OVERVIEW REPORT ON ECOLOGICAL QUALITY (EcoQ) AND ECOLOGICAL QUALITY OBJECTIVES (EcoQOs)

Report prepared within the framework of the OSPAR Commission

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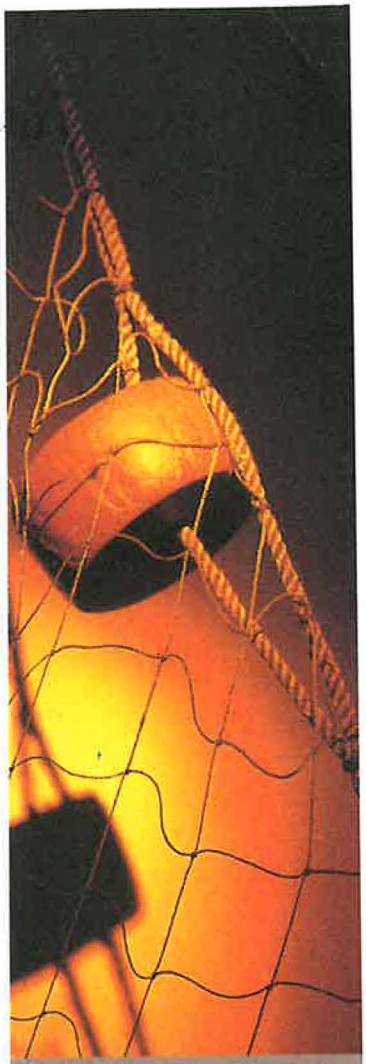

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This report summarizes work done on the topic of setting Ecological Quality Objectives (EcoQOs) within the Oslo and Paris Commission. Norway has acted at lead country for this topic. The report was approved for publication by Norway at the ASMO (Assessment and Monitoring) commitee meeting in Copenhagen in March 1997.

Contents

1. Background

In the Joint Assessment and Monitoring Programme (JAMP) of OSPAR issue 6.1 concerns ecosystem health:

How can ecosystem health be assessed in order to determine the extent of human impact?

The activities to address this issue is contained as part of the Assessment and Monitoring procedure:

- develop Ecological Quality Objectives (EcoQOs) and identify suitable indicator species,
- define a biological monitoring programme in relation to EcoQOs.

Norway has agreed to be lead country for the work under the Assessment and Monitoring Committee (ASMO) concerning EcoQOs. This is continuation of work started under the North Sea Task Force (NSTF).

At the IMPACT meeting in October 1995 it was agreed that Norway should circulate a questionnaire requesting existing relevant information on EcoQOs to contact points by 20 December 1995 and that contact points should respond to Norway by 1 April 1996. Norway should prepare a draft overview report on EcoQ and EcoQOs taking into account the results of the previous three workshops and any other relevant material. This draft overview report should include a final section with recommendations on the procedure for developing EcoQOs. This draft report were to be sent to national EcoQO contact points by 31 May 1996 with comments to be returned by 31 July 1996. Norway was then to submit a final report to the IMPACT 1996 meeting.

Due to delays in requesting information and in submission of information it was not possible to meet the summer deadlines for preparing the draft overview report and circulate it to contact points.

A draft overview report was presented and discussed at the meeting of the IMPACT working group in Berlin, 22 - 25 October 1996. A revised version of the draft overview report was circulated to Contracting Parties after IMPACT 1996, with a deadline of 15 January 1997 for comments. Based on the comments received, a further version of the draft overview report was made. This was submitted to the ASMO meeting in Copenhagen, 7 - 11 April 1997 as document ASMO 97/6/2.

Following discussion at ASMO 1997, ASMO agreed:

a. to adopt the overview report on EcoQ and EcoQOs (ASMO 97/6/2) with the inclusion of the amendments listed at Annex 26 concerning the complementary role of the source-orientated and the target-orientated approaches, the precautionary principle and the efficiency of measures;

b. that the final version of the report should be brought to the attention of all ASMO working groups which dealt with assessment criteria

c. to invite Norway as lead country and host of the third workshop to publish the report.

This final version of the overview report has been amended as agreed at ASMO 1997.

2. Summary of previous workshops

2.1 The sequence of workshops

Three workshops have been arranged to discuss the concepts and issues of Ecological Quality (EcoQ) and Ecological Quality Objectives (EcoQOs):

1. North Sea Task Force: Experts meeting Ecological Quality Objectives, Bristol, UK, 11-12 March 1992.
2. North Sea Task Force Workshop on Ecological Quality Objectives, Geilo, Norway, 20-22 September 1993.
3. ASMO Workshop on Ecological Quality Objectives, Ulvik, Norway, 12--14 June 1995.

These workshops have been attended by participants from Belgium, France, Germany, The Netherlands, Norway, Portugal and the United Kingdom.

The workshops have been a sequence of meetings with a stepwise progress in topics and outcomes. At the first workshop in Bristol, emphasis was placed on a common terminology and on definitions. At the second meeting at Geilo, emphasis was on the criteria for selecting variables to be included in expressions of EcoQ and EcoQOs. At the third meeting in Ulvik, the general approach and core of information for expressing EcoQ was further elaborated, while the procedure for deriving EcoQOs that are linked to eutrophication was considered as an example.

2.2 The Bristol workshop, March 1992

An inventory of current and proposed techniques for establishing EcoQOs was made based on presentations by the workshop participants on the current positions in different countries. The inventory included the following approaches:

- AMOEBA approach for marine and freshwaters in the Netherlands.
- Environmental Zoning for marine waters in the Netherlands.
- Water Quality Criteria for freshwaters, fjord and coastal water in Norway.
- Mussel watch in the USA.
- Freshwater methods in the UK, to be transferred to saline waters.
- Methods for freshwaters in Germany.
- Large Marine Ecosystems.
- Sewage sludge disposal sites in the UK.
- Maps of vulnerable coastal sites in Norway and UK.

The meeting produced a glossary of terms with definitions to be used to enable progress at the meeting. The definition of Ecological Quality was taken from a draft of the European Commission Ecological Quality of Water Directive:

> *Ecological quality is an expression of the structure and function of the ecological system taking into account natural physiographic, geographic and climatic factors as well as biological, physical and chemical conditions including those resulting from human activities.*

This definition has been used also at the subsequent workshops.

The glossary of terms also included

> *Ecological quality reference level which was defined as the level of ecological quality where the anthropogenic influence on the ecological system is minimal,*
>
> and
>
> *Ecological quality objective which was defined as the desired level of ecological quality relative to the reference level. (It was noted that the purpose of the EcoQO is to ensure that the ecological quality is either maintained or improved.)*

The meeting concluded that the setting of EcoQOs for the North Sea was possible in principle and would be a useful goal, but the tools required to properly define the variables to be included in the EcoQOs are generally not yet available. It seemed possible to develop an index of quality which is built up from a number of other indices showing the quality of single variables, through the use of e.g. multivariate techniques. The meeting recommended that EcoQOs for smaller systems such as estuaries and coastal zones should be developed as a first priority.

2.3 Geilo workshop, September 1993

At the Geilo workshop, the conclusions and recommendations from the Bristol workshop were taken as the basis for further discussions. The main emphasis was on the establishment of criteria for selection of parameters to be included in integral expressions of EcoQ. This was discussed mainly on a general level, but an attempt was also made to address the choice of variables for the specific cases of a coastal marine environment and the whole North Sea. Criteria for choosing parameters were developed from both the ecosystem and pollution perspectives. Variables were also selected from a more practical and methodological perspective.

The meeting reached agreement on general criteria for selection of parameters or variables to be included in expressions of EcoQ. These criteria fall into two broad categories, one reflecting basic ecosystem properties and the other reflecting human use or impact on the marine environment. The choice of variables for expression of EcoQ of any given habitat or ecosystem needs to be made with due consideration to the specific ecological properties and human use or impacts on that given system.

Basic ecosystem properties should include:

productivity,
diversity,
stability,
resilience, and
trophic structure.

Quantitative information is also required on habitats:

habitat types,
areal extent, and
rarity within the system.

The degree of openness of an ecosystem and the degree of connectedness with neighbouring systems are also important characteristics.

A general list of parameters or variables for the description of the marine environment was produced, based on the general criteria. This list can serve as a basis for further work on selecting variables for expression of EcoQ in both smaller scale coastal environments and the large scale North Sea ecosystem. The list of parameters includes physical, chemical and biological properties as well as variables describing biological effects and human use or impact on the ecosystem.

The proposed list of parameters or variables includes to a large extent information which is presently collected from the North Sea for a variety of management and research purposes. For the future more coherent and system-oriented data collection will be required. This can be used as a basis for expressing EcoQ and setting objectives for management of the marine habitats and ecosystems with their living resources. It was recognised that there is a need to further develop information systems for handling the data required for expressing EcoQ.

The meeting agreed that more emphasis than at present should be given to fluxes of sediment, water, organisms and contaminants in coastal environments and in the North Sea. Models for water circulation should be validated and used to a larger extent to describe fluxes of water, biota and contaminants within and between habitats and ecosystems.

The meeting recognised the need to continue efforts to better reveal the links between human uses and their effects in the marine environment. Work on biological effects techniques and ecotoxicological experiments

and risk analysis need to be intensified. Further developments of models relating human uses to ecological effects should be encouraged as their application may improve the scientific basis for setting standards.

The meeting recognised that describing EcoQ and setting EcoQOs is a complex issue which requires time and reflection as there are both theoretical and practical difficulties to overcome. There is a need to proceed in a stepwise manner towards the goal of setting EcoQOs based on sound scientific principles. Further steps in this process were identified as being:

1. Developing means of expressing EcoQ based on the information content of the chosen parameters.
2. Developing tools for setting objectives for EcoQ in a way which reveals cause-and-effect links. This will help to clarify policy options.

2.4 Ulvik workshop, June 1995

The objectives of the Ulvik workshop were to eleborate further on the general core of information for expressing EcoQ and the methodology and common approaches for expressing EcoQ and setting EcoQOs. The workshop was also to develop as an example, the procedure for deriving EcoQOs that are linked to eutrophication, and to explore EcoQOs linked to other human use issues.

In the Strategy for a Joint Assessment and Monitoring Programme (JAMP), six issues have been identified as a basis for monitoring and environmental assessments. These are: 1) contaminants, 2) eutrophication, 3) litter, 4) fisheries, 5) mariculture, and 6) habitats and ecosystem health. An outline of a methodology proposed for setting EcoQOs was discussed at the ASMO April 1995 meeting and appended to the terms of reference for the Ulvik workshop. The core of information for expressing EcoQ includes quantitative variables that describe human uses or impacts on the marine systems. Such variables could for instance be input of nutrients, input of contaminants, fish landings, fishing mortality, etc. These variables can be interlinked with other variables describing the state of the ecosystem and can provide operational connections between the issues in JAMP and EcoQOs. The outline of the proposed methodology is illustrated in Fig. 2.1.

Core of information for expressing EcoQ	**Issues in JAMP**
Variables	**Contaminants**
Morphological	**Eutrophication**
Physical	
Chemical	**Litter**
Biological	
Biological effects	**Fisheries**
Human uses	**Mariculture**
	Habitats and ecosystem health

Fig. 2.1. Outline of methodology for linking Ecological Quality Objectives (EcoQOs) with the issues of human impacts on the marine environment in the Joint Assesment and Monitoring Programme (JAMP). The Ecological Quality (EcoQ) is expressed as a core of information (state and flux variables) reflecting basic ecosystem properties and human uses or influences. The integral expression of the core of information can be related to each and all of the different issues for given ecosystems or regions.

National progress and progress in the EU were reviewed. Presentations included:

- EU-directive on ecological water quality
- UK quality objectives
- Scottish practice of classification
- Water quality system development in France
- Water system exploration in the Netherlands
- Quality objectives in Belgium
- Quality targets in Germany
- Norwegian classification system and environmental targets.

In discussing the issue of eutrophication it was recognised that different types of areas may have very different sensitivities to changes in nutrient input, and that 50% reduction in inputs may not bring about desired EcoQ. Nutrients are qualitatively different from xenobiotics because the former are naturally present.

Possible EcoQOs were considered in relation to a nutrient effects diagram (Fig. 2.2). Dag Aksnes introduced the concept of Measures of Ecological Quality (MEQ) as an approach based on quantitative indices in order to avoid excessive complexity. With regard to such MEQs there is a need to concentrate on key eutrophication issues for each specific area. Thus for the Netherlands as an example, key issues are the inshore problem of Phaeocystis, offshore problems of toxic algae, and oxygen depletion in stratified areas.

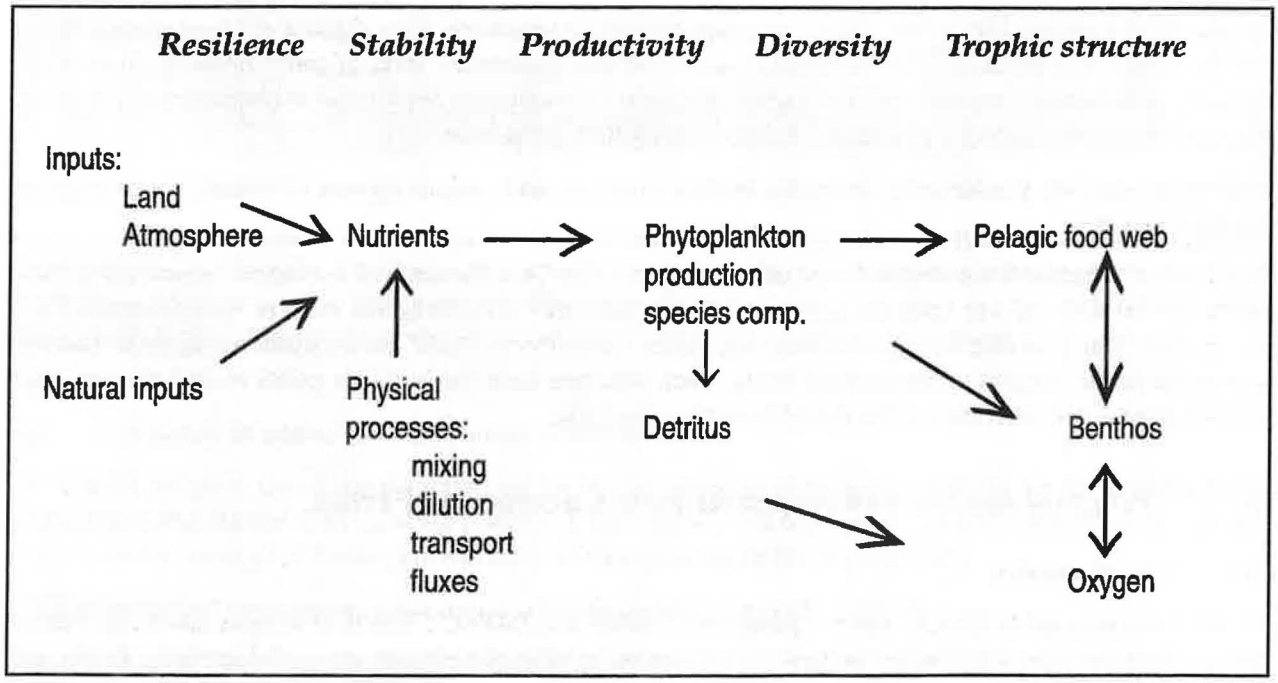

Fig. 2.2. Issue eutrophication. Diagram illustrating linkages between nutrient input, main components of the ecosystem, and eutrophication effects. On top are shown the five elements of ecosystem properties which should be reflected in the core of information expressing Ecological Quality. Eutrophication is clearly linked to the properties productivity, diversity and trophic structure.

Dangers of being too simplistic were recognised. Thus annual productivity alone may not always be a sufficient measure of eutrophication as the ecological effects of eutrophication may depend on the producing species and temporal distribution of production through the year. Increasing silicon to nitrogen and phosphorus ratios may favour diatom growth at the expense of less desirable species.

Specific targets, such as maintaining oxygen concentrations above 5 mg O_2/l at the Oyster grounds are already defined. Another target might relate to decreasing the rate of oxygen consumption in stagnant fjordic basin areas. More generally, benthic communities are important as indicators of eutrophication effects.

The meeting discussed the use of mathematical models when addressing the issue of eutrophication. Modelling will not provide all of the answers, but models are part of an integrated package of tools for the study of ecosystems. Suitable models generally have two parts covering:

i. Hydrodynamic processes
ii. Biological processes

Compared to biological process models, hydrodynamical models are relatively simple to validate although the validation may still be an extensive and comprehensive process.

Modelling can work with loads, fluxes and concentrations. Specific situations can be effectively investigated using modelling techniques. Modelling boundaries for eutrophication applications must be carefully chosen to keep complexity within manageable limits. Is the cut-off at phytoplankton the optimum approach or should modelling extend to include more of the foodweb?

On a small local scale, such as looking at possibilities for fish farming without causing ecological damage in fjords, modelling has a clear and vital role to play.

The meeting discussed the principles and linkages involved in defining EcoQ and setting EcoQOs. A general diagram illustrating the linkages was produced and served as a framework for the discussion (Fig. 2.3).

An ecosystem can in its simplest form be depicted with the main components: physical environment, nutrients, phytoplankton, pelagic food web, benthic food web, and detritus, with oxygen being a chemical component reflecting the overall metabolism of the system. In reality, any ecosystem is very complex with many species with complex life cycles, population dynamics and interactions. Descriptions of ecosystems need to be simplified, and the scientific challenge is to choose the appropriate level of simplification where main features of the system are retained. Ecological quality is a quantitative description or characterization of the state of the system, taking into account the basic ecosystem properties:

resilience, stability, productivity, diversity, trophic structure, and various aspects of human use or impacts on the ecosystem.

Human use or impacts are linked to the issues of the JAMP. Thus for each of the issues, quantitative variables can be defined and used on equal terms with variables describing the state of components of the ecosystem. This provides linkages between the issues identified in JAMP and ecosystem properties that are contained in the integral expression of EcoQ. Such linkages form the basis for political and management actions to maintain or improve the EcoQ by setting EcoQOs.

3. Progress reports and responses from Contracting Parties

3.1 Questionnaire

A letter was sent out to EcoQO contact points and ASMO and IMPACT Heads of delegations on 22 February 1996 requesting information on new developments of relevance to the issue of describing EcoQ and setting EcoQOs. In their progress reports, Contracting Parties were asked to consider the following list of key words or issues:

- The fundamental concept of EcoQO.
- Use of models and other tools for establishing EcoQOs.
- Environmental quality criteria in relation to EcoQOs.
- Application of key indicator species within EcoQOs.
- Level of knowledge needed to develop practical EcoQOs.
- Consequences of applying EcoQOs.
- Roles of habitats and habitat diversity in EcoQ and EcoQOs.
- Monitoring requirements in relation to EcoQOs.

Responses to the questionnaire were received from the Common Wadden Sea Secretariat (CWSS), the European Commission (EC), France, Germany, the Netherlands, and Portugal. The responses and information recieved are summarized below.

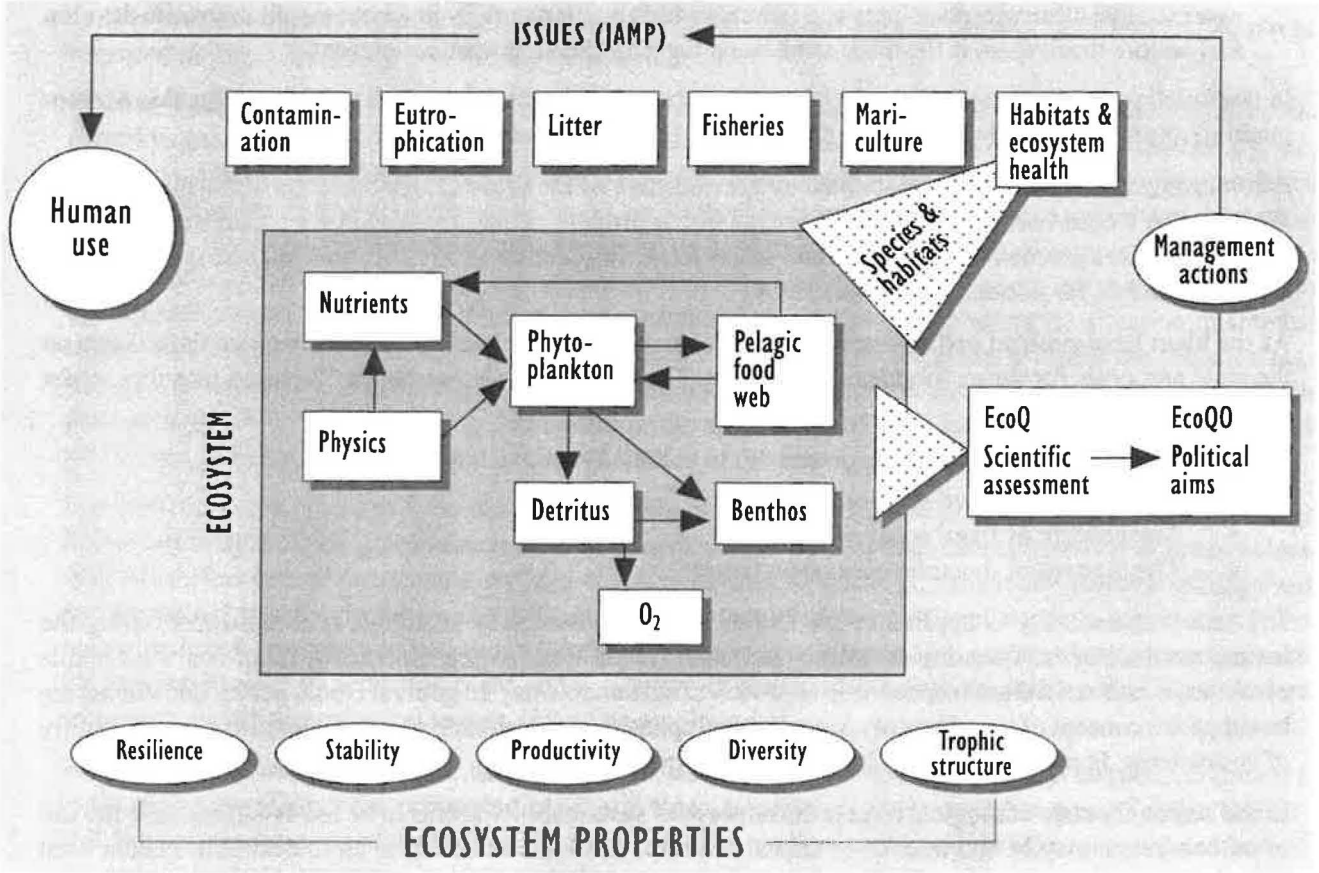

Fig. 2.3 Conceptual framework for the methodology of describing Ecological Quality (EcoQ) and setting Ecological Quality Objectives (EcoQOs). EcoQ is an integral expression of the state of an ecosystem, reflecting basic ecosystem properties and human use. The human use variables are linked to the issues of the Joint Assessment and Monitoring Programme (JAMP), and provide a basis for setting objectives related to management actions.

3.2 Common Wadden Sea Secretariat (CWSS)

The CWSS refers to the «Progress report on the implementation of ecological targets for the Wadden Sea» presented to the IMPACT-95 meeting (IMPACT 95/7-Info 2). This document describes background information on the concept of Ecotargets and their implementation in the Wadden Sea.

CWSS forwarded two papers on the topics of Ecological targets and EcoQOs:

> «Ecological targets in the Wadden Sea. Development of ecological targets as a political instrument; previous attempts and the present state in the Wadden Sea». Norbert Dankers and Jaap de Vlas, 1994. Ophelia Suppl. 6: 69-77.
>
> «Marine Ecological Quality Objectives: science and management aspects». Volkert de Jong. Pp. 17-24 in: Wege zum Verständnis von Küstenökosystemen. Økosystemforschung Niedersächsisches Wattenmeer.

Dankers & Vlas (1994) give an overview of the development of ecological targets as a political and management tool with reference to the Wadden Sea. Behind the consensus of conserving the Wadden Sea three major views emerged:

> The functional approach, where nature is providing goods and services which may be used in a sustainable way. The limits for use is set by the environment.
>
> The classical approach, where a certain situation (e.g. successional stage in an ecosystem) is regarded as highly valuable and management is aiming at preservation of this value.
>
> The natural development approach, where natural processes are allowed to take place. The resulting ecosystem may be considerably different from the present. In the natural development approach it is

assumed that all structures, plants and animals which occur naturally in a system will maintain, develop and restore themselves if the basic conditions for their development are present.

In the functional approach the concept of sustainability is essential. The Dutch PKB (Wadden Sea Memorandum) approach is a hybrid between the functional and natural development.

A common guiding principle was adopted by the ministers of the Wadden Sea countries at the 6th Trilateral Wadden Sea Conference 1992: «To achieve, as far as possible, a natural sustainable ecosystem in which natural processes proceed in an undisturbed way». However, it has become clear that such broad guidelines are not sufficient for political decisions.

As the ideas have evolved and matured, representatives of different backgrounds have given their views on the aims and goals for future Wadden Sea policies. The aim and goals have been classified into four major categories:

1. The concept of sustainability
2. The concept of fixed species targets
3. The concept of fixed ecosystem targets
4. The concept of dynamic ecosystem targets

The term sustainability is applied to the use of natural resources by mankind, without undermining the natural resource basis. The adopted guiding principle for the Wadden Sea specifically mentions 'sustainable ecosystems' and not the anthropocentric approach of sustainable use. In general Dutch policy documents are based on the concept of sustainability, sometimes emphasising sustainable use, and sometimes sustainability of ecosystems. In practical politics it becomes a mixture.

In the search for clear ecological targets the concept of sustainability seems to be too broad because the use of an ecosystem may be too intense or take a unwanted direction resulting in an undesirable system even though the use is sustainable and the ecosystem is recognised with all species and natural processes occurring.

The concept of fixed species targets is based on the AMOEBA system. The system was designed to represent the state of the environment based on a selected number of variables, such as the abundance of certain characteristic species. In the process towards a tool for management certain values were assigned to these variables and they became targets. Abundance values were based on 1930s values. The weakness of this system is that abundance numbers for only some species were available in the 1930s. The aim is a system similar to that in the 1930s (probably one successional stage) while a natural system may alter considerably, and even climax systems do develop and are subject to cyclic changes. According to Dankers and Vlas the AMOEBA is not useful in the development of quantifiable targets but can be useful to indicate whether a situation is diverging from a specified situation.

In the discussion of ecosystem targets it should be a clear distinction between environmental quality objectives and ecological quality objectives. Environmental quality objectives should be limited to chemical or physical ecosystem parameters, which in general is not too difficult targets to assign quantifiable values (loads, concentrations). More difficult is to predict all effects on the ecosystem of different levels of contaminents. Using the concept of fixed ecosystem targets and assigning values to ecological quality objectives present several problems. The Wadden Sea is an evolutionary young system which is still developing. It is a dynamic and open system with strong physical, chemical and biological fluctuations. It is furthermore a heterogenous area consisting of different habitats and biotopes. It has become clear that natural and dynamic ecosystems develop and show unpredictable fluctuations. Aiming at quantified fixed targets does not take into account these dynamic aspects of ecosystems.

Descriptive ecological targets seems more promising. Using the concept of dynamic ecosystem targets the policy is aiming at a natural development of the ecosystem. It is assumed that all structures, plants and animals which occur naturally in a system can maintain, develop and restore themselves if the basic conditions for their development are present. This means that physical and biological processes should as far as possible act undisturbed, and that background levels of disturbances (physical, chemical, etc.) should be kept below certain levels. To this concept belongs the more descriptive form of ecological targets based on historical, geographical and scientific information. Often it will be possible to indicate in what number a

species would normally occur in such a reference, but it should be stressed that these numbers should not be regarded as target for policy and management scenarios.

For the Wadden Sea an Ecological Target group has decided to describe ecological references (values assigned to parameters describing the reference situation) using classification according to area, biology and chemistry. Since the reference should give the direction of the target, a qualitative reference was considered sufficient. For six characteristic Wadden Sea areas political targets are defined. These are values assigned to parameters describing the desired ecosystem based on political decision-making. Biological targets are not clearly defined. The chemical conditions are considered to be among the main factors that determine whether the Wadden Sea ecosystem can function as a natural system. Based on the reference situation quantified targets have been developed. When targets have been established it is important to assess the present situation and decide on the measures in order to initiate a development from the present situation towards the desired target. When the targets are descriptive or the approaches of sustainability or natural development are chosen, it becomes complex and extensive studies of the present ecosystem is necessary.

It is difficult to return to a pristine ecosystem and therefore if such situations are known at all, they can not be used directly to develop parameters. It seems more wise to develop parameters based on intrinsic values in nondisturbed natural ecosystems, e.g. age structures within populations, natural composition of longlived and shortlived species, predators and prey, and the presence of all successional stages in a system. A basic condition is that physical processes should operate without disturbance. Management has to be set up with the present siuation as a starting point and a monitoring programme has to be developed. All parameters which are chosen as ecological targets should be monitored.

In their conclusions, Dankers and de Vlas emphasised that the concept of ecological targets has shown a cyclic development that has proceeded in several steps. Experience has shown that quantification is difficult, the future often unpredictable, and the causal relationship between management action and numbers of the target organism uncertain. In later steps the general aims and goals have been described and emphasis has been laid upon management actions providing the right conditions. These conditions can be reached by

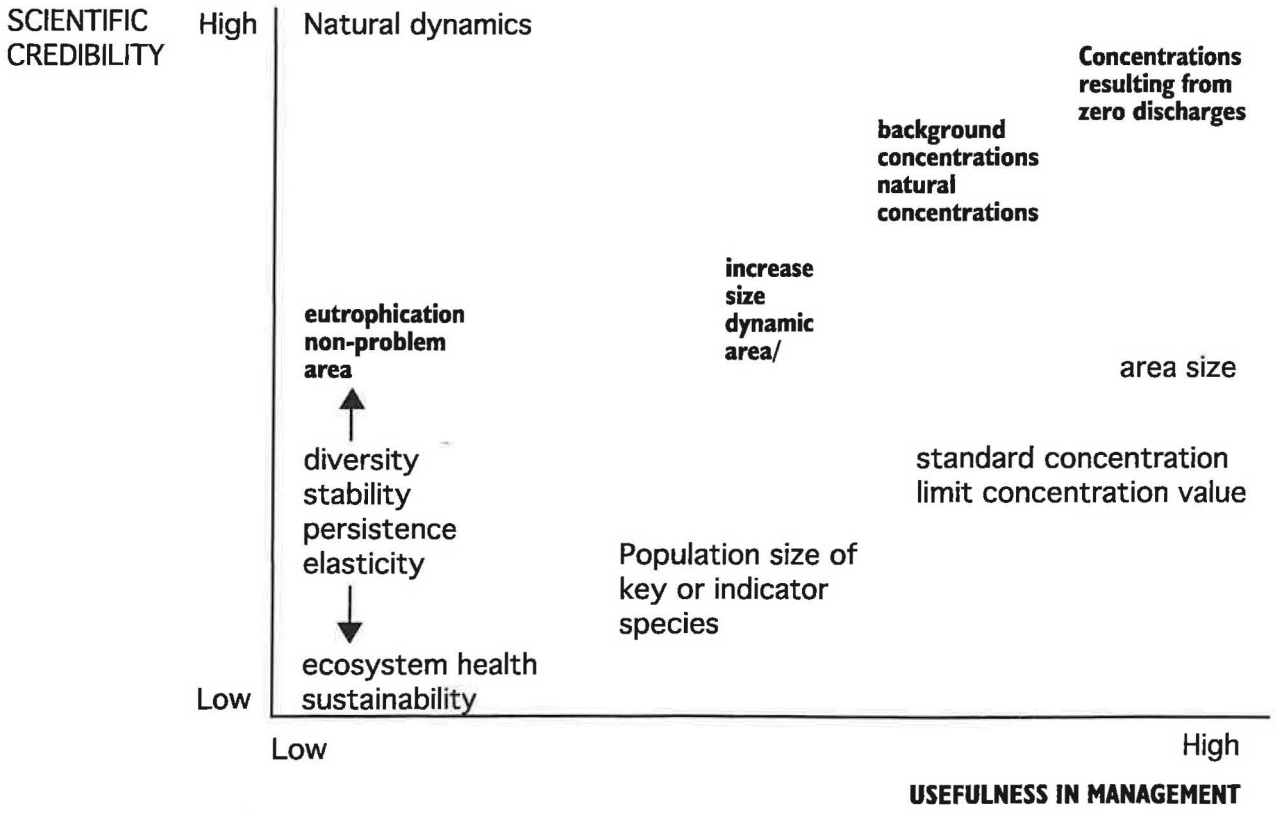

Fig. 3.1 Various aspects of ecological objectives presented according to an estimation of their scientific credibility and their usefulness in management. (From de Jong).

zoning, interweaving (continuously adjusted levels for all disturbing activities) or by setting strict values for background levels of disturbances. New indicators of sustainability should be developed, which should be structure and process parameters indicating the intrinsic values of ecosystems. It has also become clear that man should be accepted as an integral part of the ecosystem.

The paper by Folkert de Jong, presented at the 5th German ecosystem research symposium in February 1996, gives an overview of the development of marine EcoQOs and viewpoints on the relationships with science and management. de Jong presented a diagram showing how different concepts and terms relate to scientific credibility on the one hand and usefulness in management on the other (Fig. 3.1). According to de Jong, concepts such as «ecosystem health» and «sustainability» have low scientific credibility and low usefulness in management beacause of their vague definitions and lack of operationality. Also terms like «diversity», «resilience» and «stability» were given low scores with regard to both scientific credibility and usefulness in management since they are considered as unripe and controversial concepts that have not been operationalized.

Terms related to the Ecotarget concept were considered to score high on scientific credibility and usefulness in management. «Background concentrations» of naturally occurring substances and «concentrations resulting from zero discharge» for xenobiotic substances were considered to be highly useful concepts with high scientific credibility. The concept of «increase the area which is natural, undisturbed or dynamic» was considered a useful objective in management and one that has a relatively high scientific credibility. The concept «eutrophication non-problem area» was on the other hand considered to have low usefulness in management as long as it is not further specified.

de Jong (1996) concluded that the responsibility for the development and application of EcoQOs is not a scientific one. It is a political responsibility, and in his view EcoQOs should not become identified with scientific concepts. However, for improving the scientific quality of ecological objectives it is important that scientists deliver relevant scientific information to nature managers.

3.3 Germany

As the German EcoQO contact point, Uli Claussen provided information in a letter on the status of the development of EcoQO in Germany. He also forwarded a paper with information about the quality targets for German inland waters.
«Quality targets for concentrations of hazardous substances in surface waters in Germany», U. Irmer et al., Ecotoxicology and Environmental Saftey 32: 233-243. 1995.

A German national working group is elaborating the concept for deriving EcoQOs for marine waters. The working group deals intensively with the question whether EcoQOs are the suitable tool for deriving political measures to improve the quality of the environment. Therefore it is necessary to clarify whether:

- the natural variability of parameters considered is known and can be investigated by acceptable expense for the specific environment, e.g. the Wadden Sea,
- a distinction between natural and anthropogenic influences on the parameters under consideration in a specific time frame and on a regional basis is feasible,
- in a specific period changes can be realized with regard to the great natural variability,
- any cause-effect relationships are existing to be able to distinguish between natural and anthropogenic effects.

The German view is that only positive answers to these questions would allow to take EcoQOs as an suitable tool for improving the marine environment. They still keep the principle of reducing the pollution at source as the main measure of highest priority. EcoQOs might serve in this context as an indicator and as a tool to set further targets for reduction if it turns out that the reduction measures at source are insufficient. For these reasons there is at present not a commonly accepted concept for the EcoQOs for marine waters and it is too early to make conclusions with regard to them. There are open questions which will be dealt with in the near future.

3.4 The Netherlands

The EcoQO contact person Jacob Asjes has submitted information on the developments regarding EcoQOs in the Netherlands. Two more or less different approaches are followed, the «Aquatic Outlook» Programme and Nature Conservation Policy in the Netherlands. At present they are trying to integrate these two approaches for the North Sea.

Within the Dutch Aquatic Outlook programme, extensive work on the concept and implementation of EcoQOs has been carried out in recent years. In order to construct a set of verifiable objectives, a first essential step in the process has been the development of a set of indicators which can provide an adequate picture of the complex system. Once such a set has been defined, actual objectives (target values) for each of these have to be formulated. Subsequently, this system can be used to assess the need for policy measures for the protection or restoration of the marine environment.

In selecting the indicators an optimum should be sought between the need to gather comprehensive information on the one hand, and the need to provide information which is easily surveyable and can be gathered with the available resources on the other. The set should cover all essential aspects of the system. To be useful in policy formulation the variable should be related to human impacts on the ecosystem and influencable by policy measures. In addition, it must be possible to define a target value for the indicator. Lists of criteria for selecting individual indicators and sets of indicators have been worked out.

The indicators should describe the various aspects of the environment:

- physical (describing habitat characteristics)
- chemical
- ecotoxicological (e.g. prevalence of fish diseases, imposex, induction of EROD activity, amount of oiled seabirds)
- biological (e.g. population numbers)
- human activities (e.g. fishery intensity, chemical inputs).

The development of the set of indicators forms important steering to the development of a monitoring programme which should provide the necessary actual information.

The second fundamental step in the formulation of the EcoQOs in the Aquatic Outlook programme is the establishment of target values for each indicator. An objective basis for the development of these target values is formed by the values for the indicators as they occur in situations undisturbed, or minimally disturbed, by human influence. These indicator values describe the natural reference situation. By doing so an objective yardstick is constructed for each indicator. The values for the reference situation can be invoked from historical data or data from other geographical areas which are comparable but undisturbed. In view of the reference and actual values of the indicators, EcoQOs can then be formulated as target values which are to be achieved by the appropriate policy measures. Obviously, in the comparison of actual and reference or target values, the occurring variability should be taken into account.

A visual representation of the yardstick approach is shown in Fig. 3.2. Several yardsticks for biological target variables can be visualized in the AMOEBA representation. This is a radar diagram where the reference values on a standardized scale for the different organisms are arranged systematically on a circle. The distance from the edge to the center of the circle represents the population size present in the reference situation. The current numbers are then superimposed. If the current poulation size is larger than the reference value, the value will lie outside the circle; if smaller within the circle. All the points representing

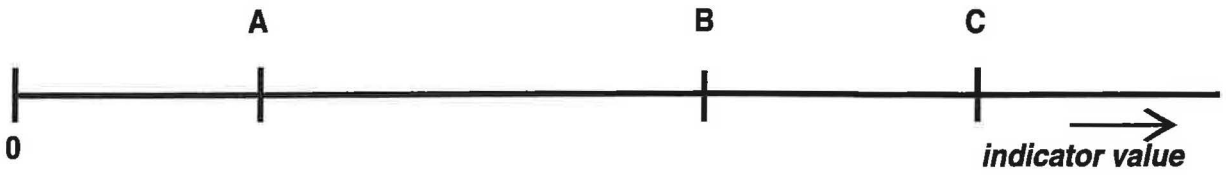

Fig. 3.2 An indicator yardstick. A: actual value, B: target value, C: reference value.

current numbers are connected by a line producing an AMOEBA like shape. Further information and examples of the yardstick approach and AMOEBA are given by Colijn et al. (1996) in a paper presented at the Scientific Symposium on the North Sea Quality Status Report 1993 («Ecological Quality Objectives in perspective», F. Colijn, R. Laane, H. R. Skjoldal and J. Asjes, pp.249-254).

Asjes forwarded the leaflet «Nature conservation policy in the Netherlands» which gives a resume of the The Dutch Nature Policy Plan which was published in 1990. The criteria for assessing ecological targets consentrate on biological diversity and naturalness. The Nature Policy Plan focuses on the establishment of a National Ecological Network, a coherent network of existing and still-to-be-developed nature areas. All the current nature conservation areas form the core areas of the Ecological Network.

Biological diversity of species and naturalness of ecosystems are very important concepts in relation to nature conservation policy. These two concepts form the starting points for elaborating a system of target nature types. Species that are of national and international interest are called target species. A species is a target species when it meets at least two of the three criteria; the species is of international importance and a relatively large part of its geographical range is located in the Netherlands; the trend of abundance is downward, by 25 % the last 40-50 years; the species is rare in the Netherlands. Naturalness is defined in terms of degrees of human interference. A system of target nature types for the Netherlands therefore inevitably has to consider degrees of naturalness and human interference. Therefore target nature types are divided in four categories which are:

- natural,
- controlled,
- seminatural,
- multifunctional.

In the Netherlands 132 nature target types are defined and classified into this scheme.

3.5 France

Christian Auger has submitted a document, «Introducing a new concept: coastal and offshore Ecological Quality Objectives. Analysis and comments» (1st draft, March 96), which summarizes some of the developments in the NSTF and ASMO work on EcoQOs. The definition of EcoQO is considered as are the concepts of Environmental Quality Objectives and Ecological Targets. Setting EcoQOs in relation to eutrophication of a bay is considered as a theoretical example.

Some comments on the implementation of EcoQO is provided. It is noted that EcoQO is not an assessment tool for the ecological quality of an ecosystem but rather the level of quality to be reached or maintained. A key question is whether we can recognize changes induced by man from those that are caused by nature.

3.6 Portugal

Maria Fátima Brito has in a letter informed that there is little work done concerning EcoQO and no Ecological Quality criteria has been established in Portugal. There has been some research in estuaries aiming at identifying indicator species. Some species have been identified as biological indicators but there is not yet consensus to their use nor is there a national monitoring programme. Some studies apply models that relate the water quality to indicator species development (plankton, macroinvertebrates and fish) using physical, chemical and bacteriological parameters.

3.7 The European Commission

DG XI of the European Commission has in a letter from D. G. Lawrence provided information on work related to EcoQOs in the Commission. Two documents were also forwarded, «Proposal for a Council Directive on the ecological quality of water» (June 1994) and «Communication from the Commission to the Council and the European Parliament. European Community Water Policy» (February 1996).

The proposed Ecological Quality of Water Directive contains a definition of EcoQ which has been adopted for use in the NSTF and ASMO work on the concept of EcoQOs. This proposed directive has not yet been adopted and may be succeeded by a new proposed Water Resources Framework Directive suggested in the

Commission Communication on EC Water Policy. Both directives would require the setting of EcoQOs for all Community surface waters, including coastal waters.

The Commission has commissioned a study from a British research institute, WRc, on «The Harmonised Monitoring and Classification of Ecological Quality of Surface Waters in the European Union». The Commission advised that the results of this study would be of great interest for the present process and that we might wish to await the report from WRc before finalizing the present report. The WRc report together with a short Commission summary and conclusions paper were expected to be sent to member states by the middle of June this year (1996). We did, however, not receive this report prior to finishing the draft version of the present report.

3.8 Other countries

Norway and the UK did not submit any specific information on new developments. Both countries have participated on all three previous workshops and presented information related to the issue of EcoQO there.

Belgium informed that information would be submitted but this was not received. Belgium participated at the last workshop in Ulvik and presented some information there.

4. Discussion

4.1 Challenges and need for EcoQOs

The marine environment and marine ecosystems are threatened by a range of impacts due to human use and activities. These are identified and priority issues are listed in JAMP.

There are two main challenges from both scientific and management point of views:

1. *Can an ecological or environmental disturbance due to human activities be recognised and distinguished from the multitude of changes due to natural variability? and*
2. *Can an ecological or environmental disturbance from a particular human activity be regognised and distinguished from changes resulting from other human activities?*

Unless an observed environmental change can be ascribed as due to man and not being a natural phenomenon, there is a weak case to mobilise the necessary support and resources from politicians and society for mitigating actions. And unless an observed change can be ascribed to a specific human activity, it is difficult to recognise and agree on what are the required actions. The precautionary principle offers limited guidance on priorities unless backed by scientific information. The precautionary principle prescribes that preventive measures are to be taken when there are reasonable grounds for concern that substances or energy may cause harm to the marine environment. Reasonable grounds for concern generally implies some level of scientific knowledge although there is no conclusive evidence. The grounds for concern would generally be strengthened as the scientific knowledge improves towards the point when conclusive evidence is reached. At that stage there is no need to apply the precautionary principle to justify measures.

The marine ecosystems are open in the sense that there are large movements and exchanges of water, sediments, contaminants, dead organic material, plankton, fish, seabirds and mammals between different coastal and offshore areas. Due to this openness and fluxes of material, a third major challenge is:

3. *Can the spatio-temporal relationships between the primary human input or activity and the resulting environmental impacts be described?*

Unless such relationships can be identified and described it is difficult to know which and where mitigating actions have to be taken. This can be illustrated with an example. The oxygen content of the deep water of Kattegat has shown decreasing trends over the last few decades, and situations with low oxygen or anoxic conditions that result in mortality of benthos occur now frequently in late summer and autumn. It is likely that this is due to a combination of increased sedimentation and decomposition of organic material from local inputs of nutrients and increased organic demand and lowered content of oxygen resulting from nutrient input to water transported into Kattegat from the coastal regions of the southern North Sea. Improvement of the EcoQ of Kattegat may therefore require actions both locally and in regions «upstream» to Kattegat.

We may be faced with serious environmental problems in some coastal and offshore areas of Europe's seas. Taking the southern North Sea as a case there may by numerous threats from a number of different human activities as identified in JAMP. As an hypothetical example, changes in benthic communities in the offshore region of the southern North Sea could be due to a number of issues including eutrophication, contaminants, and fishing activities. If monitoring reveals changes in benthic communities there is a need to establish if they are due to natural variability or to man, and in the latter case which of mans activities contribute and by which proportions to the observed changes.

The need for EcoQOs must be seen against the backdrop of these challenges. EcoQOs should be formulated so that they safeguard the integrety and sustainability of the marine ecosystems from the totality of man's activities. At the same time they must be operational and provide couplings between the state of the environment and the different human activities so that the necessary and correct actions can be taken to reach the EcoQOs. This is a formidable task but not impossible. It will require strong dedication and resolve to cooperate from environmental and resource managers and politicians. It also requires a stronger and more focused system-approach to the scientific investigations and monitoring of the marine ecosystems.

It should be emphasised that we are still in an early phase of developing an EcoQO- approach. It should also be noted that the framework suggested is general and flexible to accomodate a number of approaches based on information ranging from simple and qualitative to complex and quantitative.

With regard to pollution, it should be emphasised that an EcoQO-approach should not suspend or hamper the source-oriented approach that involves combating pollution at source, but that the two approaches should act as complements. In this respect it is noted that there are as yet no internationally accepted tests or procedures available that would allow to specify the amount of anthropogenic discharges/emissions that would not have harmful effects on the marine environment. A further difficulty is that there is hardly any knowledge about long-term and synergistic effects.

4.2 The concepts of EcoQ and EcoQOs

The following definition of Ecological quality (EcoQ) taken from the proposed EU Directive on the Ecological Quality of Water, has been used as the basis for discussions and development of the EcoQO approach by NSTF and ASMO:

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

The logic has been that you cannot set objectives to something you cannot define and describe. Based on the above definition of EcoQ, Ecological Quality Objective (EcoQO) has been defined as:

> *EcoQO is the desired level of EcoQ relative to the reference level.*

The EcoQ reference level has been defined as the EcoQ where the anthropogenic influence on the ecological system is minimal.

The concept of EcoQ can be taken as an integral expression of the state of an ecological system or ecosystem. This expression is seen as a vector of information for different parameters or values for different variables. This set of variables is called the Core of information for expressing EcoQ.

As an integral or composite expression, EcoQ can be taken as being synonymous with the term Ecosystem health.

The set of variables to be included in expressions of EcoQ can be simple or complex depending on the specific system under consideration and the perceived or documented threats by human activities for that system. In a simple form EcoQ can be expressed as a set of one or more indices or indicators. The simplest version would be that corresponding to one indicator, e.g. a marine analog to the «canary in cage» approach. In several European countries as well as in the USA and Canada, there is now work on establishing a set of indicators for the state or health of marine environments or ecosystems.

EcoQ can be expressed in a more complex form as a set of values for a large number of selected variables. The Dutch AMOEBA can be seen as a version of such an approach.

4.3 General framework and methodology for setting EcoQOs

Figs 2.1 and 2.3 taken from the report from the Ulvik workshop, can be used to illustrate the framework and methodology for setting EcoQOs.

The first step is to select variables to be used in the core of information for expressing EcoQ. The criteria for selecting these variables were eleborated at the Geilo workshop. The variables should reflect basic ecosystem properties on the one hand and human use or impacts on the other. This provides a coupling between the EcoQ and the issues in JAMP (Fig. 2.1).

The choice of variables for which information is needed must address each of the main issues of JAMP which is relevant for a given ecosystem. For example with regard to eutrophication, information may be needed on input of nutrients, nutrient concentrations, water masses and their fluxes, nutrient budgets, production, biomass and species composition of phytoplankton, biomass and structure of benthic communities, and oxygen concentration and consumption in deep water and sediments. For contaminants one would like to have information on inputs from point and diffuse sources, contaminant concentrations as appropriate in water, sediments and biota, fluxes of contaminants associated with sediments and organic material, transport and concentration of contaminants in the food chains, and biological effects of contaminants on different organisms. For the issue of fisheries there may be need for information on biomass removal (catches) of different species, fishing mortality on target and non-targeted species, fishing activity such as areal extent and depth of penetration in sediments by trawling, and trophic relationships between targeted and non-targeted fish species and other components of the ecosystem.

The second step in the methodology would be to assemble the required quantitative or qualitative information on the chosen variables. Some of this information would be the data collected and reported in the framework of JAMP. There would however be need for additional data collected e.g. for resource management or research purposes.

The third step is to express the information collected and assembled. This can be done in different ways. Usually the information has to be condensed and expressed graphically or otherwise to more easily conway the contained information to managers, politicians and the public. Ways to condense and express the information include an indeces approach, multivariate techniques to project the information in multivariate parameter space, or to go forward with the information for each variable separately such as in the AMOEBA approach. The data treatment usually encompass a standardization step where each variable is standardized to equal weight in ensuing analyses.

The fourth step is to determine the EcoQ reference level. This can in principle be done by alternative approaches and either for each single variable or for composite or derived variables such as indeces. The reference level(s) should preferably reflect the conditions of the ecosystem in the pristine stage or one where the anthropogenic influence is minimal. One approach would be to use information from earlier periods when the activities and impacts by man were considerably less. However, there is generally a scarcity of quantitative data as one goes back to the first part of the present century while the level of anthropogenic influence already at that time could be significant. A second approach could be to use information from comparable habitats or ecosystems where the anthropogenic influence is known to be small. A third approach is to use quantitative information on cause-effect and dose-response relationships to extrapolate back to the zero anthropogenic influence situations. Such an approach is possible for nutrient input in some cases where hydrodynamically based models have been shown to explain much of the variability in nutrient budgets.

The fifth step is to establish objectives associated with the expression of EcoQ. This step involves both a political dimension and a scientific dimension. The scientific dimension consists of the expression of the present EcoQ and reference level of EcoQ, and guidance as to what level of improvement in the case of deteriorated environments would be possible at which costs. It is a political responsibility to establish environmental goals. The political dimension is therefore to decide on the desired level of EcoQ based on realistic assessments of possibilities and costs. The established EcoQOs will in the end be a reflection of the political ambitions and aims.

The step of establishing EcoQOs contains a scientific assessment as one of the elements. Once EcoQOs have been established, assessment will be a periodic activity when checking whether the trend of develop-

ment is in the right direction and EcoQOs are reached. The scientific assessment of EcoQ will to a large extent be a condensed or summary version of the assessment part of JAMP. The data collection in JAMP is governed by the identified issues. The environmental assessment is a comprehensive statement on the state of the marine environment or ecosystems. The expression of EcoQ assembles this information in order to allow an assessment of each separate issue as well as the combined impact by all human activities addressed in the different issues.

The assessment criteria for each issue such as eutrophication, contaminants and effects of fisheries need to be used also as the set of criteria when assessing the EcoQ. There may be a need to harmonize the assessment criteria developed for each issue in isolation when applied in the holistic context of EcoQ.

The integral nature of EcoQ and EcoQOs with cause-effect linkages contained in the information provides a mechanism for feedback to management actions. The more precise the cause-effect linkages are known and supported by data, the more precise and cost-effective can the remedial actions be. It must be emphasized that there is at present a general scarcity of the necessary cause - effect information. To establish such information has proved difficult and would require an increased and better coordinated and targeted effort. If this is not achieved there is a danger that the remedial or preventive actions nevertheless taken to safeguard the marine environment and its living resources may not be the most effective ones.