REVIEW AND GAP ANALYSIS OF ENVIRONMENTAL INDICATORS FOR FISHERIES AND AQUACULTURE

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EXECUTIVE SUMMARY

Fish stocks around the world have been declining for years. Currently, around 75 per cent of global fish stocks offer no possibility for increased catches. Many of these are overfished and yields are already below optimal levels. In the EU, as many as 50 per cent of the commercial fish stocks are overfished and the situation is particularly serious for many of the demersal stocks, such as cod, hake and whiting. Fishing also affects the wider marine ecosystem, including habitats and non-target species.

There has been an almost universal failure to prevent this decline in stocks and the associated damage done to marine ecosystems. In the EU, fishing and aquaculture activities are managed under the framework of the Common Fisheries Policy (CFP). Despite its 30-year existence, the CFP has so far failed to achieve sustainability in the sector.

Against this background, there is increasing pressure to understand and manage the relationship between fisheries and aquaculture and ecosystems. In the EU, this is also necessary to fulfil policy commitments on sustainable development and environmental integration. To make management more effective, fisheries managers and others need to be able to monitor and evaluate the results of different measures. Well-designed indicators can help assess progress towards policy objectives, as well as provide a basis for communicating with stakeholders. Ultimately, the use of indicators should promote action to improve management systems in pursuit of policy goals and objectives.

The aim of this report was to conduct a review of current work in Europe and internationally on indicators for integration of environmental considerations into fisheries policy. The report outlines the fisheries policy context within which indicators are being considered, followed by a review of the work done by different organisations and countries, and ends with an evaluation and some recommendations for next steps.

A substantial amount of work on indicators has been carried out, especially in Northern Europe, and the European Commission is committed to developing indicators to measure progress on environmental protection requirements under the CFP. Some indicators for target stocks have traditionally been used in fisheries management. In general, however, very few indicators are actually in use and even fewer are used to evaluate management actions. Key areas that lag behind in the development of indicators are: socio-economic driving forces leading to environmental degradation, external relations, fisheries in the Mediterranean and aquaculture.

It seems as if the main challenge is to find suitable indicators corresponding to different elements in the management framework. Any process to develop indicators therefore has to start with a clear articulation of the objectives, within a systematic management framework. The process must also be underpinned by an effective communication strategy involving all stakeholders.

There are a number of other constraints affecting the development of useful indicators. An obvious problem is the lack of a coordinated approach across countries,

sectors and fisheries. Another is data availability – indicators require a harmonisation of reporting at various levels, and in many cases new data will have to be collected. In general, more data are available on the biological and environmental dimensions of sustainable development than on the socio-economic and institutional dimensions. Sometimes progress is halted by such fundamental issues as terminology.

A formal process to develop, test and implement indicators for more effective management of fisheries and aquaculture in the EU still needs to be established. This process should ideally involve all the main players already doing work on indicators, including stakeholders from the fishing industry and the environmental sector. We suggest that the guidelines set by the FAO be followed to develop a so-called Sustainable Development Reference System (SDRS), using the new CFP objectives as a starting point. A framework such as the Pressure-State-Response framework can be used to ensure a balanced coverage of different elements, but this should not be allowed to drive the process.

The chosen set of indicators should not be restricted to management issues for which data are already available. Once a possible set of suitable indicators has been identified, new data needs will have to be considered together with any necessary changes to the Council Regulation establishing a framework for data collection (EC Regulation 1543/2000). In the end, indicators need to be simple to use and cost-effective, and this must be taken into account in the selection process. Once the indicators have been selected, reference points or values will need to be agreed in consultation with stakeholders and scientists, followed by tests and any necessary modifications. Finally, unless steps are taken to ensure that the indicators are used by decision-makers and the managers to improve the management system, the entire process, including the associated monitoring and reporting, will be a waste of time and money.

1. INTRODUCTION

Fish have been caught and farmed for millennia and remain an important source of nutrition and income for millions of people around the world, particularly people in developing countries. Although statistics suggest that global catches increased through the 1990s, it is argued that world fisheries landings have in fact been declining slowly since the late 1980s, by around 0.7 million tonnes per year (Pauly *et al*, 2002). There has been an almost universal failure to prevent this decline, with around 75 per cent of the global fish stocks offering no possibility for increased catches. Many of these stocks are overfished and yields are already below optimal levels. Worst affected stocks come from the Atlantic, the Central East and North-East Pacific, the Black Sea and the Mediterranean (FAO, 2000).

Against this background, and with heightened public interest in the marine environment, there is increasing pressure to understand and manage the relationship between fishing and aquaculture, and ecosystems. At EU level, there is indeed a duty to integrate environmental considerations within EU fisheries policy, as a way of achieving sustainable development. Sustainable development here implies maintaining fisheries resources and the supporting marine ecosystem for the benefit of present and future generations.

With sustainable development as their ultimate objective, EU fisheries managers and others need to be able to monitor and evaluate the results of different management measures. Well-designed indicators are a tool that can help policy makers assess progress towards agreed policy objectives, as well as providing a basis for communicating with other stakeholders and the general public. Ultimately, the use of indicators should promote action to improve management systems in pursuit of policy goals and objectives.

There is currently no agreement on suitable indicators to evaluate the sustainable development of the fisheries sector, but researchers in organisations throughout the EU and globally are working to ascertain the state of the marine environment in their part of the world. At a broader scale, organisations such as the International Council for the Exploration of the Seas (ICES) and the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic have made significant progress in addressing questions about the impacts of fisheries on marine ecosystems. However, assessment of the environmental performance of the fisheries sector has mainly been limited to the health of target fish stocks, in order to guide the setting of annual limits on total allowable catches (TACs).

The EU institutions have on several occasions committed themselves to developing indicators in support of environmental integration.

In the 2001 Green Paper on the Future of the CFP, the Commission recommended that a system be developed to monitor and assess the progress of the CFP towards sustainable development and in pursuing policy objectives. Environmental, social and economic indicators and related reference points are to be developed by drawing on the work of the European Environment Agency and the FAO. The Commission's 2001 Biodiversity Action Plan for Fisheries and Aquaculture and a 2001 communication outlining the elements of a strategy for the integration of

environmental protection requirements into the CFP also included commitments to developing environmental indicators. The most recent example is the Commission's 2002 action plan on environmental integration (COM(2002)186), according to which the Commission hopes that an initial set of indicators will be used as the basis for a 2005 report on the environmental performance of the CFP.

IEEP was contracted to conduct a review and gap analysis of environmental indicators under development or already in use by fisheries managers and policy-makers. The study was commissioned by English Nature, on behalf of co-sponsor Scottish Natural Heritage and a network of European environmental advisors on fisheries and marine nature conservation and marine environmental protection. The review and gap analysis is to constitute phase one of a three-phase process being undertaken by the network to support the work on indicators of the European institutions.

The project involved intensive research over a two-month period by a team led by IEEP. It included a comprehensive literature review involving database and Internet searches, as well as library searches at FAO in Rome, IEEP and through the Cambridge University Library. A simple questionnaire was sent to a range of research organisations, individuals, ministries and agencies in Member States and the European institutions. It was also forwarded to members of the project steering group, co-ordinated by English Nature. Telephone and face-to-face interviews supplemented the information gathered by other means.

The resulting report outlines the fisheries policy context within which indicators are being considered, followed by a review of selected indicators and indicator frameworks. Section 4 presents findings on the development and use of environmental indicators related to fisheries and aquaculture, both internationally and within Europe. A brief description of the work of a number of major organisations on fisheries/environmental indicators is given in Section 4. Finally, a gap analysis is presented, highlighting areas where more attention is needed, followed by conclusions and recommendations in Section 6. A reference section lists all the literature cited in the body of the report.

The initial report, concluded in the late Spring of 2002, has subsequently been updated to reflect further developments, but we do not claim to cover all work on indicators within the subject area.

2. MANAGING THE EU FISHERIES SECTOR

There have been diverse attempts to manage and control fishing and aquaculture activities around the world, for example, by allocating fishing areas and the use of resources to different users, and limiting specific fishing and farming practices. For fishing vessels registered in the EU, and to a lesser extent EU aquaculture installations, the management framework is provided by the Common Fisheries Policy (CFP). Despite its 30-year existence, however, the CFP has so far failed to manage its sector in the interests of the industry or the environment.

This section briefly outlines the main environmental issues associated with today's fisheries sector, followed by an overview of key elements of the CFP, and the need for a new CFP post-2002. A table summarising the main impacts and current policies is provided at the end.

2.1 The State of Fisheries and the Marine Environment

Overexploitation of the EU's major commercial stocks is a growing problem. As many as 50 per cent of the EU's commercial fish stocks are too heavily exploited and/or include a small proportion of mature fish. The situation is particularly serious for demersal fish stocks such as cod, hake and whiting. According to EU scientists, if current trends continue, many stocks are at risk of collapsing. Meanwhile, employment in the sector continues to decline.

The situation can be attributed to a range of failures, from weaknesses in scientific advice and failure to follow this advice, to poor implementation, monitoring and enforcement of rules. The present regime has so far largely failed to address many of the broader factors that influence the behaviour of operators, particularly over-investment in the sector.

The depletion of commercial fish stocks is not the only negative environmental impact linked to the fisheries sector, although data on other impacts are less readily available. Fishing is associated with changes to the health and functioning of marine ecosystems, including the deterioration of habitats and species. In the Mediterranean, for example, fishing is concentrated in coastal areas where biodiversity is greatest. Its impacts are evident not only in the local disappearance of species but also in the reduction of coastal and marine habitats (EEA, 1998).

The interaction between the environment and aquaculture varies considerably depending on the production method. For example, extensive oyster farming has been practised since the 17th century and involves collecting small wild oysters on solid supports in the intertidal zone, later culturing them either on the bottom, in bags on trestles or on line-floats (CEC, 1995). This system is relatively environmentally benign. At the other extreme, intensive cage farming of marine or freshwater fish can depend on a significant amount of civil engineering work, the use of other natural resources such as water and feed fish, and the extensive use of chemical inputs to maintain animal health (CEC, 1995). Some effects are localised and reversible once the activity stops, others may last a long time or be irreversible.

The impacts of the EU fisheries sector do not confine themselves to EU waters, but extend to areas of the high seas and waters of third countries where EU fishing vessels are also active. In addition, the 8 million tonnes of fish products imported annually by the EU are associated with the environmental impacts of production in their countries of origin, and of their transport.

2.2 The Common Fisheries Policy Context

The CFP provides the overarching framework for the management of the fisheries sector in the EU. The basic objectives of the CFP are set out in the Treaty of Rome, under the Agriculture Title, which calls for increased agricultural productivity, a fair standard of living for the agricultural community, and availability of supplies at reasonable prices. Further objectives are set out in the new so-called 'basic' Regulation 2371/2002 agreed in December 2002, which is to 'protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine ecosystems' (Article 2). To achieve this, the precautionary principle should be applied together with a progressive implementation of an ecosystem-based approach to fisheries management.

The broad objectives of the CFP are delivered through a series of detailed technical regulations and standards applied in areas of common interest, for example, regulating catches of certain fish stocks. In some areas, however, such as the management of inshore fisheries and aquaculture, management is largely the responsibility of the Member States. The main components of the CFP are as follows.

- *Conservation management* – using scientific advice, generated in particular by ICES, a series of Total Allowable Catches is proposed and adopted every year which in effect sets a limit on the amount of fish that can be landed. These TACs are allocated nationally in the form of quotas, and are predominantly applied to fisheries in the Atlantic, North and Baltic seas. TACs and quotas are complemented by technical conservation measures defining more precise rules on fishing activities, for example, specifying particular gear restrictions or closed areas. As part of the reform, multi-annual recovery plans for stocks outside safe biological limits and management plans for other stocks, if necessary, will be agreed.

- *Market policy* – once landed or harvested, fish and fish products fall under common marketing rules. These aim at stabilising markets, guaranteeing supplies of fish products and ensuring reasonable prices for consumers and reasonable incomes for workers in the sector.

- *Structural policy* – the development of the fisheries sector is supported by the provision of subsidies, including part-funding for vessel building and decommissioning projects, aquaculture investment, investment in marketing and processing facilities, and infrastructure such as harbours and landing facilities. The structure of the fishing fleet has also been subject to Multi-Annual Guidance Programmes (MAGPs), which set limits on the capacity and/or effort of the national fleets. From 1 January 2004, responsibility for fleet management lies with the Member States and is based on reference levels for capacity taken from the last

MAGP. Aid for vessel building, export of capacity and joint ventures will be phased out by the end of 2004, and a new emergency measure to encourage scrapping of vessels has been put into place.

- *External policy* – this governs the activities of EU fishing vessels active on the high seas or in the waters of third countries, and international trade in fish products.

2.3 A New Common Fisheries Policy

As the responsible institutions struggle to cope with the worsening state of fisheries and the marine environment, the approach to fisheries management continues to evolve. Science-based limits on fish catches and associated quotas are likely to remain of paramount importance, but there is growing pressure to adopt a precautionary and ecosystem-based approach to fisheries management, as well as greater emphasis on changing the behaviour of individuals within the sector. This shift in emphasis is reflected in the developing global fisheries management framework, most notably in the 1995 UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks, which entered into force in December 2001, and the 1995 FAO Code of Conduct on Responsible Fisheries. It is also reflected in the new 'basic' Regulation of the CFP and the ongoing discussions on the implementation of CFP reform.

In March 2001, the Commission set out its views on possible objectives for the future of the CFP in its Green Paper (COM(2001)135).

- Establishing sustainable fisheries that will ensure the maintenance of quality and the diversity of ecosystems. There is a need to strengthen and improve conservation policy to prevent further degradation of the marine environment and its resources.
- Contributing, through fisheries management, actions to achieve the objectives set out in Article 174 of the EC Treaty. This requires that the overall impact of other human activities affecting the marine environment should be reduced, as a complement to fisheries policy measures.
- Integrating health requirements into the CFP to protect public and animal health and safety, while continuing to supply products at a reasonable price to the consumer.
- Shaping fleet capacity according to the availability and sustainability of resources.
- Promoting improved governance, enhancing stakeholders' participation in the management and decision-making process, at regional and local levels.
- Ensuring effective enforcement of CFP rules.
- Securing a self-sufficient and competitive fisheries and aquaculture sector, able to compete in a globalised economy.
- Addressing problems of structural adjustment resulting from a commitment to sustainable fisheries.
- Promoting sustainable fisheries in international waters, through the creation of partnerships with developing countries.
- Improving the quality and quantity of relevant scientific data to support decision-makers, and promoting multidisciplinary scientific research.

The Commission has also identified additional objectives in order to integrate biodiversity concerns into fisheries policy, as a means of implementing international commitments on biodiversity conservation (COM(2001)162).

- Promoting the conservation and the sustainable use of fish stocks and feeding grounds through the control of exploitation rates as well as through the establishment of technical conservation measures (reduction of over-capacity

and fleets' fishing effort; integration of multi-species considerations into management plans; definition of precautionary limits and reference points for fishing mortality rate and stock biomass; establishment of tailored precautionary levels for stocks' exploitation and associated management actions).

- Reducing the impact of fishing and other human activities on non-target species and marine coastal ecosystems, to promote the sustainable use of marine resources and preservation of coastal biodiversity, eg improve size and species selectivity by introducing selectivity devices or minimum mesh size; amended minimum landing sizes for fish and shellfish; temporal and spatial closure of fishing areas to enhance the survival of juveniles and to maintain genetic diversity).

- Preventing aquaculture practices from affecting sensitive areas that may be important for habitat conservation. Pollution and genetic contamination from fish farms should be avoided.

Today, we know that some of these objectives were included in the new 'basic' Regulation, and that substantial improvements have been made to the structural aid programme for the sector, hopefully promoting a more sustainable development of the sector. Further improvements are on the way, with proposals on shark protection, discards and partnership agreements under discussion, and other proposals underway.

3. INDICATORS AND INDICATOR FRAMEWORKS

The following summary provides a context for the subsequent review of indicator work that is being conducted within the EU and internationally. The challenge is to find suitable indicators to reflect the different elements of fisheries management, from biological standards through to socio-economic incentives; indicators that will inform decision makers and the public in such a way that future fisheries policies and consumption choices properly reflect environmental issues.

3.1 What are Indicators?

According to the OECD (1998), an indicator is a parameter, or a value derived from parameters, which points to, provides information about, or describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with its value. Indicators are pointers that can be used to reveal or monitor conditions and trends in the fisheries sector and the marine environment (Garcia and Staples, 2000).

Or, according to Department for Environment, Food and Rural Affairs (Defra) in the UK, indicators are quantified information which help to explain how things are changing over time. They have three basic functions: simplification, quantification and communication. Indicators generally simplify in order to make complex phenomena quantifiable so that information can be communicated.

The single most important function of an indicator is to communicate information that is relevant to a particular societal goal or objective. Indicators should be easily understood by those who need to make decisions based upon them, and be analytically sound and practical to use, through data collection and analysis.

Indicators can be based on either processes or outputs. Process-based indicators aim to assess the organisational efficiency of processes that achieve results, whereas outcome-based indicators measure results or the degree to which an environment goal has been met. In the context of environmental indicators, they need to communicate the complex inter-relationships between natural species and abiotic [physical, chemical] components of the environment (Smeets and Weterings, 1999). They should reflect the state of the system with respect to how well goals and objectives are being pursued or achieved, providing a transparent link between policy objectives and management action (Garcia *et al*, 2000).

According to the European Environment Agency (EEA) (Smeets and Weterings, 1999), indicators are used for three major purposes:

1. to supply information on environmental problems in order to enable policy-makers to value their seriousness;
2. to support policy development and priority setting by identifying key factors that generate pressure on the environment;
3. and to monitor the effects of policy.

Indicators can help to harmonise reporting at various levels from local to regional, national and international level, particularly where countries are required under conventions and agreements to report on progress towards sustainable development (Garcia *et al*, 2000).

The United Nations Commission on Sustainable Development (UNCSD, 2001) has developed indicators for sustainable development in order to:

1. translate physical and social science knowledge into manageable units of information that can facilitate the decision-making process;
2. help to calibrate and measure progress towards sustainable development goals;
3. provide early warning to prevent damage; and
4. communicate ideas, thoughts and values.

Table 1. Some examples of different types of indicators

Type of indicator	**Function**
Process-based indicator	Aim to assess the organisational efficiency of processes that achieve results.
Outcome-based indicator	Measure results or the degree to which an environment goal has been met.
Headline indicator	Strategic; providing feedback on progress against overarching policy objectives, eg a measure of stock health or ecosystem diversity.
Operational indicators	Measure the more detailed components of headline indicators, eg stock mortality or recruitment, or number of species within a particular ecosystem.
EcoQ metrics[1]	Measure the pressure of a particular problem on a Ecological Quality to enable evaluation of progress towards the EcoQ Objective.
Driving force indicator	Measure human activities, processes and patterns that have an impact on sustainable development of a sector or issue.
Pressure indicator	Represents the pressure on the environment exerted by different driving forces.
State indicator	Refer to the 'state' of a particular environmental or socio-economic resource or feature, eg water quality, stock numbers.
Response-type indicator	Measure policy response to achieve objectives, eg number of boats decommissioned if capacity reduction is an objective supported by aid for decommissioning.

1. Term for indicator used by ICES and OSPAR/CONSSO in their work on Ecological Qualities and Objectives for these qualities.

There are different types of indicators, often corresponding to the level in a management system where an indicator works, or just due to the fact that different groups working on indicators have approached the subject in slightly different ways. Some examples are given in Table 1.

It is important to note that indicators are only one tool for evaluation; scientific and policy-related interpretation is usually required for them to acquire their full value. They often need to be supplemented by other qualitative and scientific information, particularly research to explain the causes of change as measured by indicators (OECD, 1998).

3.2 Indicators – Conceptual Frameworks for Systems Analysis

In order to clarify the inter-relationships between human beings and the environment, the OECD, the European Environment Agency (EEA) and Eurostat have adopted conceptual frameworks for the derivation of indicators. Perhaps the most comprehensive proposal for the analysis of fisheries systems and the development of guidelines for sustainable development and indicator frameworks has emerged through the work of the FAO (see Section 3.3).

The conceptual frameworks are essentially variations on a similar theme and provide a convenient way to organise indicators in relation to system components and ensure they correspond to different purposes within the system. Frameworks may represent the different dimensions of sustainable development (eg economic, social, environmental and institutional/governance), called a Sustainable Development Reference System or SDRS.

Alternatively, a framework can be devised in a way that better reflects the *pressures* of human activities, the *state* of human and natural systems and the *responses* of society to changes in those systems. Commonly used terms for this type of framework are Pressure-State-Response (PSR), Driving force-State-Response (DSR) or Driving force-Pressures-State-Impact-Response (DPSIR) (Garcia *et al*, 2000; Smeets and Wetering, 1999; EEA, 2000; FAO, 1999; Coffey and Baldock, 2000). EEA, Eurostat and European institutions tend to use the DPSIR framework, while OECD uses PSR and the UN Commission on Sustainable Development favours DSR.

The DSR framework is a modification of the Pressure-State-Response (PSR) framework for environmental indicators. In the DSR framework, the term ‘pressure’ has been replaced by that of ‘driving force’ in order to accommodate more accurately the addition of social, economic and institutional indicators. The term driving force allows the impact on sustainable development to be both positive and negative, as is often the case for social, economic and institutional indicators.

The DSR matrix incorporates these three types of indicators horizontally and the different dimensions of sustainable development vertically. *Driving force* indicators encompass human activities, processes and patterns that impact on sustainable development. *State* indicators refer to the ‘state’ of sustainable development and *response* indicators highlight policy options and other responses to changes in the state of sustainable development. In the DPSIR framework, social and economic developments or *driving forces* (D) exert *pressures* (P) on the environment resulting in changes to its *state* (S).

This leads to *impacts* (I) on environmental quality, which may elicit a societal or policy *response* (R).

There are critics of these frameworks. DPSIR and its variations, as linear cause-effect models, have limitations because they over-simplify reality and ignore many of the linkages between issues and feedbacks within the socio-ecological system. The relations between the elements of the framework such as driving forces and pressures may not always be simple; responses to one pressure can become a pressure on another part of the system. The demarcation between components is not always clear and debate on the usefulness of these models is ongoing (Garcia and Staples, 2000).

Further, Sainsbury and Sumaila (2001) suggest that indicators and reference points should explicitly relate to the high-level objectives of management. To manufacture indicators to fit into indicator categories (such as PSR) may not focus reporting activities on the whole of the management system, nor on overall fisheries management performance. From this perspective, fisheries management and the pursuit of sustainable development is an interactive system and thus the performance of the whole cannot be judged from the performance of one part alone. This requires an explicit recognition of the hierarchy that links high-level objectives to operational indicators, reference points and performance measures (see Box 1). The hierarchy fits more closely into an SDRS framework.

Box 1. Hierarchy for reporting and assessment of a whole management system
(Sainsbury and Sumaila, 2001)

Principle: a high level statement of 'how things should be'.
Conceptual objective: a high-level statement of what is to be attained.
Component: a major issue of relevance within a conceptual objective.
Operational objective: an objective that has a direct and practical interpretation, usually for a component.
Indicator: something that is measured, not necessarily numerically, and used to track an operational objective. An indicator that does not relate to an operational objective is not useful in this context.
Reference point: a 'benchmark' value of an indicator, usually in relation to the operational objective, such as desired targets, undesirable limits or triggers for specific management responses. A target reference point could serve as an operational objective.
Performance measure: a relationship between the indicator and the reference point that measures how well intended outcomes are being achieved.

Examples of this hierarchy for sustainable fisheries are given by Garcia (2000), Garcia and Staples (2000), FAO (1999), ICES (2001), and the Marine Stewardship Council (2001). A transparent and defensible approach for reporting against fishery sustainability objectives has been developed for some Australian fisheries, and the FAO and Canada are considering adaptations of this approach (Sainsbury and Sumaila, 2001).

Without a basis for comparison, changes in indicators (eg over time) cannot be meaningfully interpreted in relation to the objectives being pursued. For this, 'Reference values' are needed. Such reference values are often set in the form of targets, limits, milestones, standards, trends or benchmarks. In fisheries, the commonly used reference

values are conventionally called target reference points or limit reference points and mainly concern the target stocks. A broader set of reference points needs to be developed and agreed covering all the other key dimensions of sustainability such as those relating to fishing effort, capacity, bycatch, discards, biodiversity and habitats (Garcia *et al*, 2000).

3.3 How to Find Suitable Indicators

The FAO guidelines for developing indicators on sustainable development set out five sequential steps that need to be addressed in order to develop a meaningful set of indicators out of thousands of actual and potential indicators (FAO, 1999). These are:

1. specifying the scope of the Sustainable Development Reference System [or other indicator framework] (eg its purpose, which human activities to cover, the issues to be addressed and the boundaries of the system under consideration, ie fishery, area, region, ecosystem);
2. developing a framework to agree on components within the system;
3. specifying the criteria, objectives, potential indicators and reference values (targets, thresholds or standards);
4. choosing a set of indicators and reference values; and
5. specifying the method of aggregation and visualisation.

One of the biggest obstacles to establishing a set of practical and effective indicators is the issue of definition or terminology. Before the development of appropriate indicators can begin, the meaning of commonly used terms and jargon must be agreed. By using agreed terminology, misunderstandings and semantic arguments, which may prevent the adoption and use of appropriate indicators, will be avoided. The FAO guidelines provide a glossary of terms that was agreed through the expert consultation in 1999 (see 4.2.3). According to the FAO, the choice of indicators should be based on the following criteria:

- policy priorities and objectives;
- practicality/feasibility;
- data availability;
- cost-effectiveness;
- understandability;
- accuracy and precision;
- robustness to uncertainty;
- scientific validity;
- acceptability to users/stakeholders (consensus among parties);
- ability to communicate information;
- timeliness;
- formal (legal) foundation; and
- adequate documentation.

The OECD has also developed a set of criteria for selecting environmental indicators based upon three simple ideas: policy relevance and utility for users, analytical soundness, and measurability (OECD, 1998).

4. REVIEW OF INDICATORS UNDER DEVELOPMENT AND IN USE

This section describes the outcomes of the desktop review, responses to the emailed questionnaire, telephone conversations and some face-to-face interviews to identify environmental indicators either under development or in use by fisheries managers and policy-makers. It expands upon some of the major work being undertaken on the development and/or use of environmental indicators in marine capture fisheries and aquaculture, from a European context. A series of tables shows the indicators that emerged during the review, and a list of the key organisations and individuals who responded to our questions or have published substantial literature on the subject can be found in Annex 1.

4.1 Use of Indicators in Fisheries and Aquaculture Management

A number of European organisations have already been devoting time to the development of environmental indicators for fisheries, particularly wild capture fisheries. The development of environmental indicators for aquaculture policy appears less advanced, with the exception of quality/state indicators for the environmental impacts of specific aquaculture operations.

Despite this, few policy-makers or fisheries managers are using a broad range of indicators in a systematic way to inform their decision-making processes. The most progressive use by policy-makers of a comprehensive set of sustainable development indicators for fisheries and aquaculture (including the ecological dimension) appears to be in Australia. In addition, the USA conducts environmental assessments of TAC scenarios prior to setting annual catch levels, in which a broad range of environmental and economic indicators with associated reference point values is used.

In Europe it is the northern countries including Norway, northern EU Member States and to a certain extent the Baltic States that are most active in developing ideas for the application of an ecosystem-based approach to the management of human activities in the marine environment. This includes work by ICES, OSPAR, EEA and HELCOM (in association with IBSFC and the Baltic 21 Action Programme). The work conducted by ICES and OSPAR focuses on the North-East Atlantic, principally the North Sea. Meanwhile, work relating to the Mediterranean and the waters off southern EU Member States does not appear to be getting the same level of attention.

4.2 Environmental Indicators for Marine Capture Fisheries

4.2.1 OSPAR, the North Sea Conference and CONSSO

Work related to indicator development by a range of organisations from northern Member States, ICES and OSPAR has been ongoing since the early 1990s. In particular, Ecological Qualities (EcoQs) and Ecological Quality Objectives (EcoQOs) have been developed by OSPAR to address human influences on ecosystem properties. The basic ecosystem properties included in the conceptual framework are:

- diversity;

- stability;
- resilience;
- productivity; and
- trophic structure.

OSPAR's Biodiversity Committee (BDC) has made further progress on the work conducted by ICES and researchers from national organisations. Through OSPAR and the North Sea Conference processes, indicators (called EcoQ metrics) and reference point values have been discussed for a number of issues.

Stakeholders, policy-makers and scientists met in 1999 and decided that EcoQOs should be developed for ten issues related to species, community and ecosystem levels, and the structural (diversity) and functional (process) aspects of ecosystems (ICES, 2001a). Under the guidance of OSPAR (BDC and the Eutrophication Committee), Norway, the Netherlands and ICES explored indicators for the following:

1. Commercial fish species
2. Threatened or declining species
3. Sea mammals
4. Seabirds
5. Fish communities
6. Benthic communities
7. Plankton communities
8. Habitats
9. Nutrient budgets and production
10. Oxygen consumption

In 2001, BDC drafted a background document on the progress made on EcoQOs so far. This formed the basis of the OSPAR report to the 5th North Sea Conference and was forwarded for consideration by the Committee of North Sea Senior Officials (CONSSO) in January 2002.

At the 5th North Sea Conference in Bergen, the Ministers agreed on a set of issues and related elements for which EcoQOs will be developed (Table 2a). They also agreed that EcoQOs for each of the elements listed in Table 2b will be applied as a pilot project for the North Sea. For the remaining elements (see Table 2a), objectives will be developed by 2004 and applied within the framework of OSPAR, in coordination with the work on marine indicators by the EEA. OSPAR 2005 is invited to review progress, in collaboration with ICES and other relevant bodies.

The indicators listed in Table 2a are in various stages of development, including those already in use (such as precautionary reference points for spawning stock biomass of commercial fish species), those adopted at the North Sea Ministerial Conference in March 2002 (changes in the average weight and average maximum length of fish communities), those likely to be adopted in the near future (breeding productivity of kittiwakes) and those needing more work or a longer term approach (eg seabird population trends).

Currently, there is an obvious gap between the OSPAR/ICES work on Ecological Qualities (EcoQ) and Ecological Quality Objectives (EcoQO) and the development of policy and management measures under the CFP (ICES, 2001a). To some degree, the OSPAR process involves a different group of stakeholders and government officials (ie primarily nature conservation officials and advisors).

Table 2 a. Ecological Quality Elements for the ten issues selected by OSPAR

Issue	Ecological quality element
1. Commercial fish species	(a) Spawning stock biomass of commercial fish species
2. Threatened and declining species	(b) Presence and extent of threatened and declining species in the North Sea
3. Sea mammals	(c) Seal population trends in the North Sea (d) Utilization of seal breeding sites in the North Sea (e) Bycatch of harbour porpoises
4. Seabirds	(f) Proportion of oiled Common Guillemots among those found dead or dying on beaches (g) Mercury concentrations in seabird eggs and feathers (h) Organochlorine concentrations in seabird eggs (i) Plastic particles in stomachs of seabirds (j) Local sand-eel availability to black-legged Kittiwakes (k) Seabird populations trends as an index of seabird community health
5. Fish communities	(l) Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community
6. Benthic communities	(m) Changes/kills in zoobenthos in relation to eutrophication (n) Imposex in dog whelk (*Nucella lapillus*) (o) Density of sensitive (eg fragile) species (p) Density of opportunistic species
7. Plankton communities	(q) Phytoplankton chlorophyll *a* (r) Phytoplankton indicator species for eutrophication
8. Habitats	(s) Restore and/or maintain habitat quality
9. Nutrient budgets and production	(t) Winter nutrient (DIN and DIP) concentrations
10.Oxygen consumption	(u) Oxygen

Table 2 b. Elements and objectives selected for the North Sea pilot project

Ecological quality element	Ecological quality objective
(a) Spawning stock biomass of commercial fish species	• Above precautionary reference points[1] for commercial fish species where these have been agreed by the competent authority for fisheries management
(c) Seal population trends in the North Sea	• No decline in population size or pup production of ≥ 10% over a period of up to 10 years
(e) By-catch of harbour porpoises	• Annual bycatch levels should be reduced to levels below 1.7% of the best population estimate
(f) Proportion of oiled Common Guillemots among those found dead or dying on beaches	• The proportion of such birds should be 10% or less of the total found dead or dying, in all areas of the North Sea
(m) Changes/kills in zoobenthos in relation to eutrophication[2]	• There should be no kills in benthic animal species as a result of oxygen deficiency and/ or toxic phytoplankton species
(n) Imposex in dog whelks (*Nucella lapillus*)	• A low (< 2) level of imposex in female dog whelks, as measured by the *Vas Deferens* Sequence Index
(q) Phytoplankton chlorophyll *a*[2]	• Maximum and mean chlorophyll *a* concentrations during the growing season should remain below elevated levels, defined as concentrations > 50% above the spatial (offshore) and/or historical background concentration
(r) Phytoplankton indicator species for eutrophication[2]	• Region/area - specific phytoplankton eutrophication indicator species should remain below respective nuisanceand/or toxic elevated levels (and increased duration)
(t) Winter nutrient concentrations (dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP)[2]	• Winter DIN and/or DIP should remain below elevated levels, defined as concentrations > 50% above salinity related and/or region-specific natural background concentrations
(u) Oxygen[2]	• Oxygen concentration, decreased as an indirect effect of nutrient enrichment, should remain above region-specific oxygen deficiency levels, ranging from 4–6 mg oxygen per liter

1 In this context, 'reference points' are those for the spawning stock biomass, also taking into account fishing mortality, used in advice given by ICES in relation to fisheries management.
2 The ecological quality objectives for elements (m), (q), (r), (t) and (u) are an integrated set and cannot be considered in isolation. ICES will give further advice during the implementation phase.

Box 2. Definitions of terms used by OSPAR and the North Sea Conference

Ecological Quality (EcoQ) is defined as *'An overall expression of the structure and function of the marine ecosystem taking into account the biological community and natural physiographic, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities.'*

Ecological Quality Elements are *the individual aspects of an overall Ecological Quality*.

An **Ecological Quality Objective (EcoQO)** is the desired level of an ecological quality (EcoQ), ie the target. Such a level may be set in relation to a reference level.

4.2.2 International Council for the Exploration of the Sea (ICES)

In 2001, the ICES established an Advisory Committee on Ecosystems (ACE). The Working Group on Ecosystem Effects of Fishing Activities (WGECO) (established in 1990) reports to ACE. ACE and WGECO have been responding to requests from OSPAR and the North Sea Conference processes (including the Committee of North Sea Senior Officials – CONSSO) regarding the development of the scientific components needed to advise them in their work on an ecosystem approach to fisheries management and better integration of environmental concerns into fisheries management (ICES, 2001a), specifically on Ecological Qualities (EcoQs) and Ecological Quality Objectives (EcoQOs). In 2001, WGECO graded possible metrics for properties covering key ecological qualities.

This work took on a greater importance and urgency after the adoption of the Bergen Ministerial Declaration on 21 March 2002. The Ministers noted that ICES should collaborate with OSPAR to review progress on the pilot project in the North Sea testing the agreed EcoQOs and Ecological Quality elements (see Table 2b), but gave no details for roles and responsibilities. ICES, through the expertise of its Working Groups and advisory process, is likely to help coordinating the monitoring required for many of the EcoQOs and/or evaluating the results of this monitoring, and is already providing guidance to the relevant scientific information needed for the medium and long-term objectives (see Table 2a).

This has led WGECO to scrutinise the proposed EcoQOs and especially the ones referred to as 'in an advanced stage of development'. WGECO, ICES and the larger scientific community will continue to monitor progress on the OSPAR/CONSSO pilot projects. In their report from 2002 (ICES, 2002), WGECO states that this is important for two reasons: 'as a test of the effectiveness of the EcoQ and EcoQO framework as a measurement and evaluation tool' and 'as a test of the commitments of governments and agencies to use the EcoQs as a basis for management action'.

The ICES Working Group on Fishery Systems is developing criteria for performance evaluation of fisheries management systems. This could be important in identifying 'response' type indicators. The group is particularly looking at intensive and extensive

strategies for comparing fisheries management regimes, including decision-making processes, objectives and goals, legislative basis and instruments for management, and behavioural adaptation of fishers to changes in regulations (ICES, 2001b).

4.2.3 FAO Guidelines on Indicators for Sustainable Fisheries

In 1999, the FAO and Australia jointly conducted an expert consultation on sustainability indicators for marine capture fisheries. The result was a set of guidelines for developing and implementing such indicators (FAO, 1999). Having established an agreed set of definitions with particular reference to sustainable development, the guidelines set out five sequential steps that need to be addressed in order to develop a meaningful set of indicators out of thousands of actual and potential indicators (see Section 3.3). The FAO guidelines also provide a glossary of terms that was agreed through the expert consultation in 1999 and a number of criteria for the choice of suitable indicators (see Section 3.2).

The FAO also participates in the UN-formed Commission on Sustainable Development (CSD), which is developing indicators of sustainable development using the PSR framework. The Commission is looking at all four dimensions of sustainable development: environmental, social, economic and institutional/governance and a few of the indicators relate to fisheries and the wider marine environment. Other areas of involvement include the development of indicators to assess the performance of Regional Fishery Bodies (RFB) and a pilot study on the construction of socio-economic indicators for the Mediterranean in cooperation with the General Fisheries Commission for the Mediterranean (GFCM).

4.2.4 OECD's Core Set of Environmental Indicators for Fisheries and Biodiversity

In its publication on environmental indicators, *Towards Sustainable Development*, the OECD lists a set of core indicators for wild capture fisheries as well as fish, bird and mammal species in an overarching set of indicators for biodiversity (see Table 3). It is not clear from the report whether the biodiversity indicators relate only to land-based species and land use, or whether the fish, bird and mammal species also include marine species (OECD, 1998).

Table 3. Environmental indicators for fisheries and biodiversity (OECD, 1998)

Pressure	**State**	**Response**
Wild capture fisheries		
Fish consumption Exports of fish and fish products Intensity of fish catches Intensity of use of fish resources	Size of spawning stocks	Regulation of stocks (eg quotas)
Biodiversity		
Habitat alterations	Threatened species (fish,	Protected areas (by

[probably a land-use indicator]	birds, mammals) Area of key ecosystems	management category and by ecosystem type) Protected species

Ongoing work by the OECD's Fisheries Division is focussing specifically on marine capture fisheries using the PSR framework and assessing primarily the economic aspects of the fisheries sector. Issues to be addressed include the volume and value of catch, fleet characteristics and government financial transfers. The end users of this work should be OECD member countries, but the results are likely to be of interest to non-member countries as well.

4.2.5 European Commission

Single species and target stock indicators for the ICES regions have been developed by ICES and are used by the European Commission in fisheries management under the CFP. In recent years, they have been refined into stock specific reference points based upon a 'precautionary approach', but these still relate principally to spawning stock biomass and fishing mortality rates.

Furthermore, the European Commission has suggested the development and use of indicators in fisheries management as a way to monitor progress in the integration of environmental protection requirements into the CFP (COM(2001)143). Its communication contains an outline of possible performance indicators for seven broad categories, covering ecosystem (habitats), ecosystem (trophic relationships), fishing industry, aquaculture, consumers and public opinion, science, and decision-making. In what is referred to as a 'two-dimensional array', possible indicators under the DPSIR Framework are put forward for each category. The Commission also suggests that a further geographical dimension should be added to the framework structure because 'for example, an indicator of impact on consumers in northern Europe may not function as well for a Mediterranean country'.

Some 88 possible indicators are listed in the matrix, but there is no editorial comment upon their appropriateness, practicality or data requirements. It would appear that the indicators have been tailored to respond or fit into the DPSIR categories rather than having a direct relationship to policy objectives. Having noted that, some of the indicators are relevant for reporting against policy objectives. A copy of the matrix is presented in Annex 3.

The Commission cooperates with the EEA, ICES, the EC Joint Research Centre (JRC) and Eurostat, as well as national research agencies, in order to explore a working method for developing and implementing appropriate indicators. It is currently awaiting the results of a study that was put out for tender in late 2002.

4.2.6 European Environment Agency (EEA)

The EEA has been working on the development of indicators through a series of expert meetings and the commissioning of a scoping study to develop a potential core set of

indicators on the environmental performance of European marine fisheries and aquaculture.

A draft report has been put together by the National Centre for Marine Research (NCMR) in Greece with input from the European Topic Centre on Water. A potential core set of indicators for the environmental performance of European marine fisheries and aquaculture is proposed in the report. Indicators are presented with reference to the DPSIR Framework (described in Section 3 of this report). For each potential indicator, further reference is made to timeframes for their use based upon data availability and suitability, ie whether the data necessary to report against each indicator is 'A - available for the EEA's 2002 environmental signals report, I – intermediate, data available by 2003, or L - long term, data available'.

In August 2002, the report was released to a wide range of stakeholders, including the EU Member States, for consultation (Zenetos et al, 2002). The results of the scoping study were presented at a joint workshop in Brussels on 28-29 October 2002 arranged by the EEA, DG Fisheries and DG Environment. Since then, a more limited set of indicators have been posted on the EEA website: www.eea.dk

4.2.7 Eurostat

According to Eurostat (1999), its mandate is to focus upon driving forces, pressures and responses within the DPSIR framework, while the state and impact components are apparently the domain of the EEA. However, Eurostat acknowledges that the boundaries between the components of the framework are blurred, and the EEA provided Eurostat with many of the data that were used in its first edition of *Towards Environmental Pressure Indicators for the EU*.

The Eurostat Fisheries Working Group met with ICES and national representatives in February 2002 to discuss the development of sustainability indicators for wild capture fisheries (David Cross, pers comm).

4.2.8 Work in the Baltic Sea region

The International Baltic Sea Fishery Commission (IBSFC) appears to have made significant progress in tackling the conceptual issues related to the impact of fishing upon the marine environment. The Commission has developed an Action Programme for Sustainable Development of the Fishery which recognises not only the impacts other human activities may have on the fisheries sector, but also the potential impacts of fishing on fish stocks, discards, bycatch mortality of seabirds and marine mammals, habitats, and ecosystems. IBSFC has articulated a range of goals aimed to reduce the impacts of fishing and aquaculture on biodiversity and the marine environment in the Baltic Sea. However, the indicators aimed at assessing IBSFC performance do not yet reflect the broader ecosystem concerns (see Table 4).

Table 4. IBSFC indicators of sustainable development (Source: www.ibsfc.org)

Dimension	Indicators
Biological	Spawning stock biomass (SSB) – of commercially important stocks Fishing mortality Recruitment
Economic	Landings per country – total landings in tonnes of cod, salmon, herring and sprat Number of fishing vessels per country operating in the Baltic Sea Average engine power per country – total kilowatt of the fleet divided by vessel numbers Fish consumption per capita per country
Social	Number of full time fishermen in the Baltic Sea region, per country

Broader ecosystem indicators and assessment frameworks for the Baltic may be produced through a new Global Environment Facility (GEF) project on the development of an ecosystem-based approach to managing the Baltic Sea, of which IBSFC is a participant. The objective of the GEF Baltic Sea Regional Project is to introduce ecosystem-based assessments to strengthen the management of coastal and marine environments through regional co-operation. The long term goal is to provide the three relevant international commissions, HELCOM (the Helsinki Commission), IBSFC and ICES, with new management tools for sustainable ecosystem management and to contribute to increased social and economic benefits for coastal fishing and farming communities in the recipient countries. Recipient countries of the GEF and World Bank funding are Estonia, Latvia, Lithuania, Poland and the Russian Federation (http://www.ices.dk/gef/GEF.htm).

4.2.9 The Netherlands

Lanters and Enserink (1998) describe a project conducted in the Netherlands to develop a framework for ecological indicators that related to key Dutch policy themes with particular reference to the North Sea. Called GONZ (Dutch acronym for Development of Environmental Indicators for the North Sea), the project was initiated in 1998 in response to the growing demand for a more ecosystem-based approach to policy making and management of the North Sea. In was restricted to the Netherlands, but the framework created was similar to that used by OSPAR. The main ecological objectives for the North Sea were identified, followed by a selection of indicators necessary to evaluate the effectiveness of policies. Scientists assisted policy makers in refining their policy goals into practical and quantitative objectives through an iterative process which resulted in preliminary indicators related to the main policy issues for nature and the management of marine ecosystems.

Following the identification of the key policy objectives, ecosystem components and properties were identified. Ecosystem properties were then linked to measurable indicators that fell into two categories: ecosystem health indicators and human use indicators. Table 5 shows the basic structure of the GONZ assessment framework (as it was in 1998) for the evaluation of water and nature policy.

Altogether, 53 ecosystem health indicators and 40 human use indicators were proposed. Some of the ecosystem indicators could also be used as indicators for effects of human

pressures. Of the proposed human use indicators, 70 per cent were directly or indirectly connected to fishing (Lanters and Enserink, 1998).

The GONZ project was initially led by the Ministry of Waterways, but the responsibility now lies with the Ministry of Agriculture, Nature and Fisheries. The process of developing indicators for the Dutch natural policy, including the marine environment continues. The Ministerial Declaration from the North Sea Conference is seen as a new point of departure for further development of the natural policy and future work on indicators, and recommendations by the NSC are expected to be complemented by a few national-based indicators. This work will mainly be undertaken in 2003.

Another piece of work, involving the Netherlands, Germany and Denmark, that has produced a number of useful parameters relating to fisheries management is the Trilateral Monitoring and Assessment Program (TMAP) for the International Wadden Sea. The countries involved have agreed on a number of ecological targets (or ecotargets) for improving the quality of six habitat types in the Wadden Sea. Targets for birds and mammals have also been adopted. Several of the parameters identified as necessary to provide the information needed to implement the program relate to fish and fisheries.

Table 5. Basic structure of the GONZ assessment framework

Policy Theme	Ecosystem Component	Ecosystem Quality (property)
Biodiversity	Species	Single species reference points Diversity indicators for major species groups
	Communities	Community metrics for plankton, benthos and fish
	Ecotypes	Area of specific ecotypes
Ecological processes	Productivity	Production rates at primary, secondary and tertiary levels Decomposition
	Food chain	Bulkfood organisms Top predators Complexity of food chain Trophic structure for benthic and fish communities
	Hydro-enmorfodynamics [*sic*]	Area of dynamic ecotypes

4.2.10 Ministry of Agriculture and Forestry, Finland

In Finland, a preliminary set of indicators for sustainable use of renewable natural resources, including fisheries, was developed by the Ministry of Agriculture and Forestry in 1999. Since then, the system has been tested. The set of indicators has enabled the authorities to collect national data on these resources, including information about pressures, threats and future trends. Since the publication of a national strategy for the use of renewable resources in 2001, the initial set of indicators is now being updated to correspond with the strategy.

Table 6. Criteria, objectives and indicators for sustainable development of fisheries
(Finnish Ministry of Agriculture and Forestry, 1999)

Criterion 1: Productivity, renewal and utilisation of fish species and populations

Objective 1.1: The renewal and productivity of fish and crab populations are maintained and these populations are used sustainably

- Indicator 1: The distribution of fish species with commercial interest and of endangered species
- Indicator 2: Proportional abundance of populations, spawn populations and partial populations
- Indicator 3: The genetic diversity of fish species and populations
- Indicator 4: Natural fish production and production for stocking
- Indicator 5: The amount of stocks (by species) compared to the amount of the catch
- Indicator 6: The profit of fish stocking
- Indicator 7: The age structure of the fish catch
- Indicator 8: The amount of the catch from professional and from recreational fishing
- Indicator 9: The amount of the catch by species
- Indicator 10: The state of the water environment
- Indicator 11: The number and size of the reproduction areas
- Indicator 12: The number of barriers of migration

Criterion 2: The effects of the fishing industry on the environment

Objective 2.1: The effects of the fishing industry on the environment are taken into consideration

- Indicator 13: The nutrient load from fish farms

Objective 2.2: Fishing industry operations are such that they improve the state of the environment

- Indicator 14: The number and amount of the catch
- Indicator 15: The importance of the catch to nutrient rotations
- Indicator 16: Refurbishment

Objective 2.3: The health and well-being of fish are taken care of

- Indicator 17: The health of fish in fish farms
- Indicator 18: The health of fish in natural populations
- Indicator 19: The number of fish and crab deaths

Criterion 3: The profitability of the fishing industry

Objective 3.1: The preconditions for an economically profitable fishing industry exist

- Indicator 20: The production of fish farming, its value and the number of fish farms
- Indicator 21: The catch of professional fishing, its value and the number of full-time fishermen
- Indicator 22: Produce prices
- Indicator 23: The future expectations of entrepreneurs

Criterion 4: The social importance of the fishing industry

Objective 4.1: The fishing industry has a positive effect on national health

- Indicator 24: The number of recreational fishermen and the value of the catch
- Indicator 25: The quality of fish products

Objective 4.2: The fishing industry has a positive effect on the national economy and on the viability of rural areas

- Indicator 26: Full-time employees in fishing industry
- Indicator 27: The value of fish exports
- Indicator 28: The expenses of recreational fishing
- Indicator 29: The amount and value of fishing tourism
- Indicator 30: Net revenue and places of employment in the fishing tackle, ship, industry, etc.
- Indicator 31: The production and import of fish fodder
- Indicator 32: The consumption of fish as food and the percentage of domestic fish
- Indicator 33: The consumption of fish as fodder and the percentage of domestic fish

Objective 4.3: The general opinion about the fishing industry is positive

- Indicator 34: The opinion of consumers about the fishing industry and its production, products and fishing possibilities

4.2.11 The Blue Plan – A System of 130 Indicators for Sustainable Development in the Mediterranean Region

The Mediterranean Commission on Sustainable Development (MCDS) conducted a workshop to discuss sustainable development indicators being developed by the Blue Plan's Regional Activity Centre (MCSD, 2001). Of 130 indicators under development, five relate specifically to fisheries and aquaculture activities. A further six relate to 'actors and policies'. Using the PSR framework, the following table shows the current use of indicators for the dimensions of sustainable development relating to Mediterranean fisheries and aquaculture.

Table 7. Some indicators of sustainable development in the Mediterranean
(MCSD, 2001)

Pressure	**State**	**Response**
Fisheries and aquaculture		
Value of marine catches at constant prices Number and average power of fishing boats	Fishing production per broad species groups Production of aquaculture	Public expenditures on fish stocks monitoring
Actors in sustainable development (note: not specifically for fisheries and aquaculture)		
		Number of jobs linked to the environment Number of associations involved in environment and/or sustainable development Number of enterprises engaged in 'environment management' processes
Policies and strategies for sustainable development (note: as above)		
		Public expenditure on environmental protection as a percent of GDP Existence of environment national plans and/or sustainable development strategies Number of Agenda 21s adopted by local authorities

4.3 Environmental Indicators for Aquaculture

Work on environmental indicators for the aquaculture sector is in general less advanced, and there are currently no indicators for aquaculture at EU level.

4.3.1 The European Union

Until recently, the primary aims and objectives of EC aquaculture policy have been to enable the aquaculture sector to contribute to the supply of fish products and to provide

alternative employment in many fishery dependent regions. The legal framework relating to aquaculture involves a mixture of Community and Member State instruments.

In theory, prior to an aquaculture development (eg a new fish farm) being approved, an Environmental Impact Assessment should be undertaken in accordance with relevant national legislation and the Council Directive 85/337 on the assessment of the effects of certain public and private projects on the environment. The Water Framework Directive and the habitats and birds Directives are also relevant horizontal Community Directives, which should influence national legislation on aquaculture development and production. The only target articulated in the Commission Biodiversity Action Plan (BAP) for Fisheries and Aquaculture is the promotion of measures to reduce direct impact of aquaculture on the environment. This will presumably occur through the development of some guidelines for use of FIFG funds. There are no indicators put forward in the BAP.

4.3.2 FAO Guidelines for indicators on aquaculture

In September 2001, FAO organised another expert consultation; this time to contribute to the preparation of technical guidelines for the selection and use of indicators for sustainable aquaculture development. Its approach was similar to that of the FAO indicators for capture fisheries (FAO, 1999) and based on the distinction of four types of indicators: natural resource indicators, economic and financial indicators, social indicators, and governance/institutional indicators. The process of developing the technical guidelines is ongoing (R. Varjopuro, pers comm).

The new FAO Committee on Fisheries (COFI) Sub-Committee on Aquaculture met for its first session in Beijing in April 2002. The Sub-Committee will be responsible for taking forward the issue of indicators for sustainable development of the aquaculture sector but at this first meeting, the topic of indicators was only one among many to discuss. The Sub-Committee will meet again in Trondheim, Norway, in August 2003.

4.4 Matrix of Environmental Indicators for Fisheries and Aquaculture

Table 8 summarises the results from the review and shows all indicators under development (ie either being actively worked upon or proposed somewhere as potential indicators) or in use by an organisation. The indicators have been extracted from the literature, through the questionnaire and/or through interviews with relevant individuals.

The framework used to organise the list of indicators relates specifically to the high-level and sectoral objectives contemplated by the Green Paper on the Future of the CFP (COM(2001)135), the EC Biodiversity Action Plan for Fisheries and Aquaculture (COM(2001)186), and the Commission Communication on Elements of a Strategy to Integrate Environmental Protection Requirements into the CFP (COM(2002)143). In addition, where possible, criteria for indicators have been assigned a category from the DPSIR/DSR/PSR frameworks used by EEA, UNCSD, MCSD and OECD: D/P (*Driving force* or *Pressure*), S/I (*State* or *Impact*) or R (*Response*).

Table 8. Matrix of environmental indicators for fisheries and aquaculture

High level objectives
1. Contribute, through appropriate fisheries management action, to achieve the environmental objectives set out in Article 174 of the Treaty[1]: • preserving, protecting and improving the quality of the environment; • prudent and rational utilisation of natural resources; • protect human health; • and promoting measures at international level to deal with regional or world-wide environmental problems[2].

Sectoral objectives	**Principles**	**Criteria/sub criteria (D/P;S/I;R)**	**Potential Indicators**
Establish responsible and sustainable fisheries that ensure healthy marine ecosystems maintaining the quality, diversity and availability of marine resources and habitats[3]. To promote the conservation and sustainable use of fish stocks[4]. To reduce the impact of fishing activities and other human activities on non-target species and on marine ecosystems to achieve sustainable exploitation of marine and coastal biodiversity[5]	Maintain fisheries resources Rebuild depleted stocks (reversibility of impacts)	State of target resources: quality, diversity and availability (S/I) [including species not currently assessed, ie deepwater stocks]	% stocks outside safe biological limits and fully and/or sustainably exploited Spawning stock biomass (SSB) [relative abundance of target stocks] (using precautionary and limit reference points) Size and/or age structure of stocks Natural mortality Fishing mortality Fishing effort Catch per unit of effort (CPUE) Total catch (retained plus discarded)
		State of by-product (commercial bycatch) resources (S/I)	Relative abundance (SSB) Size and/or age structure/composition Total catch (retained plus discarded) Fishing mortality Fishing effort CPUE

[1] COM(2001)135 Green Paper on the future of the Common Fisheries Policy
[2] COM(2001)143 Elements of a strategy for the integration of environmental protection requirements into the Common Fisheries Policy
[3] COM(2001)135 Green Paper on the future of the Common Fisheries Policy
[4] COM(2001)162 Vol. IV Biodiversity Action Plan for Fisheries
[5] ibid
[6] ibid

Sectoral objectives	Principles	Criteria/sub criteria (D/P;S/I;R)	Potential Indicators
To avoid aquaculture practices that may affect habitat conservation through occupation of sensitive areas[6]	Maintain biodiversity at ecosystem, species and genetic levels Reduce impacts of fishing on non-target, ecologically related species	State of biotic communities including fish, non-fish and benthic communities (S/I) Implementation of bycatch reduction strategies (R)	Total catch (retained plus discarded) – ratios catch/bycatch; discards/bycatch Average weight and maximum length of fish Biodiversity index – proportion of species at range of trophic levels; species richness (spatial and/or temporal); species assemblages; genetic diversity Trophic structure Productivity – primary production Breeding productivity of ecologically dependent species (eg kittiwakes) Species composition in catches – presence of indicator / charismatic / sensitive species Population trends or relative abundance – • ecologically dependent species (predators dependent on harvested species) • icon/indicator species • sensitive, endangered, protected or threatened species (eg harbour porpoise) Distribution Density of benthic organisms % research funding spent on research into selectivity and bycatch reduction devices and/or strategies Numbers of 'bycatch action plans' or bycatch reduction/management strategies implemented
	Maintain ecosystems (specifically related to aquaculture activities – catchments and regions) Minimise aquaculture effects on non-aquaculture uses of the environment	State of biotic and/or abiotic systems (S/I) Pressures on community structure and biodiversity (D/P)	Total production Carrying capacity Water quality (eutrophication or pollution) – waste water; water discharge; biodeposition Cumulative impacts on catchments/regions – sedimentation, nutrient loads Brood stock sustainability Volume (weight) wild caught fish used as feed (by species) – source stock sustainability; food chain impacts Escapement of cultured species Disease

Sectoral objectives	Principles	Criteria/sub criteria (D/P;S/I;R)	Potential Indicators
	Maintain habitats Prevent further or future loss or damage to habitats Habitat integrity Restoration of habitat (eg shellfish beds)	Sensitivity and vulnerability of habitats to specific human impacts (D/P and S/I) Importance and specificity of their ecological functions (S/I) Rarity of particular habitats (D/P and S/I) Environmental impact of fishing gear (D/P and S/I)	Spatially explicit information on habitat type, function and extent of threats Total area fished (by method) % area protected (permanent, seasonal, by function/type or threats – eg nursery areas, rarity, vulnerability) Use of environmentally sensitive fishing gear Number and type of aquaculture operations (eg numbers of extensive systems, semi-intensive systems and intensive systems) Site selection for aquaculture operations – habitat loss
Bring fleet capacity into line as soon as possible with the availability and sustainability of resources[7]	Reduce fleet overcapacity and fishing effort/fishing mortality	Fleet capacity (D/P) Fishing effort (D/P) Fishing mortality (D/P)	Fleet capacity by region or fishery management unit % fleet overcapacity by region/fishery management unit Total fishing effort by fishery management unit Fishing mortality by stock
Integrate health requirements into the CFP, in order to protect public and animal health and safety, and ensure the stable supply of the European market at prices reasonable for the consumer[8]	Maintain quality standards		Water quality ('downstream effects on other species')

[7] COM(2001)135 Green Paper on the future of the Common Fisheries Policy
[8] ibid

Sectoral objectives	**Principles**	**Criteria/sub criteria (D/P;S/I;R)**	**Potential Indicators**
Promote better governance by putting in place more transparent, accountable and flexible management and decision-making processes which involve stakeholders at regional and local levels and ensure emergencies and conservation problems of a local nature are adequately addressed[9]	Establish appropriate fora for stakeholder involvement Implement appropriate institutional arrangements to ensure accountability	Participation mechanisms (R) Accountability mechanisms (R) Legal framework (R) Development of management and research plans (R) National legislation requiring EIA of aquaculture operations (R) Information (R)	Mechanisms for participation established and reviewed periodically Accountability mechanisms (reporting arrangements) met Legislation reviewed and streamlined % of fisheries covered by management and/or research plans Compliance with EU Directives relevant to aquaculture Numbers of EIAs by Member State % of aquaculture operations complying with Codes of Conduct Assessment of success in pursuing objectives with reference to established indicators Dissemination of results
Ensure effective enforcement of CFP rules through transparent arrangements which can guarantee a level playing field across the Union[10]	Establish appropriate enforcement institutions/arrangements	Effective monitoring and surveillance systems (R) Effective prosecution systems (D/P and R) Deterrent system of penalties (D/P and R)	Rate of compliance (difficult to measure) Number of penalties Number of infractions detected Number of successful prosecutions Enforcement expenditure (by Member State) Enforcement capability (by Member State)

[9] COM(2001)135 Green Paper on the future of the Common Fisheries Policy
[10] ibid

Sectoral objectives	**Principles**	**Criteria/sub criteria (D/P;S/I;R)**	**Potential Indicators**
Secure an economically viable and self-sufficient fisheries and aquaculture sector which can be competitive in a globalised economy[11]	Internalise 'external' costs Removal of subsidies that lead to overfishing Introduction of alternative incentive mechanisms	User pays/polluter pays or cost recovery (D/P) Reform subsidies (D/P) Market based mechanisms – exclusive harvest rights; ecolabelling (D/P)	Revenue raised; management costs Structural fund expenditure Number and type of alternative incentive mechanisms implemented
Address the problems of structural adjustment that will result from a commitment to sustainable fisheries[12]	Social and economic dimension of sustainable development	Economic and social policies do not contribute to a shift in driving forces towards further environmental degradation (D/P)	Employment trends Market demand and production (wild caught versus farmed, by species) Consumption Trade (tariffs, import quotas, imports/exports, share of markets by volume, share of exports by commodity/product) Fleet capacity trends Use of alternative incentive mechanisms (exclusive harvest rights, ecolabelling) Subsidy regimes Structural fund expenditure (government financial transfers)
Promote the responsible and rational exploitation of fishery resources in international waters and develop partnerships with third countries in a manner coherent with Community development policy[13]	Principles should be the same as fisheries in EU waters (see above)	Criteria should be the same as fisheries in EU waters covering the range of D/P, S/I and R aspects of policy and indicators (see above)	Numbers of formal management plans incorporating objectives, measures, research capacity, implementation, data collection programmes, enforcement and control capacity and implementation, and indicators.

[11] ibid
[12] ibid
[13] ibid

Sectoral objectives	Principles	Criteria/sub criteria (D/P;S/I;R)	Potential Indicators
Improve the quality and amount of relevant data to support decision-making and to promote multidisciplinary scientific research which will allow for obtaining timely and qualitative scientific information and advice on fisheries, associated ecosystems and relevant environmental factors[14]	Improving policy performance in order to achieve high-level and operational objectives Building multi-disciplinary research and stakeholder groups to assess policy performance	Practical and effective indicators and reference points (R) Research and data collection capacity exists (R) Broader participation in performance assessment (R)	Management performance monitored System/hierarchy of objectives, indicators and reference points developed and tested Research and data collection plans developed and implemented Appropriate fora created for broad participation in performance assessment

[14] ibid

5. EVALUATION

5.1 The Policy Framework

The clear articulation of policy objectives within a systematic management framework should be the starting point for the development of indicators and is thought by many to be the most important element in the process of pursuing sustainable development (FAO, 1999; Garcia and Staples, 2000; Garcia *et al*, 2000; Sainsbury and Sumaila, 2001). Objectives articulate what decision-makers are trying to achieve and their specificity will depend upon the scale or level at which management measures are implemented. General objectives for overall sustainable development may be embedded in the CFP, but these will have to be accompanied by more specific 'operational' objectives for individual components of the fisheries system, such as management measures or policies for an individual fishery. Setting appropriate objectives should make indicator and reference point development almost self-evident in many cases (Garcia *et al,* 2000).

With the CFP reform decisions taken in December 2002, the overall objectives for fisheries management in the EU have been set out. But until further, more operational objectives emerge in 2003, the development of useful and practical environmental indicators cannot be fully completed. It may also be necessary to change some of the fundamental principles underpinning the CFP, set out in the Treaty. At the very minimum, Article 6 of the Treaty requires fisheries policy to be developed and implemented in a way that respects the environmental objectives set out in Article 174 of the Treaty (Environment Title):

- Preserving, protecting and improving the quality of the environment;
- Protecting human health;
- Promoting prudent and rational utilisation of resources; and
- Promoting measures at international level to deal with regional and global environmental problems.

In order to support further improvements in the Common Fisheries Policy, growing emphasis is being placed on monitoring the effects of policies and practices and associated changes in the marine environment. In the Green Paper on the Future of the CFP, the Commission emphasised the central role to be played by monitoring and indicators. The development of fisheries/environment indicators has also received political support from the Fisheries Council in its Conclusions submitted to the Gothenburg Summit in June 2001. This refers to the 'need to develop specific indicators for the fisheries sector to measure on an integrated basis ecological, economic and social sustainability. The indicators should enable monitoring of key parameters of important fish and shellfish stocks, evaluation of time trends in such stocks and assessment of potential impact on bio-diversity.' These commitments were further developed in the Community action plan to integrate environmental protection requirements into the CFP (COM(2002)186), suggesting that the development and testing of indicators will be a first step to improve monitoring and evaluation of the process of environmental integration. This approach was endorsed by the Council at its meeting on 27-28 January 2003.

Indicators are also needed to monitor the effectiveness of other EU policies directly relevant to the fisheries sector, such as the Sustainable Development Strategy.

5.2 Data Requirements and Availability

Obviously indicators need to be underpinned by data. Data availability, its quality and quantity vary greatly between fisheries and countries. A great deal of data is already collected by Member States. However, its consistency across countries and/or usefulness to assess policy performance may need attention. In general, more data is available on the biological and environmental dimensions of sustainable development than on the socio-economic and institutional dimensions.

According to Garcia *et al* (2000), the first consideration should be how best to use existing data and programmes of data collection and information. However, there will probably be a need to collect new types of information, particularly from fishermen and/or fishing communities. As funds are always limited, use should be made of rapid assessment techniques where data from broad areas is needed. A number of these techniques are being or have been developed, particularly in the area of ecological and environmental monitoring and assessment. These methods provide guidance on a number of important aspects including matching efforts to scale, choice of proxies and surrogates, field sampling methods, training, equipment and data handling (Garcia *et al*, 2000; Bax *et al*, 1999).

It will be necessary to agree on a common minimum set of information to be collected. To this end, a review of the Council Regulation 1543/2000 which establishes a Community framework for the collection and management of the data needed to conduct the CFP is due to take place in 2003. In the Biodiversity Action Plan, the Commission suggests that indicators for marine ecosystem health, including fish stocks and other species will be developed as part of that review. The EEA report prepared by the European Topic Centre on Water contains a section on data availability, also highlighting the constraint that limited data puts on the use of indicators.

5.3 Practicalities and Limitations

There is general agreement that fisheries management and aquaculture policy needs to be broadened to match the principles of sustainable development and the requirements of human as well as ecosystem well-being (Garcia *et al*, 2000). As mentioned above, this will require a broadening of the data collected as well as much more complex fishery management models. There is a need to understand sustainable development at sub-sector and sector levels, as well as through inter-sectoral perspectives (eg Integrated Coastal Zone Management). The frameworks that will be required might not be entirely compatible with more conventional modelling approaches. This means that broader

indicator systems will need to be combined with modelling of only some parts of the system.

Policy makers are going to have to choose and/or prioritise indicators in order to determine data collection needs, further research needs and assessment processes to be used (ICES, 2001a). Fisheries managers in the European Community currently have difficulty coming to grips with management decisions for 14 commercial fish and benthic species in the North Sea assessed on a yearly basis, along with seven species for which TACs are set without assessment. With the need to take assessments for non-target species and habitat impacts into account, the task of the policy makers will become more complicated and more politicised. Finding ways of overcoming these obstacles will be very important if the adoption of an ecosystem-based approach to fisheries and aquaculture is to be successful (ICES, 2001a).

There is significant uncertainty about how effective indicators such as the EcoQs devised by ICES for OSPAR and CONSSO will be in actually measuring the response of the marine system to the impact of fishing and/or aquaculture activity. The OSPAR Biodiversity Committee (BDC) report of November 2001 listed the following limitations or risks that should be addressed when establishing EcoQs or indicators:

- oversimplification of reality;
- risk that monitoring requirements may be complex, cover a wide area and need much data;
- imposing values on others (if there were insufficient consultation);
- lack of common vision for how we want the ecosystem to be (if not negotiated);
- lack of knowledge about the consequences of establishing EcoQs (if established with insufficient preparation);
- risk of not including all relevant environmental aspects;
- risk of becoming over complex for management purposes;
- potential for conflicting objectives; and
- lack of appropriate forum for dialogue and decision-making.

The research community will need to work closely with the advisory and management community to test and validate how well indicators reflect what is happening to the system and how well policy makers are using the information provided (ICES, 2001a; Garcia *et al*, 2000; Sainsbury and Sumaila, 2001). As ICES points out in their report from 2002: 'to be worthwhile the tool [indicators] must be used for improving decision-making about the uses of marine ecosystems, including, but not restricted to, fishing.'… 'If it appears that the tool is not used, one must ask what justification there is to invest the large amount of scientific effort that will be required to make the EcoQ and EcoQO framework adequately comprehensive.'

An important point also highlighted by the OSPAR BDC was that ways to increase communication and facilitate a dialogue with stakeholders in the process of developing indicators must be found.

5.4 Gap Analysis

In Section 3.2 of this report, a hierarchy for reporting and assessment of whole management systems was described (Sainsbury and Sumaila, 2001). For fisheries and aquaculture policy at EU level, such a hierarchy or Sustainable Development Reference System (SDRS), as described by FAO (1999), Garcia and Staples (2000) and Garcia *et al* (2000), is yet to be developed. The Green Paper on the future of the CFP highlights the need to develop a system to track progress towards sustainable development and the performance of management against stated objectives. It is fair to expect that a strategic reporting framework will be developed under the new CFP.

A starting point for this exercise will obviously be the new objectives of the CFP, including the articulation of more operational objectives, along with any new institutional structures and arrangements, and new legislation. From this will evolve the ability to design an SDRS and associated indicators for EU fisheries and aquaculture policy. A broader set of reference points also needs to be developed, covering all the other key dimensions of sustainability such as those relating to fishing effort, capacity, bycatch, discards, biodiversity and habitat (Garcia *et al*, 2000). Some target reference points are now to be set for the recovery of overfished stocks, as part of the new recovery plans.

At present, four key areas seem to be lagging behind in the development of indicators for fisheries management: social and economic driving forces of environmental degradation; external relations; the Mediterranean; and aquaculture. All these four areas do, however, fall into a single category: headline indicators. Each area represents a policy angle or a sub-set of overarching fisheries or aquaculture policy. They should have Community or CFP level indicators in their own right.

5.4.1 The Potential of Headline Indicators

Many of the indicators set out in the matrix (Table 8) are aimed at the stock, fishery or regional scales of fisheries policy and account for specific features or details of the environmental dimension of sustainable development. Eurostat, UNCSD and, until recently, EEA have tended to use rather simple and blunt indicators such as total catch or landings to indicate the 'state' of EU fisheries in a broader context of natural resource policy performance. As can be seen by the multitude of possible indicators presented in this report, catch and landings are not really indicators of anything much and are not adequate to describe how successful (or not) fisheries and aquaculture management is in pursuing sustainable development. A relatively simple set of indicators relating to the overarching objectives of the CFP is needed.

The EEA report proposes a series of environmental integration indicators within the DPSIR framework, some of which might be useful as headline indicators.

5.4.1.1 Using the driving forces behind environmental degradation as headline indicators

Garcia and Staples (2000), FAO (1999), Deere (2000), EEA (2002), OECD and others contemplate the connection between economic and social driving forces and environmental sustainability and thus have listed, proposed or are developing related indicators. These are summarised in Table 8. The link between the environmental and the economic and social dimensions of sustainable development becomes evident when looking at the driving forces behind human activities, processes and patterns. Fishing and aquaculture activities obviously provide food (nutrition), employment (livelihoods) and in some cases wealth. There are incentives (either market-based mechanisms or subsidies) to invest in production capacity and benefits to be realised from trade, whether on small-scale/local level or on large-scale industrial/international level. Driving forces such as increasing market demand for a wider range of fish and fish products, whether domestic or foreign, the desire by government(s) and/or business to maintain or increase employment in a sector, the incentive to trade in fisheries services (eg technology, vessels, fishing gear and access rights), or simply the need to provide protein to communities all have the potential to lead to environmental degradation. With 40 per cent of total fish production entering international trade and demand growing (Deere, 2000) it is important to establish the effects that these driving forces have on the sustainable development of the fisheries and aquaculture sectors and on the marine environment.

A number of other driving forces need to be understood at the macro-level in order to adapt fisheries and aquaculture policy to better pursue sustainable development. A debate about the legitimacy of using these kinds of indicators to inform future policy-making with a wide range of stakeholders is needed. One important topic is whether market demand and consumption trends over time drive the sector in various directions (see Box 3). Other issues to debate, probably at the political level, include whether employment (numbers, sectors, etc) and employment policies of Member States (eg maximising fisheries employment versus managing a decline in fisheries employment) contribute to the success or failure of fisheries policy. Another more obvious driving force is aid to the sector and even though some substantial changes were made in December, its effects on sustainable development need to be explored further. Even with the abolition of aid to the building of new vessels after 2004, indicators of Structural Funds expenditure and links to overcapacity of fleets may continue to be useful headline indicators. Food security and food production policies can be driving forces behind aquaculture development. The extent to which these contribute to environmental degradation also needs to be examined.

Box 3. Driving forces – trade, market demand and consumption (from Deere, 2000)

Establishing the effects of trade in fish and fish products on sustainable development and the environment is complicated by several factors.

- Existing studies of trade analyse changes in the volume and value of trade in fishery products by looking at changes in fish prices. Inadequate attention is dedicated to assessing the relationship between trade and price information to the status of fish stocks, ecosystem health, levels of consumption and demand, or management regimes and changes in government economic or trade policy.

- Statistics on trends in trade flows of many fishery products are not always complete and the status of fish stocks is not always known with accuracy.
- Trade studies rarely start with a fish stock and then consider the impact of international trade factors on it.
- The fisheries sector is one of the most complex in terms of production, management and product diversity. It is also affected by numerous exogenous economic factors (eg changes in the economic situation in a country and non-fishery sector factors, such as land-based pollution, the El Niño effect, and oil spills).
- Assessments of the sustainability of fisheries and likewise the impacts on international trade will vary depending on whether considerations of marine biodiversity and ecosystem health as well as social and cultural factors are included.
- Few studies consider the impact of the structure of the fisheries industry on trade and investment trends and the distribution of benefits. The growth of larger vertically and horizontally integrated fishing and food companies through take-overs and strategic partnerships may result in shifts in bargaining power that affect prices, products markets and international trade opportunities, fishing intensity and the access of the poor to fish.

5.4.1.2 Using response-type indicators as headline indicators

Response-type indicators related particularly to the institutional dimension of sustainable development may assist policy makers in understanding how policy measures are mitigating (or not) governance and regulatory failure. The effectiveness of policy responses, which include the establishment of long-term management plans with clearly stated objectives and clearly articulated rights, roles and responsibilities of the sector and other key stakeholders, can be measured through relatively simple indicators that answer questions regarding how policy reform has led to changes in behaviour.

It is also possible to create other incentive structures, such as eco-labelling, based on market forces or cost recovery/user pays policies so that the beneficiaries of fisheries (ie the fishing operators) pay in proportion to the benefits they receive. The success of these kinds of policy reforms can also be measured through response-type headline indicators.

5.4.1.3 Using pressure, state and impact related headline indicators

The indicator matrix presented in Table 8 lists a broad range of indicators that would fit these categories. They are not repeated here.

5.4.2 Mediterranean Fisheries

Much of the work on indicators is occurring within international organisations or the northern Member States (eg OSPAR, IBSFC, ICES, the Netherlands, Sweden and Finland). Even though some work on indicators is being done in Spain and the National Centre for Marine Research in Greece conducted the EEA scoping study on indicators, broader indicator development for the Mediterranean lags behind. The regional fisheries organisation GFCM is struggling to get to grips with scientific assessments of target species and has begun to look at the issue of indicators in fisheries management.

The Green Paper acknowledged that much needs to be done to bring Mediterranean fisheries management to a level similar to the rest of Community waters. This has been followed up with an action plan for the conservation and sustainable exploitation of fisheries resources in the Mediterranean Sea (COM(2002)535), including a range of suggestions to improve the situation but highlighting other aspects than indicators. Given this, it seems unlikely that GFCM will turn its attention in a systematic way to develop broader environmental indicators in the near future. Nevertheless, it will be important for any work on EU indicators to fully reflect issues relating to Mediterranean fisheries.

5.4.3 High Seas and Third Country Fisheries

There is a clear need for the system for reporting on sustainable development of the fisheries and aquaculture sectors to include indicators that provide information about how well EU fishing access agreements with third countries pursue sustainable development. It should be obvious that within agreements between the EU and third countries, the nested objectives and measures should be similar to targets and indicators set out for fisheries in EU waters.

Furthermore, in order to contribute to the overall picture of EU fishing impacts upon the global marine environment, a set of headline indicators for its external fisheries policy should be developed. This should include the number of agreements, the number of management plans established, as well as some measure of research capacity and data collection activities.

5.4.4 Aquaculture

At Community level, there is a commitment to develop a set of biodiversity indicators by 2003. In view of the content of the Commission's Biodiversity Action Plan for Fisheries, these indicators should also cover the aquaculture sector.

As suggested previously, headline indicators for the driving forces behind aquaculture development could be identified and used to indicate potential environmental impact, for example, market demand and consumption trends for farmed fish and shellfish. More direct indicators of environmental pressure, state and impacts have been contemplated by EEA, FAO and the Australian government and these could be built into Community level

monitoring of the progress in environmental integration into aquaculture activities in Member States.

Environmental indicators for aquaculture can be broadly grouped into three categories: environmental considerations within facilities (eg carrying capacity, water discharge, pollution/waste); within catchment areas or regions (eg cumulative impacts, nutrient loads, habitat use, loss or restoration, community structure and biodiversity, number and type of farms/operation); and issues related to other aspects of the environment (feed stock sustainability, escape of cultured specimens, disease, food chain impacts, brood stock sustainability).

As mentioned earlier, ongoing work by the FAO COFI Sub-Committee on Aquaculture might prove useful for the Community development of aquaculture indicators.

6. CONCLUSIONS AND RECOMMENDATIONS

The most comprehensive guidelines for developing indicators can be found in FAO (1999), Garcia and Staples (2000), Garcia *et al* (2000) and Sainsbury and Sumaila (2001). Any one of these publications outlines a logical and practical process that ought to be followed when developing indicators. The key message to emerge from these publications is that indicator development must start with a clear articulation of objectives within a systemic management framework and the process must be underpinned by an effective communication strategy involving all stakeholders.

The main message from the FAO guidelines is that indicators need to be developed within a systematic reference system in order for them to be useful. In particular, the scope of the system for which indicators are being developed and its dimensions and criteria need to be agreed before indicators are even contemplated. Setting objectives for each of the criteria is an essential part of indicator development and in many cases this will help identify the relevant indicator and its associated reference value. The most obvious constraint upon the development of useful indicators is the lack of a coordinated approach across countries, sectors and fisheries. The FAO guidelines provide a first step in making such an approach possible.

In order to gain the long term commitment of institutions and the support of stakeholders, Garcia *et al* (2000) suggest publicising the initiative, familiarising all concerned with (i) the fishery issues; (ii) the role of an adequate system of indicators; and (iii) the role of the various partners. As previously mentioned in Section 3 of this report, indicators need reference points or threshold values. As threshold values or reference points involve a degree of value judgement, decisions about reference points should be made by policy makers in consultation or partnership with stakeholders and scientists.

Those responsible for assessing and reporting on sustainable development through a reference system of indicators will need to address practical issues relating to the organisation and process required, such as institutional support and capacity. This will include ensuring an appropriate flow of data and the human and financial resources to collect this data on a long-term basis; ensuring a set of formal linkages within the fishery sector and among stakeholders; and establishing a formal process to develop, test and implement indicators.

Some recommendations for future work:

- A process to develop EU headline indicators for fisheries and aquaculture should to be established based upon clearly articulated CFP objectives.
- The main players from National Ministries (fisheries, environment and marine protection), OSPAR, ICES, EEA, Eurostat, the European institutions (DG Fish, Environment, JRC and possibly Development), OECD and FAO need to be brought together to coordinate efforts around the new CFP objectives and agenda. It will be important to ensure that the Mediterranean, Baltic and North-East Atlantic States participate in this exercise.

- An appropriate first step would be to follow the guidelines set by the FAO and develop a Sustainable Development Reference System framework using the objectives of the new CFP as the starting point.
- The next step would be to select a practical set of indicators based on agreed objectives and goals, taking the incomplete scientific knowledge about ecosystem components and functioning into account, but also the need for priority setting.
- Ensure a balanced coverage of different elements in relation to the full Pressure-State-Response indicator framework (but avoid being driven by this - objectives must remain the primary driver for selecting indicators).
- Consider the appropriate use of available data and pinpoint future data needs, and then identify necessary changes to the Council Regulation establishing a framework for data collection.
- Once indicators are selected, reference points or values should be determined through an iterative process between policy makers, stakeholders and scientists. It should not be underestimated how challenging and time consuming this may be. The issues are about ideology as much as about science and will need to focus on questions such as the level of risk that may be acceptable to society for certain species and whether policy objectives aim for restoration, conservation or preservation.
- In the end, the process will also have to determine research strategies and needs, and then test, modify and adapt the selected indicators.

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Annex 1. Organisations Working on Indicator Development or Use

	Organisation	Name (if known)	Mode of response	Outcome
1	Baltic 21 Action Programme [IBSFC in conjunction with HELCOM and ICES]	IBSFC Website [Robert Aps, Estonia]	N/A Email	Under IBSFC (see below), action programme for sustainable development, including definition of goals and indicators, plans and priority actions on fisheries and aquaculture
2	Denmark, Institute for Fisheries Management & Coastal Community Development	Doug Wilson	Telephone Email	Project funded by 5th Framework and Danish sources to develop simple indicators of fisheries health (abundance and habitat quality) for use as 'understandable triggers' for management actions
3	Environment Australia	Website	N/A	Guidelines for assessing ecological sustainable development of all major Australian fisheries
4	Estonian Marine Institute	Robert Aps	Email	Indicators under development (pending funding) for ICZM including fisheries
5	European Environment Agency [European Topic Centre on Water, WRc plc]	Anita Künitzer [Zoe Trent]	Email [Email via Julie Cator, WWF EPO]	Draft technical tables for EEA review of integration indicators for EU fisheries and mariculture – under embargo, not for citation Input to above study. Also indicators on impact of fishing on non-target species for Water Resources assessment 2002, Environmental Signals Report 2002 and Kiev Report 2003
6	Eurostat	David Cross	Email	Fisheries Working Group meeting to discuss indicators with ICES, Commission and national representatives in February 2002

	Organisation	Name (if known)	Mode of response	Outcome
7	FAO	Serge Garcia – wild capture fisheries Rebecca Metzner – wild capture fisheries Uwe Barg – aquaculture indicators Alain Bonzon – socio-economic indicators	Interviewed face-to-face by Stefano Moretti. Transcript of interviews written by SM	Up-to-date information on FAO and international development and/or use of fisheries and aquaculture indicators. Large amount of literature and source material provided.
8	Finnish Environment Institute	Ulla Oksanen	Telephone Email	Indicators under development relating to fisheries outputs, aquaculture production and nutrient discharges for the Finnish National Commission on Sustainable Development
9	Finnish Game & Fisheries Research Institute	Timo Mäkinen	Telephone Email	Indicators under development for fisheries and aquaculture related to strategic policy goals and targets
10	Greece, National Centre for Marine Research	Argyro Zenetos	Email	Conducted study for EEA on integration indicators for fisheries and mariculture (see above)
11	International Baltic Sea Fishery Commission	Website [Robert Aps]	N/A Email	Definition of sustainable fisheries, including goals and indicators, action programme, plans, priorities – wild capture, marine, coastal, inland fisheries and aquaculture
12	Iceland, Marine Research Institute	Jóhann Sigurjónsson	Telephone Email	Fisheries and environmental reporting produced annually by MRI in a designated report. Report not forwarded by respondent (not published in English?), not reviewed

	Organisation	Name (if known)	Mode of response	Outcome
				by project team
13	ICES	Website [Mark Tasker]	N/A Email	Published documents on Ecological Quality Objectives and related indicators by WGECO Published report from Working Group on Fishery Systems on the development of 'a framework and methodology for the analysis of fishery system performance'
14	Ireland, Trinity College Dublin	Jim Wilson	Email	Developing indicators relating to a Pollution Load Index and Biological Quality Index
15	IUCN World Conservation Union	Ed Green	Telephone	Guidelines for the International Performance Standard for the Marine Aquarium Trade by the Marine Aquarium Council
16	JRC	Jochen Jesinghaus	Telephone Email	Developing indicators model software 'Dashboard'. Not yet usable in a fisheries policy context – need a 'reasonable indicator set'
17	Marine Stewardship Council	Website	N/A	Principles and criteria, performance indicators and scoring guidelines for certifying a fishery to the MSC label
18	Mediterranean Commission on Sustainable Development	Website – Plan Blue	N/A	Blue Plan – system of 130 indicators for the sustainable development of the Mediterranean region
19	North Sea Conference (CONSSO)	Website	N/A	Draft documents (ICES advice to CONSSO)
20	OECD Fisheries Division	Anthony Cox Carl-Christian Schmidt	Email Telephone	Developing indicators for marine capture fisheries (primarily economic aspects) in OECD

	Organisation	Name (if known)	Mode of response	Outcome
				countries, using PSR framework. Continued work on 'government financial transfers'
21	OSPAR Biodiversity Committee (BDC)	Website	N/A	Draft documents on Ecological Quality Objectives (ICES advice)
22	Spain, Technological Institute for Fisheries and Food (AZTI), Dept of Fisheries Resources Basque Country	Dr Gorka Sancho	Email	AZTI currently assessing the validity of local fishery databases for possible use of ecological indicator metrics, with reference to ICES WG ECO work (see above) – researching data requirements.
23	Swedish National Board of Fisheries	Maria Hellsten	Email	Development of Environmental Quality Objectives, some of which relate to fisheries and marine environment
24	UN Commission on Sustainable Development	Website	N/A	Guidelines and methodologies for developing indicators of sustainable development
25	USA, National Marine Fisheries Service	Website	N/A	Environmental assessments prior to TAC decision-making, using broad range of indicators and reference point values for ecosystem component impacts and socio-economic impacts of a range of catch scenarios for key target species
26	The World Bank	Website	N/A	Range of documents on indicators of sustainable development, some related to fisheries and marine biodiversity

Annex 2. Possible Indicators Suggested in the Communication on an EU Fisheries Integration Strategy (COM(2001)143)

ITEM	DRIVING FORCES IN ITEM	PRESSURES BY ITEM	STATE OF ITEM	IMPACT ON ITEM	RESPONSE BY ITEM
ECOSYSTEM (HABITATS)	- Long term trends of key physical parameters - Eutrophication, pollution - Upwelling indices - …	- Climate change - Nutrients - Circulation patterns - …	- Hydrographic regime - Chemical composition of water - Habitat extent and condition - …	- Sea warming - Physical damage to seabed - Water pollution transmitted through food web	- Changes in water dynamics - Changes in productivity - Changes in fish availability - …
ECOSYSTEM (BIOCOENOSIS EG. Relation between living organisms)	- Intrinsic population growth rate* - Individual growth rate* - Individual fecundity* - Structure of trophic webs - …	- Natural mortality of populations* - Productivity at various trophic levels - Energy flow in food webs - …	- Biodiversity indices by area and by major taxa groups - Energy flow in key links of food web - Biomass*	- Changes in geographical distribution* - Changes in fish mortality* - Additional sources of food (discards) - …	- Changes in geographical distribution and migration* - Changes in growth fecundity and age at first maturity*
FISHING INDUSTRY	- Fishing tradition - Alternative employment - Fishing capacity - Market demand - Loans, subsidies - …	- Deployed fishing effort by region and by fishing gear - Gear loss - Waste - Economic needs - - …	- Fishing capacity (potential fishing effort) - Employment - Production (catch) in weight and in value - …	- Fleet size adaptations - Change in fishing behaviour effort, gear, zones - Changes in economic results	- Social unrest - Adaptation of fishing effort - Highgrading of catch - Change of gear - Withdrawal from industry

AQUACULTURE	- Market demand - Technological improvement - Need of water resources - -…	- Need of good environment conditions of farm sites - Need of food stuff of marine origin	- Fish production - Use of water - Food needs - Quality of effluent water - …	- Water quality (effluents) - Use in territory) - Supply of food stuff - Supply of fry - …	- Adaptation of farming methods - Promotion of research - Diversification of supply
CONSUMERS AND PUBLIC OPINION	- Market supply - Feeding behaviour - Buying power - Need of health protection -…	- Demand for supply at reasonable prices - Demand for ecological and sanitary standards - Political pressure	- Opinion (polls results) - Fish consumption indices - Consumption preferences - …	- Changes in market supply and demand - Public awareness of marine problems - …	- Adaptation of consumption habits - Reactions against poor quality or high prices - …
SCIENCE	- Need of scientific support - Intellectual challenge - Research facilities (personnel, installations)	- Need of basic research data - Need of research funds - Research results - …	- Budget allocated to research - Number of research projects - Inventory of research facilities - …	- Changes in budget actually used in research - Changes in geographical and thematic scope of research - …	- Research enhancement - Adaptation of research programmes - …
DECISION MAKING	- International and internal commitments - Dissatisfaction with current producers - Public opinion	- Regulatory instruments - Information campaigns - Enforcement - Subsidies - …	- Number of actions subject to impact assessment - Number of species covered by management	- Increased understanding of the problems - Political pressure - Social pressure	- Improved measures - Improved enforcement - Improved governance

(*) For key biota

In this publication, all the materials containing woodpulp are sourced from sustainably managed forests.