality objectives (EcoQOs) for the North Sea, a set of ***10 ecological issues*** has been identified: *reference points for commercial fish species*; *threatened or declining species*; *sea mammals*; *seabirds*; *fish communities*; *benthic communities*; *plankton communities*; *habitats*; *nutrient budgets and production*; and *oxygen consumption* (c.f. list in **Fig. 1**).

A number of '***ecological quality elements***' — individual parameters or variables describing the physical, chemical and biological environment of a marine ecosystem - can be used to express the overall ecological quality. Currently for the North Sea Pilot Project of OSPAR, about 21 ecological quality elements are under development, of which about half are well-advanced while the remainder needs much further work. For each ecological quality element one can define/chose one or more '***ecological quality metric***'. The appropriate values for the EcoQOs are determined by the overall desired ecosystem attributes. The quantification of EcoQ and EcoQos will vary among systems (e.g. ologotrophic to hypereutrophic areas) and depend on the priority given to various

issues. The setting of EcoQOs should be conducted in an integrated manner, to make certain that the sets are mutually attainable and collectively sufficient to ensure conservation of the particular ecosystem.

Thus, a suite of **performance indicators** compare actual conditions with a specific set of reference conditions. They measure the '*distance(s)*' between the current environmental situation and the desired situation (target): '*distance to target*' assessment. Thus, an indicator is a sign or signal that relays a complex message, potentially from numerous sources, in a simplified and useful manner. An ecological indicator is a measure, an index of measures, or a model that characterizes an ecosystem or one of its key components.

An illustration of the relationship between the various metrics (reference, target, precautionary, and limit) that define the ecological quality status ranging from 'high' to 'bad' spanning sustainable to unsustainable ecosystem goods and services is provided in **Fig. 3**. The target level(s) (also known as target reference point) identify the EcoQO that management should be trying to maintain with high probability. The ***limit reference point*** (LRP), in ICES usage, is a value that, if violated (transgressed) is taken as *prima facie* evidence of a conservation concern. By conservation concern, ICES means that there is unacceptable risk of serious or irreversible harm to the resource or system. LRPs are based on the biology of the stock/species/ecosystem, independent of human socioeconomic considerations. Outside the LRP a state is entered where there is evidence that productivity is seriously compromised, or exploitation is not sustainable, or the stock dynamics are unknown. To account for uncertainty in assessments, ICES uses ***precautionary reference points*** as a basis for scientific advice, with the intent that management consistent with precautionary reference points (i.e. applying the precautionary approach) should have a high probability of avoiding transgression of a LRP (ICES 2001).

In critically considering the criteria for good indicators (**Table 1**), it is essential that one should establish a '**cause and effect**' relationship (based on a causal chain analysis) between the human activity causing serious impacts on one or more components in the ecosystem, so that regulatory measures aimed at the **root cause** of the problem will result in a substantial decrease in the detrimental ecosystem effects. A DPSIR (Driver – Pressure – State – Impact – Response) analysis represents a useful complement to the analyses, in order to demonstrate more clearly how the overall ecosystem approach to the management of human activities safeguards the marine ecosystems. It is notable that although criterion 7 is highly desirable, it may not be an appropriate reflection of reality, for example, in the case of the ecosystem effects of fisheries connected with the levels of by-catches/discards by fishing gear/fleets and the fishing effort applied by these (e.g. over the seabed by bottom trawls). Despite there long having been substantial unanimity that such data concerning the non-target effects of fisheries on ecosystems is essential for developing meaningful indicators, there is either a major lack of willingness to collect such data or in the few cases where such data exists there is a reluctance to make the data widely available.

Table 1. Criteria for 'good indicators' (ICES 2001).

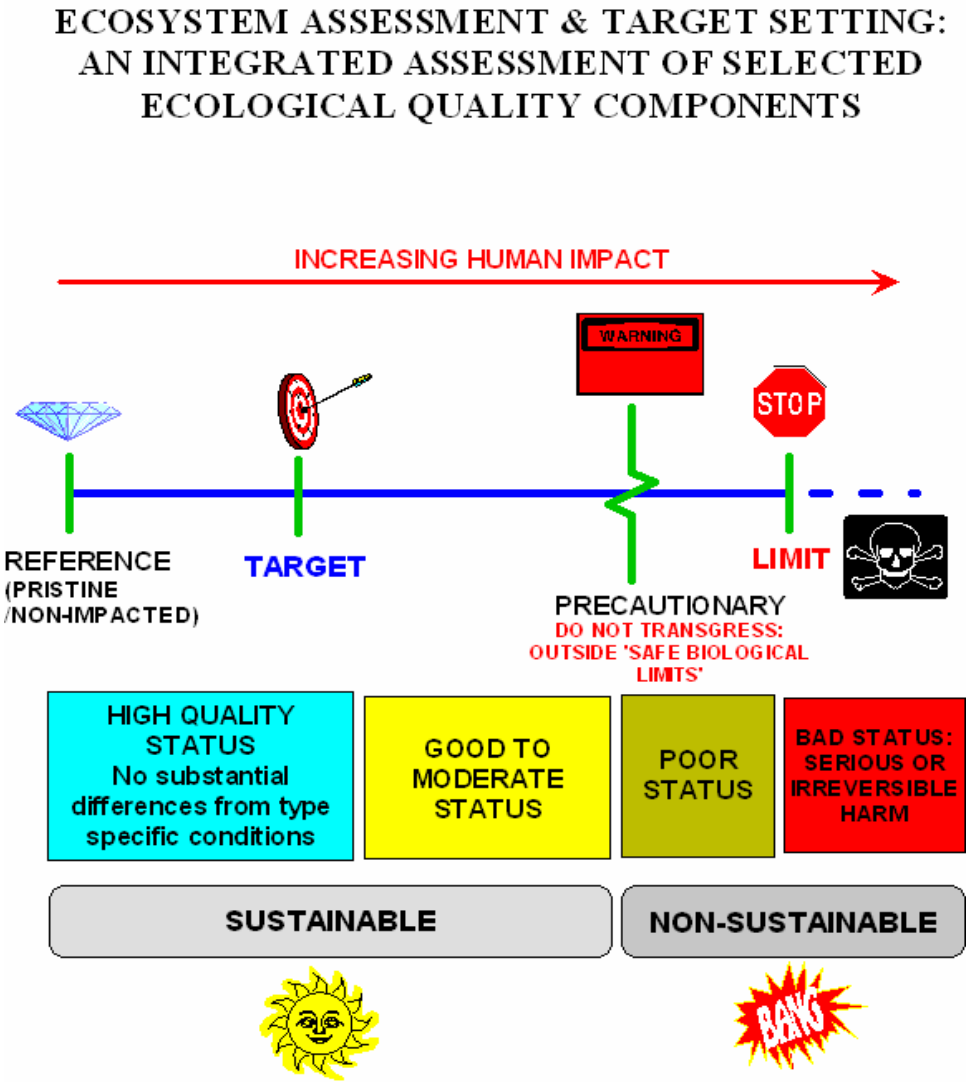
No.	**Criterion**
1	Relatively easy to use by scientists and those who will decide on their use
2	Sensitive to a manageable human activity
3	Relatively tightly linked in time to that activity
4	Easily and accurately measured with a low error rate
5	Responsive primarily to a human activity, with low responsiveness to other causes of change
6	Measurable over a large proportion of the area to which the EcoQ metric will be applied
7	Based on an existing or time series of data to allow a realistic setting of objectives

We often know intuitively what is wrong and in what direction we need to move for recovery. Too frequently, a combination of pollution (e.g. eutrophication) and 'extractive' activities (e.g. bottom trawling, dredging, marine aggregate extraction) has substantially reduced the numbers of larger

fish and benthos organisms, and marine mammal species, as well as having altered seabed structures and associated habitats that sustain bottom living fish, invertebrates (e.g. shellfish, corals) and seaweeds. These in turn distort the structure, function and integrity of ecosystems, including effects on the food web and multispecies (e.g. predator-prey) relationships, and severely reduce the value of ecosystem goods and services.

In developing EcoQOs and related indicators, it is also important to emphasize that there is a **need for prioritization**, whereby one should be devoting the greatest effort at regulating the human activities that are causing the most severe ecosystem impacts. ***Otherwise one ends up with an overtly academic exercise that lacks an ability to result in significant recovery and restoration of the ecosystem*** (c.f. case for DSPIR analyses promoted earlier).

Fig. 3. Illustration of the use of target setting combined with use of a precautionary reference point to ensure beneficial ecological status necessary for sustainable use of ecosystem goods and services.



4 ACKNOWLEDGEMENTS

I thank my colleagues in the BSRP Study Group on Baltic Ecosystem Health Issues for asking me to conduct the current assignment of developing a draft position paper on the concept of Marine Ecosystem Health. I am grateful to encouragement and support provided by the Coordinator and Assistant Coordinator of the BSRP and the Chair of SGEH.

5 REFERENCES

BBC (1993). BBC English Dictionary. HarperCollins Publishers.

CBD (1992). Convention on Biological Diversity. 5 June 1992, Rio de Janeiro (Brasil).

CBD (1995). The Jakarta Mandate on Marine and Coastal Biological Diversity; Decisions of the Second Meeting of the Conference of the Parties to the Convention on Biological Diversity. Jakarta, Indonesia, 6-17 November 1995. UNEP.

CBD (1998). Malawi Principles for the Ecosystem Approach. Fourth Conference of the Parties of the CBD. UNEP/CBD/COP/4/Inf.9). January 1998.

Christensen V, Guénette S, Heymans JJ, Walters CJ, Watson R, Zeller D, Pauly D (2003). Hundred-year decline of North Atlantic predatory fishes. Fish and Fisheries 4: 1-24.

Coffey C, Newcombe J (2000). The polluter pays principle and fisheries: the role of taxes and charges. UK Joint Nature Conservation Council (JNCC) http://www.jncc.gov.uk/pdf/thepollute2.pdf

Costanza R, Magean M (1999). What is ecosystem health? Aquatic Ecology 33(1): 105-115.

Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Naeem S, Limburg K, Paruelo J, O'Neill RV, Raskin R, Sutton P, van den Belt M (1997). The value of the world's ecosystem services and natural capital. Nature 387: 253-260.

EC (2000). Council Directive (2000/60/EC) Establishing a Framework of the Community Action in the Field of Water Policy ('Water Framework Directive'). Official Journal of the European Communities.

EC (2002). Communication from the Commission to the Council and the European Parliament: Towards a strategy to protect and conserve the marine environment. COM(2002) 539 final.

EEA (2002). Europe's biodiversity - biogeographical regions and seas. European Environment Agency, Copenhagen.

EEA (2003). Europe's environment - the third assessment. Environmental Assessment Report No. 10. European Environment Agency, Copenhagen.

FAO (1995). Code of conduct for responsible fisheries. FAO, Rome, Italy.

GESAMP (1997). Marine biodiversity: patterns, threats and conservation needs. Rep Stud GESAMP Vol 62.

HELCOM (2003). The Baltic marine environment 1999 – 2002. Baltic Sea Environment Proceedings No. 87. 48 pp.

Hopkins CCE (1999). The Integration of Fisheries and Environmental Issues: Evolution of the Ecosystem Approach. In: Schei PJ, Sandlund OT and Strand R (eds) Proceedings of the Norway/UN conference on the ecosystem approach for sustainable use of biological diversity. September 1999. Trondheim, Norway. Norwegian Directorate for Nature Management and Norwegian Institute for Nature Research (ISBN 82-426-1093-2), pp 161-169.

Hopkins CCE (2004). Biodiversity Assessment and Threats Analysis for the WWF Global 200 EcoRegion 'North-East Atlantic Shelf'. WWF Germany, Frankfurt am Main. 108 pp.

Huse I, Aanondsen S, Ellingsen H, Engås A, Furevik D, Graham N, Isaksen B, Jørgensen T, Løkkeborg S, Nøttestad L, Soldal AV (2003). A desk-study of diverse methods of fishing when considered in perspective of responsible fishing, and the effect on the ecosystem caused by fishing activity. TemaNord 2003:501.

ICES (2000). Report of the Study Group on Ecosystem Assessment and Monitoring. ICES C.M. 2000/E:09.

ICES (2001). Report of the ICES Advisory Committee on Ecosystems 2001. ICES Cooperative Research Report No. 249.

ICES (2003). Environmental Status of the European Seas. A Quality Status Report Prepared by the International Council for the Exploration of the Sea for the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. 75 pp.

IOC (2001). The final design plan for the HOTO module of GOOS. GOOS Report No. 99. IOC/INF. 1167. Intergovernmental Oceanographic Commission of UNESCO. 98 pp.

IMM (1997). Statement of conclusions from the Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues, 13-14 March 1997, Bergen, Norway.

JMM (2003). Statement on the ecosystem approach to the management of human activities: Towards and ecosystem approach to the management of human activities. Annex 5. First joint meeting of the Helsinki and OSPAR Commissions (JMM). Bremen, 25-26 June 2003.

Lubchenco J. (1994). The Scientific Basis of Ecosystem Management: Framing the Context, Language and Goals. Pp 33-39, In: Committee on Environment and Public Works, United States Senate, Ecosystem Management: Status and Potential. Proceedings of a Workshop by the Congressional Research Service, March 24-25 1994. 103rd Congress, 2nd Session. Washington. U.S. Government Printing Office.

Nilsen H-G, Aarefjord H, Øverland S, Rukke J (2002). Progress Report. Fifth International Conference on the Protection of the North Sea, 20-21 March 2002. Bergen Norway. Norwegian Ministry of the Environment. ISBN – 82-457-0353-2.

NOAA (2005). Background paper on Large Marine Ecosystems and approach to assessment and management. Protection of the Arctic Marine Environment (PAME) meeting, 22 – 23 February 2005, Copenhagen. NOAA – Fisheries, Narragansett, Rhode Island. 31 pp.

NSC 2002. Bergen Declaration. Fifth International Conference on the Protection of the North Sea. 20-21 March 2002, Bergen, Norway. Norwegian Ministry of the Environment. 170 pp.

OSPAR (2000). Quality Status Report 2000. OSPAR Commission, London.

Pauly D. (1995). Anecdotes and the shifting baseline syndrome of fisheries, Trends in Ecology and Evolution 10(10), p. 430.

Sherman K (1994). Sustainability, biomass yields, and health of coastal ecosystems: an ecological perspective. Mar. Ecol. Prog. Ser. 112: 277-301.

Sherman K, Duda A (1999). An ecosystem approach to global assessment and management of coastal waters, Mar Ecol Prog Ser 190: 271-287.

UN (1987). World Commission on Environment and Development: Our common future. Oxford University Press, Oxford.

UN (1995). Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks. Sixth Session. New York, 24 July – 4 August 1995. A/CONF.164/37 8 September 1995.

UNCED (1992). United Nations Conference on Environment and Development. Rio Declaration of the Earth Summit Agenda 21, Rio de Janeiro (Brasil). The United Nations, New York.

UNCLOS (1982). The Law of the Sea. Official Text of the United Nations Convention on the Law of the Sea with Index and Final Act of the Third United Nations Conference on the Law of the Sea. United Nations, New York, 1983.