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FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES

8

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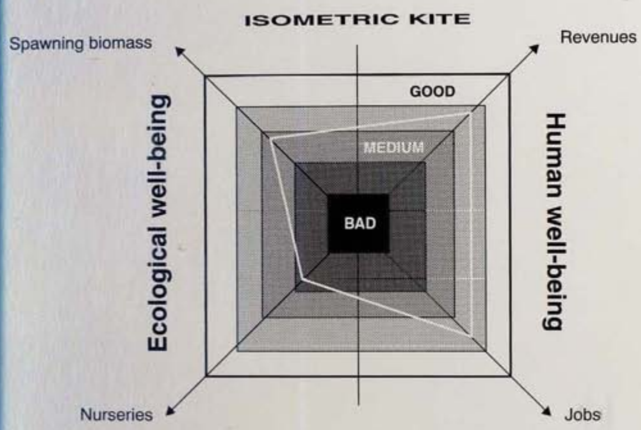

INDICATORS FOR SUSTAINABLE DEVELOPMENT OF MARINE CAPTURE FISHERIES

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Preparation of this document

These guidelines have been finalized by the FAO Fishery Resources Division (FIR) based on a draft originally developed by the Australian-FAO Technical Consultation on Sustainability Indicators in Marine Capture Fisheries organized by the Department of Agriculture, Fisheries and Forestry – Australia (AFFA) in close collaboration with FAO and held at Brighton Beach, Sydney, Australia, 18-22 January, 1999.

The following experts have contributed to their development: A. Abou El Ouafa, J. Annala, A. Bonzon, J. Chesson, K.C. Chong, V. Christensen, A. Dahl, S.M. Garcia (Co-Chairman), M. Harwood, D. Huber, T. Hundloe, K. Lankester, J. McGlade, J. McManus, M. O'Connor, C. Perrings, M. Prein, N. Rayns, J.C. Seijo, M. Sissenwine, T. Smith, L.T. Soeftestad, D. Staples (Chairman), K. Stokes, T. Ward, and R. Willmann. During the meeting, the compilation of the contributions into a coherent text was undertaken by the Steering/Editorial Committee (see names underlined). The production of the final document was overseen by S.M. Garcia and D. Staples.

These guidelines have no formal status. They are intended to be used on a voluntary basis and to provide support to the implementation process of the Code of Conduct for Responsible Fisheries. However, the language used may not strictly follow that employed in the Code and its substantive Articles. Any difference in terminology should not be understood as intending reinterpretation of the Code.

Finally, although much care has been taken to integrate in these guidelines existing knowledge and experience in other sectors in developing sustainability indicators, the experience available from the fishery sector is extremely limited. As a consequence, these guidelines are intended to be flexible and capable of evolving as experience is gained and constructive suggestions accumulate. The present document is the first version of the guidelines and will be revised and completed (additional methodological annexes will be included) as required in the future.

Distribution:

All FAO Members and Associate Members
Interested Nations and International Organizations
FAO Fisheries Department
FAO Officers in FAO Regional Offices
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Abstract

These guidelines have been produced to support the implementation of the Code of Conduct for Responsible Fisheries. They relate mainly to Article 7 (Fisheries Management) but also to Articles 6 (General Principles), 8 (Fishing Operations), 10 (Integration of Fisheries into Coastal Area Management), 11 (Post-Harvest Practices and Trade) and 12 (Research). As for the other guidelines, they are addressed primarily to the decision-makers and policy-makers in marine capture fisheries, but should also be useful to fishing companis and fisheries associations, non-governmental organizations with an interest in sustainable development and fisheries and other groups concerned with fisheries resources.

The guidelines provide general information on the issue of sustainable development of fisheries in order to clarify why a system of indicators is needed to monitor the contribution of fisheries to sustainable development. They are complementary to the *Guidelines on Fisheries Management* but provide the broader perspective needed for a sectoral and holistic approach to sustainability in fisheries. All dimensions of sustainability (ecological, economic, social, and institutional) are considered as well as the key aspects of the socio-economic environment in which fisheries operate.

The guidelines also provide information on the type of indicators and related reference points needed. However, it is recognized that it is difficult to generalize, and that there is a need to agree on common conventions for the purpose of joint reporting at national, regional and global level, particularly in relation to international fisheries, or transboundary resources.

The guidelines highlight the various frameworks that have been identified and can be used to organize the indicators and reference points, reflecting the objectives, constraints and state of the different elements of the system in a coherent picture. They also include some graphical and other representations that may be of use in conveying the information to policy-makers and to a wider audience.

The guidelines outline the process to be followed, at national or regional level, to establish a Sustainable Development Reference System (SDRS) at sub-national, national, or regional level, focussing on the design of the SDRS, its development (including identification of objectives, selection of indicators and reference points), and its implementation, including its testing.

Finally, a number of issues are highlighted, related for instance to data needs, cost-effectiveness, institutional requirements, capacity-building, and coordination.

Contents

Background

From ancient times, fishing has been a major source of food for humanity and a provider of employment and economic benefits to those engaged in this activity. However, with increased knowledge and the dynamic development of fisheries it was realized that aquatic resources, although renewable, are not infinite and need to be properly managed if their contribution to the nutritional, economic and social well-being of the growing world's population was to be sustained.

The adoption in 1982 of the United Nations Convention on the Law of the Sea (UNCLOS) provided a new framework for the better management of marine resources. The new legal regime of the oceans gave coastal States rights and responsibilities for the management and use of fishery resources within their exclusive economic zones (EEZs), which embrace some 90 percent of the world's marine fisheries.

In recent years, world fisheries have become a dynamically developing sector of the food industry and coastal States have striven to take advantage of their new opportunities by investing in modern fishing fleets and processing factories in response to growing international demand for fish and fishery products. It became clear, however, that many fisheries resources could not sustain an often uncontrolled increase of exploitation.

Clear signs of overexploitation of important fish stocks, modifications of ecosystems, significant economic losses, and international conflicts on management and fish trade threatened the long-term sustainability of fisheries and the contribution of fisheries to food supply. Therefore the Nineteenth Session of the FAO Committee on Fisheries (COFI), held in March 1991, recommended that new approaches to fisheries management embracing conservation and environmental, as well as social and economic, considerations were urgently needed. FAO was asked to develop the concept of responsible fisheries and elaborate a Code of Conduct to foster its application.

Subsequently, the Government of Mexico, in collaboration with FAO, organized an International Conference on Responsible Fishing in Cancún, in May 1992. The Declaration of Cancún endorsed at that Conference was brought to the attention of the United Nations Conference on Environment and Development (UNCED) Summit in Rio de Janeiro, Brazil in June 1992, which supported the preparation of a Code of Conduct for Responsible Fisheries. The FAO Technical Consultation on High Seas Fishing, held in September 1992, further recommended the elaboration of a Code to address the issues regarding high seas fisheries.

The One Hundred and Second Session of the FAO Council, held in November 1992, discussed the elaboration of the Code, recommending that priority be given to high seas issues and requested that proposals for the Code be presented to the 1993 session of the Committee on Fisheries.

The Twentieth Session of COFI, held in March 1993, examined in general the proposed framework and content for such a Code, including the elaboration of guidelines, and endorsed a time frame for the further elaboration of the Code. It also requested FAO to prepare, on a "fast track" basis, as part of the Code, proposals to prevent reflagging of fishing vessels, which affects conservation and management measures on the high seas. This resulted in the FAO Conference, at its Twenty-seventh Session in November 1993, adopting the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, which, according to FAO Conference resolution 15/93, forms an integral part of the Code.

The Code was formulated so as to be interpreted and applied in conformity with the relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea, 1982, as well as with the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 1995, and in the light of, *inter alia*, the 1992 Declaration of Cancún and the 1992 Rio Declaration on Environment and Development, in particular Chapter 17 of Agenda 21.

The development of the Code was carried out by FAO in consultation and collaboration with relevant United Nations agencies and other international organizations including non-governmental organizations.

The Code of Conduct consists of five introductory articles: Nature and Scope; Objectives; Relationship with Other International Instruments; Implementation, Monitoring and Updating; and Special Requirements of Developing Countries. These introductory articles are followed by an article on General Principles, which precedes the six thematic articles on: Fisheries Management, Fishing Operations, Aquaculture Development, Integration of Fisheries into Coastal Area Management, Post-Harvest Practices and Trade, and Fisheries Research. As already mentioned, the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas forms an integral part of the Code.

The Code is voluntary. However, certain parts of it are based on relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea of 10 December 1982. The Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the Parties, such as the Agreement to Promote Compliance with Conservation and Management Measures by Fishing Vessels on the High Seas, 1993.

The Twenty-eighth Session of the Conference in Resolution 4/95 adopted the Code of Conduct for Responsible Fisheries on 31 October 1995. The same Resolution requested FAO *inter alia* to elaborate as appropriate technical guidelines in support of the implementation of the Code in collaboration with members and interested relevant organizations.

Preamble

These guidelines were developed at a Technical Consultation on indicators for sustainable development of marine capture fisheries organized by the Department of Agriculture, Fisheries and Forestry, Australia (AFFA) in close collaboration with FAO, and held at Brighton Beach, Sydney, Australia, on 18-22 January, 1999. The Consultation was attended by 26 experts from 13 countries, participating in their own capacity as experts in a range of disciplines and activities connected with sustainable development of fisheries. The Consultation was supported financially by AFFA through the Fisheries Resources Research Fund with contributions from FAO and the International Centre for Living Aquatic Resources Management (ICLARM), which supported the participation of their own experts.

The guidelines were developed by small drafting groups (one for each chapter) based on the consensus developed in plenary sessions under the coordination of a Steering/Editorial Committee. The Consultation also developed a glossary of working definitions and a number of examples of criteria and indicators for the economic, ecological, social and institutional/ governance dimensions of sustainable development. These examples are not intended as prescriptive lists but should be used in conjunction with the guidelines to help understand the process of development of a system of indicators and the critical specifications of a useful set of criteria and indicators.

Interaction within the multidisciplinary group was not always easy. It reflected the difficulties one might expect to find at national or regional level when establishing a system of indicators, because of the need for the various stakeholders in the process to reach a joint understanding, develop a common language and agree on a common system of representation. The need to simplify and broaden conventional approaches to fisheries assessment and modelling created additional difficulties, forcing participants to "drop" some of the elements of complexity they normally dealt with, while adding the "forgotten" dimensions required to shift from a conventional fishery management framework (essentially based on biotechnological considerations) to a broader fisheries sustainability framework. This kind of framework represents all dimensions of fisheries together with the relevant dimensions of the broader social and economic context within which the sector operates.

If these guidelines are implemented at local, national and international level, they will represent a significant step towards improving the contribution of fisheries to sustainable development. They should be considered, however, as the first version of a guiding document that requires improvement in a number of ways. In particular, the document may have to be tailored to the various levels at which it could be implemented. It also needs better and a more complete set of methodology sheets, indicating the internationally (or otherwise) agreed techniques required to establish the key indicators and their related reference points.

In addition to these guidelines, the Consultation generated a set of scientific background papers, all related to the subject, including a thorough review of the issue of sustainability indicators, focusing on the implications for fisheries. These contributions will be peer-reviewed and published in Marine Fisheries Research, an internationally recognized journal dedicated to marine resources and fisheries.

Overview

There is a global consensus to achieve sustainable development. While a rigorous definition of sustainable development is elusive, it can be characterized as activity that improves the welfare of the current human population, without sacrificing the welfare of future generations. It recognizes that human welfare has many economic and social dimensions. The rate of sustainable development is limited by the supply of natural resources (and their rate of renewal), the availability of technology to use natural resources efficiently, and the effectiveness of social systems in distributing benefits.

Fishing is an important activity throughout the world. It contributes to human welfare by generating income for hundreds of millions of people. It provides essential dietary requirements for more than a billion people, particularly in developing countries. It fulfils cultural and recreational needs. Yet concerns have been expressed about fisheries' contribution to sustainable development and about overfishing, excess catching capacity, the depletion of some stocks, human-induced changes in ecosystems, as well as the increase and globalization of fish trade with its potential impact on local supplies and equity.

While we know that fishing is important to sustainable development, and that its contribution could be improved, the amount of objective scientific information about fishing is limited and what exists is difficult to access. In most countries, detailed information is available and management processes are in place for some important fisheries while others are poorly documented and hardly managed at all. Recognizing that information on the contribution of most human activity to sustainable development will be difficult to obtain, the nations of the world have agreed to develop and report indicators of sustainable development. Indicators should provide a practicable and cost-effective means of a) tracking progress toward sustainable development, b) predicting or warning about potential problems in the future, c) learning by comparing performance between fisheries, and d) informing policies aimed at advancing progress or avoiding problems.

Several frameworks, such as the "pressure-state-response" and the general "sustainable development" frameworks have been proposed for the design and organization of indicators of sustainable development. These frameworks complement each other and suit different purposes. What is most important is that all nations develop indicators of sustainable development for their fisheries that are consistent with international reporting commitments, and that they share this information at the relevant national, regional and global levels. Regional and national differences in fisheries are such that the goal of reporting by all nations requires flexibility. But there are important steps that should be followed in developing a system of indicators, and there are certain minimum requirements for the type of information to be reported, if the system is to be useful.

In developing indicators, it should be recognized that first and foremost, as the name implies, they should reflect the well-being of, or problems related to, the resource and human components of the system, and progress (or lack of it) towards the objective of sustainable development. Indicator-based systems are not an alternative to more comprehensive sets of information that are needed and conventionally used to manage individual fisheries and for which FAO Technical Guidelines are already available. However, trends in indicators may stimulate changes in development policies as well as in general approaches to fisheries management.

One important consideration in the development of indicators is selection of the geographical “units” for which indicators will be reported. These units should reflect the geographic scale of ecological processes that reasonably define ecosystem boundaries (recognizing that boundaries are always open for aquatic ecosystems), fishery resources and fishing activity, and political jurisdictions. While commitments have been made for national reporting, units at a regional scale (either within a nation or for shared resources of several nations) will be more appropriate in some cases. It may be useful to have indicators at finer scales (e.g. individual fisheries or sub-national regions).

Indicators should reflect the state of the system in relation to societal goals and objectives. Sustainable development is a broad goal that applies to fisheries and fisheries are one of many activities that contribute to it. While objectives for the contribution of fisheries to development may not be explicit, they are implied by the overall nature of sustainable development. Clearly indicators should measure the long-term sustainability of the ecosystem that supports fisheries and the generation of net benefits to improve the welfare of people participating in fisheries and of the broader society. There may be more specific objectives for fisheries that may also be used as the basis for indicators.

Fisheries can only contribute to sustainable development if all its interdependent components are sustained. There are many ways to represent the system, but at a minimum, the critical components are the ecosystem, the economy, society, the technology, and governance. The ecosystem includes the fishery resources that support the fishery and other aspects of ecosystems that control the productivity of the resource, including dependent and associated species. The economy is the system of costs and benefits within the fishery, and monetary flows into and out of the fishery. The fisheries’ broad contribution to sustainable development will be reflected by a net economic flow out of the fishery. The society component of the system consists of non-monetary costs and benefits which are important elements of human welfare. Governance includes the institutions as well as the rules governing the system. Indicators should reflect performance of the system in each component.

Ideally, indicators for each component should be developed by i) identifying objectives relative to the component, ii) specifying a “model” (either conceptual or numerical) of our scientific understanding of how the component functions and iii) determining the variables from the model that indicate performance relative to the objectives and for which information is available or can easily be collected and indicators constructed.

There are many criteria for selecting indicators that overlay the process described above. While these criteria are useful, there are a few critical considerations. First, indicators must be scientifically valid in the sense that, according to our best scientific understanding, they are indicative of the objective they are intended to reflect and utilize the “best scientific information available”. Second, indicators should be feasible and cost-effective in terms of their information collection demands. Third, indicators should be easily understood.

More than one indicator per component of the system may be necessary. For example, indicators for the ecosystem component should reflect not only the status of the fishery resources (i.e. are they overfished?) but also of the non-target components of the ecosystem (associated and dependent species), as well as the overall “health” of the ecosystem.

To interpret indicator changes, it is necessary to specify reference values (or reference points) that are either targets (indicating desirable states of the system and good performance) or thresholds to be avoided. These reference levels may be derived empirically by considering past performance of the system (e.g. fisheries are likely to "crash" when less than 30 percent of the spawning biomass is left) or derived from mathematical models that indicate how the system should be expected to perform.

To the extent possible, nations should strive for some common indicators for each component of a system. This will be most practical for indicators of the status of fishery resources within the ecosystem component, and indicators of revenues and costs (level of capitalization or participation) in the economy component for which generally agreed objectives and methodologies exist. But even when common indicators are not possible, valuable comparisons can be made of the direction in which each indicator is changing (e.g. "Governance is improving in 60 percent of the world's fisheries").

The usefulness of indicators will be greatly enhanced if nations and international organizations ensure that the overall indicator system is complete. For example, the complete system includes mechanisms for effective communication between fisheries stakeholders and with other ministries, sectors and the general public. There are several visual reporting methods that will greatly enhance communication. The system of indicators should be reviewed regularly so that it can be improved. Moreover, knowing that it is under routine review will encourage those that are responsible for collecting data and reporting indicators to do the best they can.

Finally, nations and international organizations should routinely (every few years) convene groups of experts to evaluate and interpret indicators. Indicators should be designed to be easily understood but, like any statistical data, they can be misinterpreted or misused. Authoritative interpretation and reporting by an expert group (with the participation of the industry and often stakeholder) will guard against misinterpretation and abuse. Of equal importance is that it will be an event that will call for action by policy-makers in response to whatever the indicators show.

Introduction

The concept of sustainable development was put on the international agenda by the World Commission on Environment and Development (WCED) in 1987[1], and confirmed by governments as an international priority at UNCED in 1992. Agenda 21 launched a process of international follow-up through the Commission on Sustainable Development (CSD). This provides for the development and application of indicators of sustainable development at various scales. The application to marine capture fisheries, where problems of unsustainable exploitation are particularly pressing, is a high priority.

The requirement for the sustainable development of fisheries is embedded in both UNCLOS and UNCED and is embodied in the FAO Code of Conduct for Responsible Fisheries, which makes the concept and principles more operational. The purpose of these guidelines is to describe how indicators of sustainable fisheries development can be developed and used. The guidelines encourage the use of indicators as a means of building a stronger shared understanding of what constitutes development in the context of the fishery sector and provide a guide to the development, use, evaluation and reporting of indicators, taking into account their ecological, economic, social and institutional dimensions.

These guidelines bring together current knowledge concerning sustainable development and indicator development in the context of fisheries and provide information for decision-makers at all levels. They propose principles and practical approaches for using indicators in the real world of fisheries. They describe how to develop and use a sustainable development reference system (SDRS) as a coherent approach to selecting indicators, reference points and the framework within which to use them, as well as techniques for visualization, communication and reporting.

This document is aimed at all decision-makers who may through their actions affect the status of fisheries. In particular, they are aimed at governments so that they can use indicators to track the progress of their fisheries towards sustainable development and the performance of their management schemes and fisheries policies against stated objectives. At an international level, the guidelines can be used to facilitate and simplify reporting under international conventions and agreements on matters relating to the sustainable development of the world's fisheries. Regional fisheries bodies and stakeholders involved in fisheries decision making, such as the fishing industry, other user groups, certification bodies, local communities and non-governmental organizations (NGOs) may also draw upon these guidelines to assist in meeting societal goals for fisheries.

These guidelines can be applied to fisheries at many different levels, from individual fisheries and coastal management units to a global level. They aim to encourage consistent usage of indicators within and between countries. Governments may also wish to adapt the guidelines to the specific requirements of their national fisheries.

The guidelines first introduce the concept of sustainable development as it applies to marine capture fisheries and the role of indicators in describing the status of and trends in the different dimensions of sustainable development. They then explain how a reference system for sustainable development helps to select the most appropriate indicators, arrange them in a framework, relate them to sustainability reference points, and produce outputs for

[1] WCED (1987): Our common future. World Conference on Environment and Development. Oxford University Press: 400 p.

communication and decision making. They review practical issues such as how to organize the process of adopting and using indicators in fisheries, how to test and evaluate a reference system for its effectiveness, and how to report the results.

A series of annexes provide a glossary, a description of the elements comprising a sustainable development reference system, the conceptual frameworks available, a description of selected ecological, economic, social, and governance/institutional criteria and indicators, a list of the most typical reference points used in conventional fisheries management, an example methodology sheet for indicators related to maximum sustainable yield (MSY), and an example sustainability checklist for fisheries management.

1. Sustainability issues in marine capture fisheries

1.1 The concept of sustainable development

The concept of sustainable development has resulted from perceived inadequacies of earlier models of economic growth and development which did not provide a broad enough base on which to make balanced judgements on the costs and benefits of various policies and tended to focus on short-term gains at the expense of longer-term aspirations. Sustainable development is simply "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987). Development in this sense relates to the quality of life and should not be confused with economic growth, although obviously the two are closely linked within our modern world systems. Other definitions and rules for sustainable development elaborate on the above definition in various ways, for example:

> *"The management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Such sustainable development conserves (land,) water, plants and (animal) genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable" (FAO Council, 1988).*

> *"Using, conserving, and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased" (Council of Australia Governments, ESD, 1992).*

All the above recognize that sustainability of activities that provide for human well-being depends on the maintenance of environmental functions which themselves, directly and indirectly, contribute to human welfare. This refers to the capacity of natural processes and their components to provide goods and services, which satisfy human needs.

An ecosystems-based view of sustainable development focuses on maintenance of the stability and resilience of the ecosystem. Sustainable development recognizes the interdependencies of human economies with their environment, and highlights the need for scientific understanding of ecosystem functioning and change.

1.2 Sustainable development of fisheries

Fishing is an important activity throughout the world. It produces more than 100 million tonnes of fish and fishery products each year and contributes to human welfare by providing a livelihood for about 200 million people. More than a billion people, particularly in the poor countries of the world, are dependent on fishery products to fulfil their need for animal protein. Fishing also contributes to human welfare by fulfilling cultural needs and by providing other social benefits, such as recreation.

However, recent reports by FAO (and by other governmental organizations and NGOs), raise concerns about the contribution of fisheries to sustainable development. Many fisheries are overfished and/or fishery resources have been depleted, thus wasting potential benefits from fisheries.

Human-induced changes in ecosystems, including changes caused by fishing, are jeopardizing the welfare of current and future generations. The fishing industry has catching capacity well in excess of the rate at which ecosystems can produce fish, so that natural resources (fish and other natural resources such as fuel oil and other non-renewable sources of energy) as well as man-made capital and human resources are not being used efficiently (at global, regional, national and local levels). The globalization of markets for fish, which has encouraged the diversion of a significant portion of fish production from local and national markets to export markets, raises concerns about how effectively benefits are distributed, relative to the welfare of a large number of people.

Considered globally, the fishing industry is a highly adaptive, market-driven and dynamic internationalized sector within the world economy. Its pressure on resources is still rising, owing to a persistent worldwide upward trend in fish consumption, in concert with continuing human population growth (especially in coastal zones). Many fishing fleets are highly mobile, and rapid technological innovation has increased their efficiency and limited the capacity of individual governments to exercise control over fishing pressure. Associated with this pressure is a variety of problems including substantial changes in ecosystem structure, wastage through discards, impacts on endangered species, loss of critical habitats, increasing conflicts and confrontations over access to fisheries, and subsidies resulting in excessive harvesting and overcapacity.

Sustainable development of fisheries will require improved governance and changes in the perspective of the main stakeholders to focus more on long-term outcomes. This would require:

- Increased awareness of factors beyond the conventional realm of fisheries management;
- Better integration of fisheries management into coastal area management;
- Control of land-based activities that degrade the marine environment;
- Stronger control of access to co-resources;
- Stronger institutions and legal frameworks;
- Greater participation by all stakeholders in the fisheries management process;
- Improved collection and sharing of information about fisheries and their environment;
- Improved understanding of the socio-economic characteristics of fisheries;
- Stronger systems of monitoring control and enforcement;
- Measures to deal with uncertainty and variability in natural resource and ecosystem dynamics; and
- Strengthening community commitment to responsible use of natural resources.

A legal framework of principles for management of fisheries already exists in UNCLOS (1982), the 1995 United Nations Implementing Agreement on Straddling Stocks and Highly Migratory Stocks (UNIA) and the FAO Code of Conduct for Responsible Fisheries (1995).

To place fisheries in a sustainable development context, policies must specifically address the trade-offs between the present and the future relating to the depletion of fish stocks as well as the disruptive impacts of fishing activity (or other economic activities), coastal settlements and waste disposal on the wider marine ecosystems. There are several objectives to consider under the heading of fisheries sustainable development:

- Sustaining fisheries harvesting and processing activities based on specified and identifiable marine ecosystems;
- Ensuring the long-term viability of the resource which supports these activities;
- Catering for the well-being of a fishery workforce within a wider community and broader economic context; and
- Maintaining the health and integrity of marine ecosystems for the benefit of other uses and users including biodiversity, scientific interest, intrinsic value, trophic structure and other economic uses such as tourism and recreation.

Indicators are now needed that can be used to determine how well these objectives are being pursued and whether the broader goals of sustainable development are being achieved.

Many of the broader objectives of sustainable development will be consistent with goals of the fishery sector such as maintenance of the fish stocks and preservation of fish habitat. Other objectives of sustainable development may, however, place limits on the way in which, or the extent to which, the fishing sector can pursue its own objectives. The need to protect endangered seabirds, for instance, may lead to restrictions on particular fishing methods and constrain the sustainable development of an industry group. A policy granting development priority to particular groups of people may also affect the way access to fishery resources is regulated. Similarly, fishing in certain areas might be restricted or excluded altogether because priority is granted to another activity such as mining, aquaculture, tourism, or nature conservation.

Managing fisheries for sustainable development is a multi-dimensional and multi-level activity, which must deal with a wider range of considerations than survival of the fish stocks and the fisheries alone. It requires information, and hence indicators, on dimensions well beyond fish stocks and fishing activity. Changes to fisheries activity should be assessed with reference to the driving forces of economic and ecological change that bear on both the demand for and the supply of fish. These external forces will include competing claims on use and management of marine ecosystems.

Figure 1 shows the relationship between more conventional fisheries management, which focuses on management of the target stocks within a management unit such as a fishery, and sustainable development of the fishery sector based on a sustainable development reference system (SDRS, described in detail below) that employs indicators and reference points. Obviously, some of the indicators will be common to these different scales but the extent of this will depend, to a large degree, on the scope and focus of objectives within the sector and the management unit. Conventional fisheries management has been concerned with sustainable development issues for a long time, but the modern trend is to broaden the concept of management to include more dimensions of the system and other fisheries and system components that are less intensively studied.

Fisheries decision making involves reconciling competing objectives and interests (from within and beyond the fisheries community) that are expressed in a variety of vocabularies and at different scales. The quality of indicators and information should be such as to help communication and coordination of actions of all those having a stake in the fisheries.

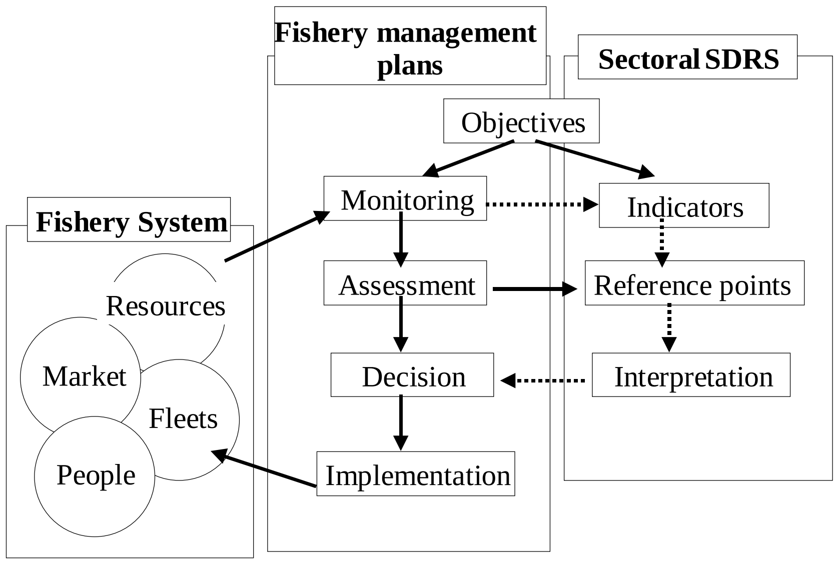

Figure 1. Relationship between conventional management schemes and a sustainable development reference system (SDRS)

1.3 The purpose of indicators

As stated above, the purpose of indicators is to enhance communication, transparency, effectiveness and accountability in natural resource management. Indicators assist in the process of assessing the performance of fisheries policies and management at global, regional, national and sub-national levels. They provide a readily understood tool for describing the state of fisheries resources and fisheries activity and for assessing trends regarding sustainable development objectives. In the process of measuring progress towards sustainable development, a set of indicators should also stimulate action to achieve sustainable development.

Indicators are not an end in themselves. They are a tool to help make clear assessments of and comparisons between fisheries, through time. They describe in simple terms the extent to which the objectives set for sustainable development are being achieved.

Indicators can be thought of as the instruments on the deck of a fishing vessel, showing the captain the orientation and speed of the vessel, the remaining fuel, and the state of the operating systems necessary to ensure that the vessel can safely continue its operations. Indicators will signal potential hazards in the vessel's pathway, but the responsibility for judging risks and changing direction rests with the captain. Just as the deck instruments do, indicators summarize large quantities of information into the few relevant signals the captain needs to take action.

Indicators provide information in two complementary ways:

- First, they provide information about activity at a given scale: for example, information about a fish stock or a specific fishing activity for a specified geographical region.
- Second, the information provided for a unit of activity at one scale allows this activity to be considered in relation to other (higher or lower) scales of activity. For example, the activity of a local fishing community may be appraised in the context of overall pressure on certain fish stocks in a broader region. Or, the economic performance of a nation's fisheries sector,

and its impact on resources, may be assessed in the context of broader evaluations of the nation's economic and environmental performance.

Questions relating to sustainable development are posed differently at different levels. Using an appropriate set of indicators, the observed state of and trends regarding fisheries resources and fisheries can either be assessed in themselves (e.g. sustainability of a fishery activity or the resource) or they can be studied with reference to sustainable development at a broader societal and ecosystem level. The application of indicators in marine capture fisheries needs to embrace both of these perspectives.

Indicators can help simplify and harmonize reporting at various levels. For example, at the **global** level, countries are obliged under various international agreements to report on progress in many facets of sustainable development. Indicators can help streamline countries' inputs to global scale reports and assessments, as well as enhance exchange of experience and comparison between countries.

At the **regional** level, indicators can assist in the process of harmonizing strategies for management of transboundary resources and for measuring the overall health of large-scale marine ecosystems. At the **national** level, countries can use indicators to produce a holistic picture of the fisheries sector and its environment.

At the fishery level, indicators provide an operational tool in fisheries management, as a bridge between objectives and management action. For example, an indicator such as an estimate of current biomass from a stock assessment model may feed into a decision rule that specifies next year's catch limit. Indicators may also be used to trigger a more general management response, such as achievement with respect to a more integrated coastal management plan.

Indicators used previously in fisheries management have tended to be biological and to focus on target species. A wider range of indicators will need to be used in assessing progress towards sustainable development, including indicators that reflect the broader ecological, social, economic and institutional objectives.

Indicators can support effective decision making and policy setting at every stage of the decision-making cycle - during problem identification, policy formulation, implementation, or policy evaluation. In developed countries, many fisheries are assessed and evaluated using models of growing complexity that require data. Model results are often very complex and their presentation may vary greatly between models. Because these findings need to be presented in a simple, understandable way, indicators play an important part in the communication of scientific results to decision-makers. In many developing countries (and developed countries in many instances), because the costs of data collection and analysis for these models may be quite high, it is not feasible to collect all the information required and a set of indicators can simplify the evaluation and reporting process.

2. The sustainable development reference system

Because there are literally thousands of indicators already in use in fisheries and thousands of others that could be used, a system for developing, organizing and using a set of indicators to track progress with respect to sustainable development is required. These guidelines are based on the development of an SDRS, which includes a framework within which to set objectives and organize the related indicators and their respective reference points. It also provides a means of presenting and visualizing the information. The terms, definitions and examples used in the following description of an SDRS can be found in Annexes 1 and 2.

In many countries much of the information required to implement a basic SDRS is already being collected. The additional work of developing and implementing an SDRS need not be time consuming or laborious but should provide a cost-effective set of indicators directly relevant to policy-making and decision-making processes. It can be seen as an investment in indicator development and should not be viewed as a technical impediment to their development. Experience in many sectors and countries has shown that meaningful indicators cannot simply be developed in a vacuum and be expected to be useful in the broader context.

An efficient SDRS, therefore, selects, organizes and uses indicators so that it

- delivers meaningful information about the achievement of sustainable development and policy objectives (including their legal basis) at the desired scale;
- is inexpensive and simple to compile and use;
- optimizes the use of information;
- handles different levels of complexity and scales;
- facilitates integration and aggregation of indicators;
- provides information that is readily communicable to stakeholders; and
- can contribute directly to improved decision-making processes.

A good SDRS will not just organize information in a useful and efficient way, it will also help to make more visible the governance and management purposes for fisheries sustainable development overall. It should signal the creation of, or reinforce, robust institutional arrangements for coordinating the actions of all involved parties in a transparent manner for the pursuit of sustainable development goals.

The development of an SDRS involves five steps:

1. Specifying the scope of the SDRS;
2. Developing a framework for indicator development;
3. Specifying criteria, objectives, potential indicators and reference points;
4. Choosing the set of indicators and reference points; and
5. Specifying the method of aggregation and visualization.

These steps will be examined in detail in the following sections.

2.1 Specifying the scope of an SDRS

The structure and scope of an SDRS will depend on the size and complexity of the system to which it is being applied, as well as on the intended uses and users of the information (for example, international agencies, the manager of a particular fishery, a member of the local community). Decisions will need to be made on:

- The overall purpose of the SDRS, in particular whether the user is considering the contribution of a fishery to broader objectives of sustainable development or to the sustainable development of the fishery itself;
- Human activities to be covered (e.g. just fishing, other uses of the fish resource, other uses of the particular area, upstream activities);
- Issues to be addressed (e.g. overcapacity, land-based pollution, endangered species); and
- What constitute the geographical boundaries of the system under consideration, based on:
    - Identification of all the fisheries and their harvesting subsectors;
    - Characteristics of the subsectors including gear, species, commercial or subsistence, etc.;
    - Nature of biological resources used or affected, e.g. straddling or highly migratory;
    - Critical habitats for the primary resource; and
    - Interaction between fisheries.

2.2 Developing and adopting a framework

Once the purpose and scope of the SDRS has been determined the next step is to develop or select a framework as a convenient way to organize indicators in relation to sustainable development. The framework can take a structural approach representing all the relevant different dimensions of sustainable development, e.g. economic, social, environmental (ecosystem/resource) and institutional/governance. It could also be oriented in a way that better reflects the pressures of human activities, the state of human and natural systems and the responses of society to the changes in those systems (pressure-state-response). Some combination of the two can be used as in the indicators framework of the UN Commission on Sustainable Development (CSD).

The choice of framework may reflect policy priorities. A framework that is already being used for other purposes can readily be adapted for use as a fisheries SDRS. Adopting a framework is really only the first stage in subdividing the broad field of sustainable development in fisheries down to an appropriate level for practical indicator selection. Although the selected framework is often not critical, it is important to use one so that meaningful indicators can be developed.

Examples of some existing frameworks based on different groupings and purposes for their development are summarized in Table 1. A more detailed explanation is given in Annex 3.

The general framework for sustainable development simply subdivides it into its human and environment dimensions. Frameworks can also be derived from definitions of sustainable development (such as the FAO definition, which results in using dimensions of resources, environment, institutions, technology and people). A framework can also be derived from the operational dimensions of the FAO Code of Conduct for Responsible Fisheries.

Framework	Dimensions	
General sustainable development framework	Human subsystem	Environment subsystem
FAO definition of sustainable development	Resources Institutions People	Environment Technology
FAO Code of Conduct for Responsible Fisheries	Fishing operations Integration into ICAM Aquaculture development	Fisheries management Post-harvest practices and trade Fisheries research
Pressure-state-response	Pressure Response	State
Commission on Sustainable Development indicator framework	Environmental Social	Economic Institutional

Table 1. Dimensions represented in some potential SDRS frameworks

The pressure-state-response (PSR) framework is a convenient way to classify components relevant to sustainable development in terms of processes, often in combination with some structural arrangement. The PSR framework considers the pressure imposed by human activities on some aspects of the system, the state of that aspect and the actual or desired societal response. It may be desirable to define indicators of pressures or driving forces since such forces are often the subjects of management intervention. Variants of the PSR framework have been developed to incorporate features such as impacts and driving forces (see Figure 2).

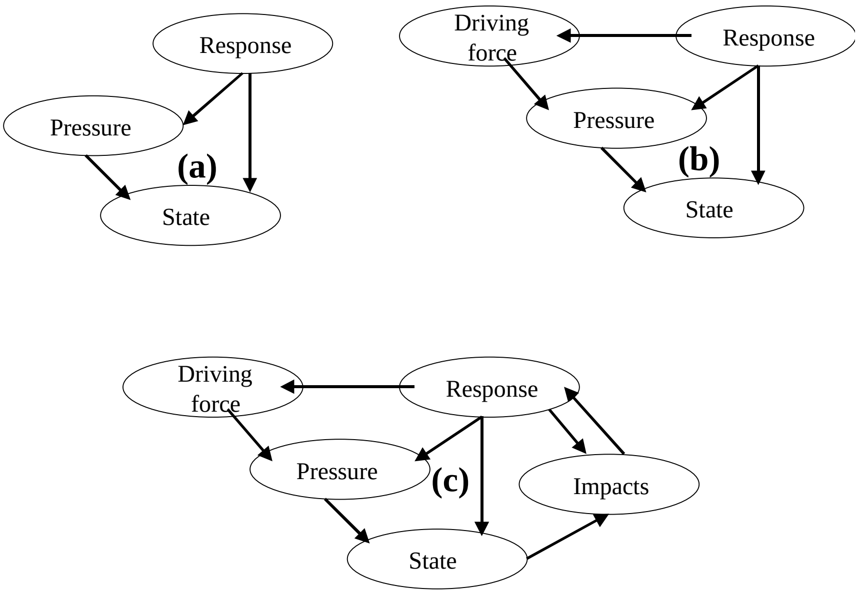

Figure 2. (a) Pressure-state-response, (b) driving forces-pressure-state-response and (c) driving force-pressures-state-impacts-response frameworks

In practice, it is not critical which framework is adopted as long as it encompasses the scope and purpose specified in Section 2.1 above. In many cases different frameworks will lead to the adoption of the same or similar sets of indicators but will provide different ways of examining the criteria to be included in the SDRS, the objectives and their related indicators and reference points.

Many structural frameworks allow their constituent parts to be subdivided hierarchically (see Figure 3). In this example, the system is broken down into the effects of fishing on humans and the environment and these categories are subdivided into food, employment, income, lifestyle, primary commercial species, “non-target” species and other environmental aspects. Further subdivision is possible. In many cases it will be essential to consider the various scales involved in the system, as shown by a simple example in Table 2.

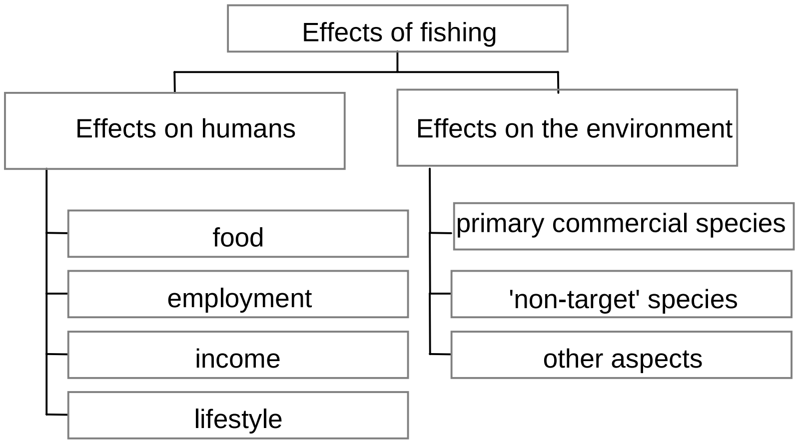

Figure 3. Hierarchical subdivision of a sustainable development framework
Source: Chesson and Clayton, 1998

		Scale (level)			
		Global	Regional	National	Local
Dimensions	Economic				
	Social				
	Ecological				
	Institutional/ Governance				

Table 2. A simple framework for indicator development based on the CSD sustainability framework and various scales relating to geographical area

2.3 Specifying criteria, objectives-related indicators and reference points

Criteria represent those properties that will be affected by the process of sustainable development. They are determined by the dimensions of the framework and within each dimension, a number of criteria should be defined for the selection of objectives, indicators and reference points. The condition or behaviour of a criterion can then be described via the indicators and reference points. The definition and purpose of an indicator was spelt out in Section 1.3. Changes in indicators over time, however, cannot be meaningfully interpreted in relation to sustainable development without considering them in relation to a reference value corresponding to the objective, which will be either a target or a constraint (limit) identified for the system. In fisheries, these reference values are conventionally called target reference points and limit or threshold reference points and mainly concern the target stock.

The selection of criteria objectives and their related indicators usually involves consideration of some conceptual view or model of how the system works and how its elements interact, often provided by an expert in the field. These conceptual views vary depending on the dimensions being considered (e.g. ecological, social, economic), and the scale (fisheries system, etc.). One goal of an SDRS is to bring together the overlapping perspectives of all dimensions of sustainable development.

Typical criteria listed against economic, environmental, social and governance dimensions are set out in Table 3. The list is by no means exhaustive, but is intended to provide a useful checklist for developing an SDRS.

Dimensions	Criteria
Economic	Harvest Harvest value Fisheries contribution to GDP Fisheries exports value (compared with total value of exports) Investment in fishing fleets and processing facilities Taxes and subsidies Employment Income Fishery net revenues
Social	Employment/ participation Demography Literacy/ education Protein/ consumption Income Fishing traditions / culture Indebtedness Gender distribution in decision-making
Ecological	Catch structure Relative abundance of target species Exploitation rate Direct effects of fishing gear on non-target species Indirect effects of fishing: trophic structure Direct effects of gear on habitats Biodiversity (species) Change in area and quality of important or critical habitats Fishing pressure – fished vs. unfished area
Governance	Compliance regime Property rights Transparency and participation Capacity to manage

Table 3. Examples of criteria for the main dimensions of sustainable development

Criteria (for instance, the relative abundance of fish in a stock) will, in general, be independent of the scale being considered. For a system using indicators to be meaningful, it must describe objectives so that progress towards them can be measured, with the use of indicators and reference points. Within an SDRS, objectives relating to given criteria will need to be identified at the various levels of the system. For instance, general objectives for overall sustainable development may be embedded in national policies, but there will also be specific objectives for individual components of the system, such as policies for an individual fishery sector, or poverty reduction in a community.

Because objectives may not be the same at the various levels being considered, different indicators relating to the criteria may be needed at different levels. The framework, the criteria and objectives relating to these criteria should together give an agreed representation of what sustainable development means from the point of view of the fishery unit being considered (a fishery, national fishing sector, global fishing) and should make indicator and reference point development almost self-evident in some cases. For a very specific objective, such as keeping fishing mortality at a certain level, the indicator and its reference point are immediately defined. When the objective is less precise, such as reducing impacts on non-target species, there will need to be some discussion about the choice of an appropriate indicator and its interpretation.

The process of developing and stating a set of objectives that is accepted by all stakeholders is itself a major step in the achievement of sustainable development. An SDRS places objectives in perspective and can help make relationships and trade-offs between objectives explicit.

For some criteria, objectives may already be well defined (for example, maintenance or rebuilding of the fish stock). For others, objectives may be implied by international agreements, legislation or public expectation (such as minimizing pollution). For yet others, objectives may never have been clearly articulated or agreed (for example, promotion of local community development).

As an example of indicators and reference points relating to one criterion of a fishery system, Figure 4 depicts the theoretical variations of a sustainability indicator of the abundance of a fish stock (its biomass, B). The objective for the particular fishery is to maintain the biomass at a level capable of supporting the optimal sustainable yield that has been specified in relation to two related reference points:

- $\mathbf{B_{lim}}$: a limit reference point indicating the lowest level of biomass compatible with sustainability of the resource; and
- $\mathbf{B_{target}}$: a target reference point indicating the level of biomass considered appropriate for the fishery and aimed at by management.

The variation in the biomass indicator in relation to the reference points identify periods of danger (when the biomass decreases rapidly towards B_{lim}), non-sustainability (when B is below B_{lim}) and sustainability (when B is above B_{lim} and at the level of B_{target}).

The traditional approach to fisheries science and management has generated a large number of potential reference points relating to stock condition, yield, revenue and fishing pressure (see Annex 5). 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, rent, by-catch, discards, biodiversity, habitat, poverty, human development and employment.

Some reference points have become international standards, e.g. maximum sustainable yield (MSY) and minimum spawning stock biomass per recruit (SSB/R) and must be included in the SDRS.

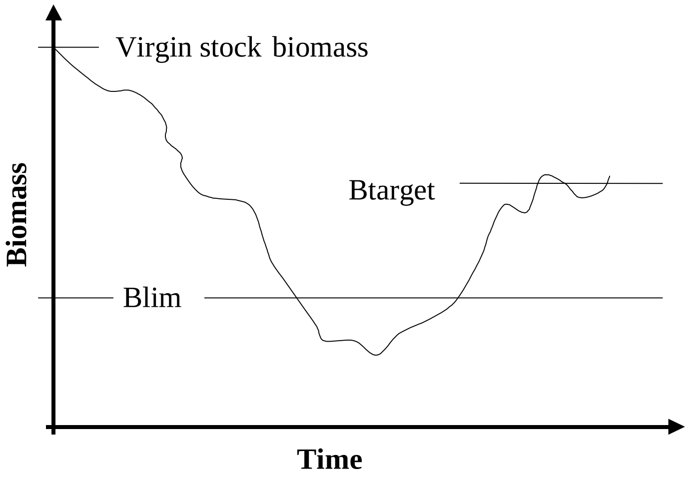

Figure 4. Example of biomass indicator and related reference points

2.4 Selecting indicators and their reference points

Even after scoping the problem, selecting the appropriate framework and determining dimensions, criteria, objectives and possible indicators and reference points, there will still be a large number of potential indicators that could be used. Indicators are generally developed from data that are already available, e.g. in institutional databases and industry records. However, the SDRS may identify areas where criteria and objectives have been developed but there is no reliable data to calculate indicators and evaluate progress against the objectives. Where such deficiencies exist, the choice of indicators for an SDRS should be restricted to a limited number of effective indicators, based on the following:

- Policy priorities;
- 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.

Proxies may be necessary as interim substitutes when use of a preferred indicator is not considered feasible.

Examples of useful criteria and general indicators relating to the ecological, economic, social, and institutional/governance dimensions, at scales ranging from global to individual fisheries are given in Annex 4. A list of the reference points used in conventional fisheries management is given in Annex 5.

Once the indicator has been selected and agreed upon, the use of standardized methodologies and specifications for indicators and reference points will help to provide a sound technical foundation for an SDRS. They also help to ensure that comparisons within and between fisheries systems are valid and consistent in their use of methodology through time. They need to be well documented and their applications widely understood. A sample methodology is given in Annex 6. The sheets include a description of the indicator, its place in the framework, its policy relevance, a description of the methodology and underlying definitions, an assessment of the availability of data and identification of the agencies involved in its development.

In summary, the steps involved in deriving indicators for an SDRS and a given framework are as follows:

1. Determine criteria and specific or implied objectives;
2. Develop a conceptual model of how the system works around which to organize them;
3. Determine what indicators and potential reference points are needed in order to assess progress towards the objectives;
4. Consider feasibility, data availability, cost and other factors determining the practicality of implementing the indicators; and
5. Document the methods used to calculate or specify the indicators.

2.5 Updating and interpreting indicators: time and uncertainty considerations

It is essential that the amount of resources required to establish the SDRS be affordable, and that the system produce information easily understood not only by policy-makers but also by other stakeholders with different educational and technical backgrounds. However, fishery systems are complex and the simultaneous interpretation of changes in a set of indicators in terms of causal mechanisms or corrective action necessary is a challenging task requiring expertise. A number of issues must be considered:

- The time dimension pertinent to the various elements of the fishery system is fundamental and will influence the period of validity (reliability) of a particular value of an indicator (its "shelf life") and the requirement for its updating. For instance, the abundance of a stock of anchovies will change faster and more often than the total size of the pelagic fleet size exploiting it. The abundance of the former may therefore have to be assessed every year while data on the latter may only need to be updated every three to five years.

- Significance of changes: Fishery indicators are measurements or results of complex calculations and the values obtained are subject to a range of uncertainty, which may or may not be known. As a consequence, variations in a given indicator are meaningful only if the changes are greater than the level of uncertainty.

The implications of these two factors are that:

- The methodology sheets should, as far as possible, identify the frequency with which the indicator should be updated.

- The indicator value should ideally be accompanied by an estimate of its variance.

- From time to time, the outputs of the SDRS should be resubmitted to an expert group, including the stakeholders, for interpretation of the changes.

2.6 Aggregation and visualization

To facilitate their use within a broader management system and their accessibility to a wider audience, indicators and their interpretation need to be presented in a form easily understood by the user.

In many instances, indicators will be presented as a simple value. However, to be able to compare indicators within and between different systems rescaling will be needed. This means converting the indicator into a ratio, i.e. dividing it by a base value, which in many instances would be the value of the related reference point. For example, if the original indicator was the current spawning biomass the rescaled indicator would be the ratio of this value to the virgin biomass, thereby ranging from 0-1.

In addition to scaling indicators it may be necessary to relate the scale of the indicator to value judgements about the extent to which it meets societal objectives. To reflect consensus, particularly in international fisheries, the scaling of such value judgements would need to be agreed among the interested parties. Table 4 presents an example.

		State (B/Bv) [1]	**Pressure (F/F_{MSY}) [2]**	**Pressure (F/F_{MEY}) [3]**	**Response (participation)**
Scale	**Good**	0.5 – 1.0	0.6 – 0.8	0.8 – 1.0	0.8 – 1.0
	Fairly good	0.3 – 0.5	– 0.6 0.8 – 1.0	0.5 – 0.8 1.0 – 1.2	0.6 – 0.8
	Average	0.2 – 0.3	1.0 – 1.3	1.2 – 1.4	0.4 – 0.6
	Poor	0.1 – 0.2	1.3 – 2.0	1.4 – 2.0	0.2 – 0.4
	Very poor	0.0 – 0.1	> 2.0	> 2.0	0.0 – 0.2

1 Assuming a limit reference point at 30% Bv and a target reference point at 50% Bv
2 Assuming a target reference point at F = 60 to 80% of F_{MSY}
3 Assuming a target reference point of 80-100% of the maximum economic yield (MEY)
Notes: B = Biomass, B_v = Virgin biomass, F = fishing mortality, F_{MSY} = Fishing mortality at the maximum sustainable yield (MSY) point, MEY = maximum economic yield

Table 4. Scaling of indicators and value judgements

A range of visualizations has been used, incorporating varying degrees of complexity and sophistication. Prescott-Allen (1996) has proposed the simple two-dimensional framework of ecosystem well-being and human well-being as a simple "sustainability barometer". A more multidimensional representation is possible using a kite diagram with several axes and illustrates the "signature" of different systems including the "ideal" one with desired values from all parameters (Garcia, 1997).

Representing indicators on a restricted number of axes often requires indicators to be combined. If indicators are to be aggregated into a single value, weighting is essential and would reflect some expert opinion or policy determination of the relative importance given to various indicators. These obviously need to be documented in the presentation of the SDRS. In many cases it will not be possible simply to combine indicators. Other aggregated indicators will need to be developed, such as the number of fisheries in which the stock biomass is above the agreed reference point.

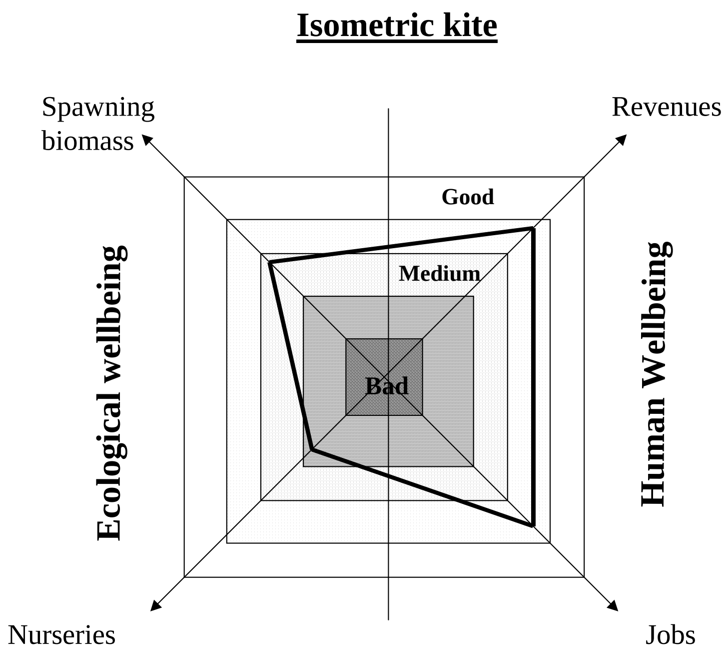

Figure 5. Kite diagram indicating the position of a fishery (black polygon) in relation to four criteria (spawning biomass, revenues, jobs and nursery areas) Source: Garcia, 1997
Note: The scale for each criteria , from “Bad” to “Good”, is indicated by the degree of shading.

In order to track progress, the dynamics of the system could be captured by either examining the trend in an indicator calculated over a period of years or by examining the rate of change of the different dimensions of the system. This could also be presented in a graph that shows the direction of progress (or lack of it) with respect to meeting sustainable development objectives.

2.7 A simple checklist procedure

The implementation of procedures for producing indicators of fisheries sustainable development is a powerful way of establishing cooperation between stakeholders (managers, fishermen, NGOs, traders, local communities and community leaders, etc.) and of signalling commitment to governance for sustainable fisheries.

A simple “checklist” procedure, however, is often an effective way to achieve an initial appraisal of the state of a fishery and of prospects for the sustainable development of fisheries and, simultaneously, to establish the basis for stakeholder communication.

If a checklist is developed covering all key criteria for fisheries management, it is relatively inexpensive to obtain the views of a wide range of interested parties on the state of the fisheries.

The checklist can be formulated as a set of questions with “yes”/“no” answers and opportunity for comment; and the enquiry can then be conducted through questionnaires and/or through a process of formal or informal interviews.

Carrying out the enquiry then requires i) that as wide as possible a spectrum of interested parties be identified, and ii) that these parties be introduced to the management process through such questionnaires or interviews.

An example checklist developed for the target fish stock is given in Annex 7.

3. Practical issues in developing and implementing an SDRS

Those in charge of assessing and reporting on sustainable development through a reference system of indicators will need to address many practical issues related to, *inter alia*: the organization and process required to implement an SDRS; the institutional support and capacity required.

3.1 Organization and process

The contribution of the fishery sector to sustainable development will depend both on its internal performance and on the macro-economic and environmental forces acting on it. As a consequence, in order to develop, institutionalize and effectively use an SDRS as a stable feature of a fishery management system, a wide range of sources of data and competencies will need to be harnessed. Those developing an SDRS will need to draw on contributions from a wide range of institutions and stakeholders.

If a country is starting to develop an SDRS for its fisheries as well as indicators for sustainable development in general, perhaps in the context of its contribution to the Commission on Sustainable Development, strong coordination will be needed to harmonize these activities. Similarly, the SDRS, its work and outcome, should become an integral part of the national (regional or global) fisheries information system.

Ensuring the flow of necessary data and the human and financial resources required for collecting data on a long-term basis requires the establishment of a dedicated institutional mechanism and set of formal linkages within the fishery sector, as well as with others with an interest in fisheries or whose activities have a bearing on them. This will involve bodies such as: ministries of planning and finance, the chambers of commerce, fishery research agencies, other natural resource agencies and coastal zone management bodies, national statistical offices, environmental agencies, industry bodies and NGOs. Depending on the purpose of the SDRS, the geographical scope of these arrangements could be global (e.g. at FAO level), regional (e.g. in the ambit of a regional fishery body), national (for the whole fishery sector) or local (for a sub-national region or an individual fishery).

Effective coordination of an SDRS will require a <u>structure</u>, a definition of <u>roles,</u> an agreed <u>process</u> and mobilization of <u>resources</u>. The following description refers to an ideal situation where governments have committed considerable resources for the SDRS. In many cases, especially those of developing countries or small island countries, a modification of this approach may be needed, based on the capacity and level of resources available. In these circumstances, the basic requirements will be the same but the level and complexity of the SDRS could be reduced to a minimum set of indicators.

The concepts of the SDRS can be employed even when there is only a very limited capacity to implement it. A simple system could be developed, choosing a few key indicators of resource condition and human well-being, based on qualitative information obtained from traditional communities by using, for example, rapid appraisal methodologies.

The structure will comprise all the institutions that need to be involved in the process, identified and selected on the basis that their work relates to the fisheries in question or they have a role in data gathering, analysis or decision making in other areas of relevance to the SDRS. There may be existing mechanisms, groups or consultative bodies involved in fisheries management or environmental assessment, such as the national or regional expert groups (e.g. for state of the environment and sustainable development reporting), advisory bodies and oversight committees, which can be used. However, specific multidisciplinary or independent expert groups may have to be created, particularly when participation needs to be enhanced.

An existing national advisory or oversight committee could assist in the SDRS process. The mandates, responsibilities and accountability of the organizations and individuals involved in the process (e.g. decision making, advising, analysing, providing data, observing) should be clearly specified. An overall coordinator for the system is required. That person may well be provided by the authority in charge of fisheries, such as the regional fisheries council, the national fisheries department, or the secretariat of a fisheries commission.

A process needs to be formalized to i) develop the SDRS, ii) trial it, and iii) use it. It is difficult to be prescriptive in relation to a process which, of necessity, will depend on national capacity. A general scenario can however be outlined with the following sequence of actions, assuming the decision to establish a fishery SDRS has already been taken:

1. Nominate a lead authority with the mandate to develop and implement the SDRS;
2. Identify a coordinator for the process;
3. Assemble a coordinating or planning group, e.g. a steering committee, and any expert groups required;
4. Undertake a desk study to plan the SDRS. This should specify the structure, the organizations needed, their potential role and contribution, the process of interaction, the basic scope of the SDRS, the framework that could be used, the key issues to be addressed, the resources needed, etc;
5. Consider and refine the plan for the SDRS by the steering committee, and seek commitment from relevant stakeholders to proceed with and support the SDRS;
6. Assign responsibilities to expert group(s) and consultative bodies, with wide participation from stakeholders. Some such groups may already exist (e.g. working groups of the regional fishery bodies). Tasks will include:

    - Developing agreement on the framework and on the respective contributions required from participating agencies to provide data;
    - Confirming the geographic area to be covered, the fisheries to be included and the issues to be addressed, to ensure a comprehensive and meaningful SDRS;
    - Developing specific aspects of the SDRS, for example:
        - Selecting a framework;
        - Clarifying objectives and identifying criteria;
        - Refining the indicators and reference points;
        - Identifying data sources, including traditional knowledge;
        - Identifying methodologies and models used in generating indicators and reference points (methodology sheets);
        - Clarifying the interpretation of the indicators and changes in them;
        - Identifying the resources needed to implement the draft plan;
        - Determining a testing protocol for a trial of the SDRS which specifies the site(s), fisheries, subsector, and (limited) set of indicators and reference points to be tested, including a timetable and criteria for evaluation of the SDRS performance; and
        - Determining a reporting format, including deciding which graphical representation to use to present the results of the SDRS.

The above process would be iterative, guided by the steering committee, and would aim to identify any policy decisions required and produce a final SDRS plan, including specification of the resources requirements and the contributions to be made by the various stakeholders.

The process may require more or fewer steps than those indicated depending on the complexity of the system being addressed (e.g. a single fishery, a national sector, or a regional set of fisheries) and the capacity of the country or commission.

Participation of the industry and NGOs from the outset is crucial to ensure their understanding and future cooperation. The involvement of stakeholders (including industry and environmental NGOs), in particular, may take different forms in different national contexts and may require the organization of meetings designed to ensure their full contribution to the process.

The adoption of the SDRS approach need not necessarily imply the establishment of permanent infrastructure, a continuous process or comprehensive coverage of a country's fisheries. For example, the work of gathering and analysing data in an SDRS context could be undertaken every few years, and apply to a limited selection of fisheries or areas, with the frequency and focus of analysis reflecting the requirements of the fisheries and the means available for conducting the SDRS.

3.2 Data and knowledge

Indicators need to be underpinned by data. Data availability and costs are major issues in the selection of indicators and adoption of an SDRS. Data availability and their quality and quantity vary greatly between fisheries and countries. The indicators chosen at the global and regional levels must have data requirements that can broadly be met across countries, and from small-scale to industrial fisheries.

Much of the data needed for an SDRS are often already being collected by different agencies or ministries. However, the availability of data is uneven across disciplines and countries. More data is available on biological and environmental aspects than on socio-economic ones. Data availability is also uneven between developed and developing countries and it may be necessary to agree on a common minimum set of information to be collected if the objective is to assess progress towards sustainable development at regional or global levels.

Rapid assessments of sustainability have sometimes taken the form of questionnaires and checklists (see example in Annex 7). The structure of these questionnaires reflects the components of the system considered most relevant for the purpose. These could be, for instance, the Articles of the Code of Conduct for Responsible Fisheries or the main components of the fishery system (such as the resource, industry, community, environment and governance). For each of these components a number of criteria are identified for which specific questions are asked, with the assumption that an accurate answer could be given in terms of "yes", "no" or sometimes "uncertain".

These questionnaires are easy to develop and could form a good basis for the development of simple qualitative SDRSs in countries with limited resources and capacity (e.g. in small island countries), allowing them to benefit from the broadening of the fisheries perspective that is a result of the SDRS process.

Questionnaires offer also a precious opportunity to increase the participation of stakeholders who can easily become involved in the design of questionnaires and their use, facilitating the assimilation of traditional knowledge and potentially improving the response of traditional fishery sectors and small-scale communities to fisheries management. Their relatively low cost allows their repeated use at not-too-lengthy time intervals, providing the basis for a long-term qualitative monitoring system, which could be implemented in practically all countries using, for example, rapid appraisal methodologies.

It is therefore worthwhile considering using questionnaires not only as the basis for a low cost SDRS but also as an integral part of more quantitative SDRS systems, described above. Questionnaires could be a useful device to generate indicators to use for some criteria of the SDRS for which quantitative indices might not be easy to generate, such as those concerned with governance.

There are several possible sources of data that should be considered. In general, first use should be made of existing data and programmes of data collection and information. This may include standard statistical reporting and monitoring, such as of catches and market information. However there is also the potential and need to use existing information that is not generally compiled or reported, such as information from fishers, communities and indigenous groups. The value and use of expert judgements should not be underrated.

In some instances, there will also be a need to collect new types of information not currently available. Important considerations include the standardization of variables and collecting protocols, and the development of an adequate sampling programme to provide estimates of parameters and associated uncertainty at appropriate levels of accuracy and geographic scale. Decisions will be necessary concerning the level of detail to be gathered in each sample unit or frame, versus the number and dispersion of these units and associated sampling costs.

As funds are always limited, use should be made of rapid assessment techniques where data from broad areas are necessary. A number of these are being or have been developed, particularly in the area of ecological and environmental monitoring and assessment. Some are based on encouraging participation by non-specialists and volunteers and can prove a cost-effective way to help further management goals via the participation of constituents. These methods provide guidance on a number of important aspects including matching effort to scale, choice of proxies and surrogates, field sampling methods, training, equipment and data handling.

Whatever the sources of data (existing reports or databases, expert knowledge, special surveys), careful attention also needs to be given to data storage and reporting. Again, there are a number of protocols available for aspects of data management. Consideration also needs to be given to such issues as data aggregation, representation of uncertainty, data type (nominal, ordinal, ratio, etc.) and data verification. The design of databases and geographic information systems for consolidating the data must be an integral part of the planning process. There are many databases around the world for which access is extremely limited because of technical difficulties in obtaining useful data subsets or bureaucratic obstacles such as the granting of clearances or the assessment of fees. In general, the design should be heavily based on the need to disseminate the data widely in a range of useful forms, while giving credit to contributors. The institutionalization must be financially supportable for the projected life of the activity.

At regional and global scales, international agreements on standards and data exchange are essential to reasonable assessment. There are international agreements under which many countries report catch within standard species groupings. However, the utility of this data is often severely limited because the catch is not subdivided in any ecologically meaningful way. There is an urgent need for the further development of such agreements to provide data by major ecosystem. Such agreements, in addition to being crucial to broad area summarization of policy decisions, would also facilitate the comparative assessment of sustainable development among nations.

3.3 Communication

The whole process should be underpinned by an effective communication strategy. Because of the necessity to obtain the long-term commitment of institutions other than those concerned with fisheries and to enlist the support of stakeholders for the system, it will be vital to publicize the initiative, familiarizing all concerned with: i) the fishery issues, ii) the role of an adequate system of indicators, and iii) the role of the various partners. An important part of the required interaction and communication will take place in the working groups and other meetings but the wider public could also be kept informed through newspapers and other media.

Making the indicators system accessible through the Internet would be an effective way to communicate the results rapidly to a wide audience. Ideally, however, the set of indicators (and the changes it identifies) should be accompanied by an expert interpretation.

Communication of the SDRS information to the policy- and decision-makers is of course essential. This implies that the fisheries division in charge of the routine implementation of the system be formally requested, and that it commit, to bring the output of the system regularly to the attention of the higher fishery authorities (e.g. when the annual review of the state of fisheries and resources is undertaken).

3.4 Capacity building

Limited technical and capital resources and gaps in scientific training in many developing societies mean that development assistance including science and technology contributions from other countries is a key ingredient of strategies of sustainable development. International cooperation is one way of building up management, reporting and monitoring capacity in countries where fisheries science and ecosystem management resources need to be developed. This should be seen as a partnership that involves local and external experts to bring together available knowledge, to organize it, and build a systematic monitoring capacity.

It is often desirable to establish stakeholder partnerships and co-management structures, involving the fisheries sector together with public policy-makers and fisheries scientists, external funders, and stakeholders representing the communities' interests. In this way it is possible for a longer view to be incorporated into investments in research, monitoring, information gathering, analysis and reporting activities, for "external costs and benefits" to be integrated, and for compromises to be sought where there are conflicting economic interests, environmental concerns and social priorities. The effective use of knowledge for sustainable development means bringing together different strands of science, local knowledge and experience in problem solving, for example:

- Combining the expertise of public, private and community sectors;

- Establishing interfaces between formal knowledge and informal understanding and know-how about fisheries and ecosystems;
- Recognizing complementarities between local and external expertise; and
- Reconciling different stakeholder interests covering urgent social needs, commercial interests, policy-makers' requirements and long-term sustainability concerns.

Capacity building in the developing countries is a process of mutual learning. The development of many processes can benefit from the integration of local, informal, formal and international expertise: for instance, a) those to assess scientific uncertainty and accommodate scientific dispute over fisheries and ecosystems, and b) others to integrate stakeholder interests and perspectives in relation to (e.g.) catch limits, permitted technology, access regimes, compliance and monitoring.

4. Testing and evaluation of an SDRS

Development of an SDRS will be an iterative and adaptive process, with experimentation and learning over time, both within and between jurisdictions and regions. Countries will wish to assess many aspects of how well an SDRS is performing, including considerations of cost and benefit.

4.1 Evaluation of the SDRS

Evaluation covers how well an SDRS is implemented. It could be covered by a model such as the ISO 9000, or through a checklist as outlined below (Table 5). This checklist could also be useful at the design stage of developing an SDRS. The important point is to ensure that all relevant aspects are covered, e.g. inclusivity and transparency.

Aspect	Question
Scope and purpose	Has the SDRS scope and purpose been clearly specified? Are the objectives consistent with sustainable development aspirations?
Specifications	Are the design and methodologies of the SDRS clearly documented and available? Do they adequately address the stated scope and purpose of the SDRS?
Participation	Has the SDRS documented a definition of “stakeholders"? Does the SDRS process include full consultation with representatives of all stakeholders? Amongst the stakeholders, is the SDRS mechanism sufficiently inclusive of fishers to encourage responsible resource stewardship?
Data collection	Is a data collection system in place to provide indicators for all dimensions of the SDRS (e.g. ecosystem; economic; social; institutional)?
Research	Has directed research been supported where knowledge was needed in the short term? Has research to assess indicator validity been supported?
Indicators	Have indicators been developed for all key criteria and do they relate to the specified objectives?
Reference points	Has a reference point been established for each indicator?
Reporting	Is a mechanism in place to report the SDRS results to all stakeholders? Is a publicly accessible description of the design and results of the SDRS available?
Acceptance/use	Are there any outstanding disagreements as to implementation of the SDRS? Has the SDRS fed into a wider sustainable development reference system? Have the SDRS outputs been widely reported (e.g. through national media)? Have the SDRS outputs been used in decision making (e.g. leading to changes in national priorities or strategies)?

Table 5. Evaluation checklist for an SDRS

4.2 Testing of indicators

In many cases, indicators used will be proxies for the underlying criterion of real interest. Examples of such indicators might be catch per unit of effort (CPUE) as a measure of relative abundance (an indicator of resource status) and level of catch as an indicator of economic performance.

A key issue in using such proxy indicators is, how well do they reflect trends in the actual variables of interest? In many instances there is no alternative to the use of proxy indicators, but there is a need to test their validity, to improve their use over time and to reject those proxy indicators that do not provide a valid reflection of the variable they are intended to represent.

There are various ways in which the validity of indicators can be tested. Several of these are possible prior to implementation, although such information and analyses are frequently not available or may be impractical to implement. The basic methods for testing include:

- Analysing other documented cases of use of the indicator, where there is additional information on the true underlying attribute, to test the performance of the proxy across a wide range of applications or situations. An example might be how well CPUE reflects trends in abundance where there are fishery-independent data available on those trends. A refinement of the method would be to look at the circumstances (types of gear or types of fish) for which CPUE does or does not appear to reflect changes in abundance.
- Intensive studies to test indicators, by collecting additional information on the underlying variable to compare with the proxy indicator for the particular system under consideration. This approach may use spatial and/or temporal contrasts to provide the information to test the indicator. It is likely to be feasible only in a small subset of cases.
- Simulation testing, which involves testing the performance of indicators using Monte Carlo simulation methods.

Retrospective testing may be useful for indicators such as outputs from stock assessment methods where the estimated performance relating to a particular variable (e.g. recruitment) may improve over time.

5. Reporting

For indicators to be a successful tool in signalling progress towards sustainable development, an adequate form of reporting the outcomes of an SDRS is essential. This means a report with information that is accurate, complete, transparent and timely. The report should enable the reader to assess the extent to which progress towards sustainable development has been achieved, as well as to evaluate the quality and the usefulness of the indicators and the SDRS used. Reports should be simple, easy to read, written in plain language readily understandable by stakeholders.

A report from an SDRS should contain as a minimum:

- A description of the SDRS used, including the framework, indicators and reference points;
- An explanation of the methodology for calculating the indicators and reference points;
- Signals from the indicators with accompanying confidence range;
- Interpretation and analysis; and
- Conclusions in relation to the objectives.

The content and format of the report should be consistent with similar reports (e.g. across fisheries in a country, across countries in a region, and globally). This will enable aggregation and comparison for interpretation at a regional or global level.

The results from an SDRS should be readily available to all those with an interest in the fishery. Access to the results will assist in gaining the support of stakeholders for actions flowing from the SDRS that are needed to achieve progress towards sustainable development.

Stakeholders should be involved in preparing such reports where relevant. Indicators and analyses using indicators should be open to validation and verification by any interested party. Peer review of national reporting performance should be routine. Transparency in reporting will also provide an opportunity for stakeholders to comment on the relevance and effectiveness of indicators and to be involved in improving the SDRS.

The target audience for an SDRS may be:

- An international body engaged in general sustainable development, such as the United Nations General Assembly, the Commission on Sustainable Development, or the Conference of Parties of the Convention on Biological Diversity;
- A global body concerned with marine resource management, such as FAO or the Intergovernmental Oceanographic Commission;
- A regional body such as a regional fishery commission, or an intergovernmental regional seas programme;
- A national level agency;
- A stakeholder group, e.g. producers, industry, consumers, the general public; or
- Local communities.

Apart from meeting the needs of the target audience, the report should also aim to be useful to a wider audience, particularly the stakeholders in a fishery.

The frequency of reporting should be sufficient to deliver meaningful information on trends towards or away from sustainable development. There is a need for consistent time series across stocks, nations or regions to ascertain trends and enable comparisons. In many fisheries around the world, biological and operational data are routinely collected and assessments conducted on an annual basis. The impact of particular ecological and economic processes may necessitate other reporting time scales for an SDRS. The reporting frequency should capture the rate of change in the system.

Information generated through national SDRSs should be provided to the national statistical agency as a contribution towards national accounting systems. At the global level, the system of national accounts (SNA) has been extended to include accounts for environmental assets and flows across the economy-environment interface — the System of Economic and Environmental Accounts (SEEA). The SEEA provides a means of organizing much fisheries information at the scale of sectoral aggregation within national economies. It may be a helpful source of information for assessments of the past and present significance of the fisheries sector within a national economy and, more significantly, appraisals of the future contribution of fisheries to a national economy.

A major issue in reporting SDRS outcomes is that indicators can highlight situations and trends that may be sensitive at national and international levels. Such sensitivity has the potential to undermine the validity or completeness of SDRS reports and the extent to which their results are available to stakeholders, and may thereby compromise progress towards sustainable development.

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Annex 1: Glossary

Biodiversity. The variability among living organisms from all sources and the ecological complexes of which they are part. This includes diversity within species and of ecosystems (CBD, 1994).

Co-management. The shared responsibility for, and involvement in, the management of local natural resources, between two sets of actors, the community on the micro-level and the State (represented by and often mediated through the regional administration) on the macro-level. Participation in co-management arrangements is based upon comparative advantages and shared interests. The state will, as a rule, retain overall decision-making authority. Also referred to as "collaborative management" and "partnerships" (Borrini-Feyerabend, 1997) (cf. **community** and **community-based management**).

Community. The local management unit, comprising i) a number of persons bounded by a shared culture, consisting of e.g. language, religion, social organization and values; and ii) the surrounding environment which provides the basis of their livelihood and the focus of their subsistence activities. The spatial character of the community, meaning the habitation part as well as the surrounding environment, may or may not be clearly delineated from the point of view of the outside (the term "village" accordingly should not be used). There will often be disagreements between the members of the community and the state as to the spatial extent of the community and the character and extent of the rights to extraction of natural resources (Kuper and Kuper, 1989).

Community-based management. Management of local natural resources by, with and for members of the local community. A specific result of conscious efforts on the part of the state to decentralize and devolve responsibilities to the lower administrative levels. Denotes management practices that recognize the importance of involving local people. The starting point is local resource degradation, and the natural outcome of the analysis of available options is management through community action (Uphoff, 1998). Often referred to as community-based natural resource management (CBNRM). May or may not be identical with the local level in a co-management arrangement " (cf. **co-management**, **community** and **governance**).

Compliance regime. The system of measures designed and implemented to ensure compliance with legislation and regulations, including *inter alia* a monitoring, control and surveillance system.

Criteria. Components of the sustainable development reference system whose behaviour can be described via indicators, proxy-indicators and reference points. For example, *fishing capacity* is a criterion related to fishing pressure, *spawning biomass* is a criterion related to the well-being of the stock and *total income* (in cash and in kind) a criterion related to the well-being of humans in the fishery.

Dimension. The classes used to describe a system. Examples include: i) ecological, economic, social and institutional; ii) pressure-state-response; iii) human and environmental; and iv) operations, management, research, aquaculture and coastal zone management.

Ecological resilience. Capacity of a natural ecosystem to recover from disturbance.

Environmental accounting. Refers to national accounting systems which have been extended to include information on the state of the environment and on interactions (e.g. pressures) between economy and environment. Environmental accounts include some information categories expressed in monetary value terms, and others in non-monetary units of measure.

Fishery management plan. A formal or informal arrangement between a fishery authority and interested parties that identifies the partners in the fishery and their respective roles, details the agreed objectives for the fishery, specifies the management rules and regulations that apply to it and provides other details about the fishery that are relevant to the task of the management authority, which may include achievement of multiple objectives.

Framework (See: **sustainable development framework**)

Global commons. The idea of governance extended to include natural resources and endowments. Understood as access to a public good wherein there is no clearly defined political process in which users cede rights to a negotiated regulatory body, often extending across juridical boundaries (Buck, 1998). High seas, for instance, represent important global commons (cf. **governance**).

Governance. The pattern of interaction between the government of a state and its citizens. Refers to the overall process of involving citizens in the political process. Governance is based upon, and contributes to, a social contract between the state and its citizens, where both parties recognize the legitimacy of the rules governing society (cf. **co-management** and **community-based development**).

Indicator. A variable, pointer, or index related to a criterion. Its fluctuations reveal the variations in those key elements of sustainability in the ecosystem, the fishery resource or the sector and social and economic well-being. The position and trend of an indicator in relation to reference points or values indicate the present state and dynamics of the system. Indicators provide a bridge between objectives and actions.

Maximum Sustainable Yield (MSY). The highest theoretical equilibrium yield that can be continuously taken (on average) from a stock under existing environmental conditions without significantly affecting the reproduction process. Also referred to as potential yield. It is estimated using surplus production models (e.g. the Schaefer model) and other methods. In practice, however, MSY and the level of effort needed to reach it are difficult to assess. Referred to in UNCLOS, it is an essential fisheries management benchmark but it is also one of the possible management reference points. It is also considered an international minimum standard for stock rebuilding strategies (i.e. stocks should be rebuilt to a level of biomass that could produce at least MSY).

Maximum Economic Yield (MEY). The theoretical greatest difference between total revenues and total costs of exploiting a fish stock under existing environmental conditions and where inputs are valued at their social opportunity costs. MEY is equal to the maximum resource rent and is obtained where the marginal product of effort is equal to the marginal cost of effort. MEY is realized at a level of fishing effort which is below that one which produces MSY.

Objective. A purpose to be achieved within the overall principles of sustainable development. Objectives are often hierarchical, referring to specific scales within the system. Objectives encompass all the dimensions and relevant criteria of sustainable development.

Opportunity costs. The benefit foregone by using a scarce resource for one purpose instead of its next best alternative; typically applied to capital and labour inputs to reflect their real costs to society as against their costs to a private entrepreneur which may be lower or higher because of subsidies, taxes and various kinds of market distortions including externalities.

Reference point. A reference point indicates a particular state of a fisheries indicator corresponding to a situation considered as desirable ("target reference point"), or undesirable and requiring immediate action ("limit reference point" and "threshold reference point") (Caddy and Mahon, 1995; Garcia, 1996). Also referred to as "reference value".

Scale. Various levels of organization to be considered within the SDRS. Scales can be based on geographical area (e.g. global, regional, national or local), sectoral activities (e.g. individual fishery, fishery sector at various geographical levels, or cross-sectorial to include other uses and activities within a system) or a combination of both.

SDRS (See**: sustainable development reference system)**

Stakeholder. Any individual, group, organization or sector in society that has a clearly identifiable interest in the outcome of a policy or decision-making situation. The interest may be in the form of a specific management responsibility, a commercial interest (resource supply, revenue, employment, trading activity), a subsistence need or some other commitment, as a member of civil society.

Standard. Reference point (or reference value) which has been formally established and enforced by an authority (e.g. MSY is established as a standard by UNCLOS and could become a minimum international standard for stock rebuilding).

Sustainable development framework. Structure used to select and organize criteria, indicators and reference points. It is based on a particular set of dimensions. Examples include: pressure-state-response; ecological sustainable development; and the FAO Code of Conduct for Responsible Fisheries.

Sustainable development reference system. The sustainable development reference system (SDRS) is a system of representation of the sustainability of a system of exploitation (e.g. a fishery or a fishery sector), composed of reference points (selected on the basis of objectives, constraints and limits) and indicators. The SDRS will generally include a wide range of indicators that covers broad ecological, social, economic and institutional objectives. However, despite having as its primary purpose the measurement of achievement and progress in sustainable development, the SDRS should also, in a general sense, provide an incentive to review strategies for achieving sustainable development.

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Annex 2: Elements of an SDRS: terms, definitions and examples

The various elements that comprise a sustainable development reference system (SDRS) are often referred to differently in different documents. In these guidelines the following nested set of concepts and definitions has been used (from the highest to the lowest level). Two examples are given.

Frameworks

A framework is the structure used to select and organize indicators and reference points. It is based on a particular set of dimensions. A number of frameworks for sustainable development are currently being used worldwide. The main difference between the various frameworks lies in their dimensions, which tend to emphasize the different needs and purposes of an SDRS (see Annex 3). Examples include:

1. The general framework for sustainable development;
2. The FAO definition of sustainable development;
3. The FAO Code of Conduct on Responsible Fishing;
4. Pressure-state-response; and
5. The CSD indicator framework.

Dimensions

The dimensions of a framework are the classes used to describe a system and for which criteria, indicators and reference points will be needed. For each fishery or sector, a number of dimensions can be defined, based on the framework selected. For example, the dimensions of the frameworks listed above are:

1. Human subsystem; environment subsystem;
2. Resources; environment, institutions, technology, people;
3. Fishing operations; fisheries management; integration into integrated coastal area management; post-harvest practices and trade; aquaculture development; fisheries research;
4. Pressure; state; response; and
5. Environmental; economic; social; governance/institutional.

Scale

In principle, an SDRS could be established at various scales depending on its purpose. The scale will determine the degree of resolution required for the definition and reporting of the indicators. For example, indicators could be assembled at global, regional, sub-regional, national, sub-national and fishery level.

Objectives

Objectives indicate what one is trying to achieve within the overall principles of sustainable development. Objectives are often hierarchical, referring to specific scales within the system and encompass all the dimensions and relevant criteria of sustainable development. Within an SDRS, a range of objectives will need to be achieved, often at the different scales identified above.

Examples are: to improve revenues and production in the country; to improve employment in a region; to reduce the levels of discarding in trawl fisheries or in a specific fishery.

Criteria

Criteria are components of the SDRS whose behaviour can be described via indicators and reference points. They represent those properties that will be affected by the process of sustainable development. They are related to the dimensions of the framework and are selected to reflect specific objectives. In general, criteria will be independent of scale. Thus to be able to examine the sustainable development of a fishery within the CSD framework (Example 5 above) the following criteria might be used: *spawning biomass* reflects the well-being of the resource; *fishing capacity* relates to fishing pressure; *income* (in cash or kind), which relates to the well-being of the human population; and *fisheries legislation* relates to governance.

Indicators and reference points

An indicator is a quantitative or qualitative value, a variable, pointer, or index related to a criterion. Its fluctuations reveal the variations of the criteria. A reference point indicates a particular state of a fisheries indicator corresponding to a situation considered as desirable (target reference point, TRP), or undesirable and requiring immediate action (limit and threshold reference points, LRP and ThRP). Reference points relate directly to human objectives (TRPs) or system constraints (LRPs). The position and trend of the indicator in relation to the target or limit reference points or values indicate and qualify the present state and dynamics of the system. They provide the elements needed to assess the situation and a bridge between objectives and actions.

For example, if the catch of mature fish per unit effort (CM/f) is taken as an indicator of spawning stock biomass, the value of this indicator at the level of maximum sustainable yield, $(CM/f)_{MSY}$, would be an acceptable target reference point (a value to aim at) according to UNCLOS provisions. It is often agreed that when this indicator reaches 20-30 percent of its value in a virgin stock, (CM/f)v, the probability of recruitment failure is very high. As a consequence, 0.3(CM/f)v could be considered an LRP or a value to get away from.

Example 1: Capital Productivity

The following sections illustrate, with two example taken from the economic dimension of fisheries, the meaning and hierarchy of the various terms used in the guidelines.

Dimension: economic

Objective: economic efficiency

Criteria: capital productivity

Indicator: financial net return/capitalized value: (T-TOC-TS)/CV. The variables are defined in the text below.

Scale: fishery (by fleet segment, e.g. trawlers)

Limit reference point: capital productivity at equilibrium as provided by a bioeconomic model or raw estimates. It is thus assumed that total trawl fleet is calculated on the basis of a defined standard vessel, which implies that the fleet is equivalent to the sum of standard vessels. Total fleet is therefore equivalent to that of a single enterprise.

Target reference point: is set on the basis of a regional development policy in accordance with the reference point.

Information	Examples of data	Source of data
Capitalized value (CV)	Investment; replacement value of vessel; depreciation rate; inflation index	Banks, administration, Treasury, industry, boat- builders
Turnover (T)	Landings; prices	Administration, auctions, processors, industry
Total operation costs (TOC)	Fuel consumption; wages; access fees	Administration, industry, insurance companies
Taxes and subsidies (TS)	Value added tax; Taxes on income; fuel subsidies; interest refund	Administration, Treasury, banks

CV: the capitalized value, is the total present value of investments of different ages. The insurance or replacement value of vessel are possible estimators of value taking into account relevant actualization factors:

$$\mathbf{CV = I + CV' \times D}$$

where: I is the investment of the present period, CV' is the capitalized value of the previous period and D is the depreciation rate.

T: the total value of landings (all species and all commercial categories). **TOC** is the sum of variable costs (VC) and fixed costs (FC).

VC: the variable costs that depend directly on level of activity, such as consumption of fuel or ice which is proportionate to number of fishing trips, or *ad valorem* expenses (auction and other costs) that are proportionate to volume or value of production. In the case of inshore fisheries, the variable costs can include wages (e.g. *pro rata* remuneration) in contrast to industrial fisheries where the wages can be considered as fixed costs.

FC: the fixed costs resulting directly from the initial decision on scale of production structure and therefore not dependent on level of activity. Some derive from strategy decisions by the vessel owner (e.g. cost of investment and financial package), others do not (e.g. insurance, access fee).

Interpretation of the indicator:

<u>Below reference point:</u> possible result of: overcapitalization, inappropriate input costs or high taxation pressure. Timely management action required, further and permanent monitoring of all variables needed (e.g. at a yearly base).

<u>Close to reference point:</u> could indicate an apparent economic equilibrium (stable or non-stable); frequent monitoring of the indicator needed (e.g. two to three years).

Above reference point: could indicate that the fishery is economically efficient (unless subsidies are high): extra rent could be extracted. The indicator should be monitored over a longer time span (e.g. three to five years).

The response can be at a fisheries management level through subsidies, access fees or total capacity authorized.

Example 2: Productivity of Production Factors

Dimension: Economic

Objective : Economic efficiency

Criteria: Productivity of the factors of production

Indicator: Resource rent (TR – TC). The variables are defined in the text below.

Scale: fishery (by fleet segment, e.g.: trawlers)

Limit reference point: The resource rent (TR-TC) is equal to zero. Corresponds to the open access bio-economic equilibrium and may reflect a level of fishing effort exceeding f_{MSY}.

Target reference point: The resource rent (TC-TR) is maximum (as qualified by objectives relating to income distribution and employment)

Information	Examples of data	Source of data
Opportunity costs of capital and labour	Capital interest rate Wages and salaries in other sectors Unemployment rate	Banks, Administration, Treasury, Industry, Boat- builders
Total revenue (TR)	Landings; prices	Administration, Auctions, Processors, Industry
Total costs (TC)	Variable costs (VC) such as fuel costs; wages; etc. Fixed costs (FC) such as capital depreciation, interest etc.	Administration, Industry, Insurance companies
Taxes and subsidies (TS)	Taxes on income; fuel subsidies; interest refund ;	Administration; Treasury ; Banks

(TR): Total Revenue: the total value of landings (all species and all commercial categories) and (TC) is the sum of variable costs (VC) and fixed costs (FC), both valued at their opportunity costs.

(VC): Variable costs: the costs that depend directly on the level of activity, such as consumption of fuel or ice which is proportionate to number of fishing trips, or *ad valorem* expenses (auction and other costs) that are proportionate to volume or value of production. Costs are valued at their opportunity costs and are net of taxes and subsidies.

(FC): Fixed costs: Costs resulting directly from the initial decision on scale of production structure and therefore not dependent on level of activity. Some derive from strategy decisions by the vessel owner (e.g. cost of investment and financial package), others do not (e.g. insurance, access fee). Capital inputs are valued at their opportunity costs and are net of taxes and subsidies.

Interpretation of the indicator:

Below the limit reference point: The fishery is likely to be seriously over-capitalized due to ineffective fisheries management of fishing capacity. It causes a net loss to the economy. Corrective management action is required together with close monitoring of the indicator (e.g. on a yearly basis).

Close to the limit reference point: The fishery is close to the bio-economic open access equilibrium (which may be stable or unstable). Fisheries management is ineffective or non-existing. Precautionary management action is needed to ensure that the limit is unlikely to be passed and that the situation is improved. Frequent monitoring of the indicator required (e.g. every 2-3 years).

At or above target reference point: The fishery is likely to be effectively managed and economically efficient resource rent could be extracted if not already capitalized in quota prices or captured through taxes or license fees. Less frequent monitoring of the indicator is required (e.g. every 3 to 5 years).

The response can comprise the introduction of an effective fishery management regime through the establishment of well defined and enforced exclusive use or property rights or through the levying of resource use taxes or fees.

Annex 3: Conceptual frameworks for sustainable development [2]

In the following sections, a number of potential frameworks are considered: i) the FAO definition of sustainable development; ii) the Code of Conduct for Responsible Fisheries; iii) the general framework for sustainable development; iv) the pressure-state-response (PSR) framework and its variants; and finally v) the ecologically sustainable development (ESD) framework. The following sections will briefly describe these frameworks highlighting their differences and relationships.

1. The FAO definition of sustainable development

The definition of sustainable development adopted by FAO can be considered a very general framework for fisheries sustainable development. This definition establishes five main components: the multiple resource in its environment; social and economic human needs; the technology; and the institutions. While the first two must be conserved, the others need to be respectively satisfied, controlled and established through the general management process.

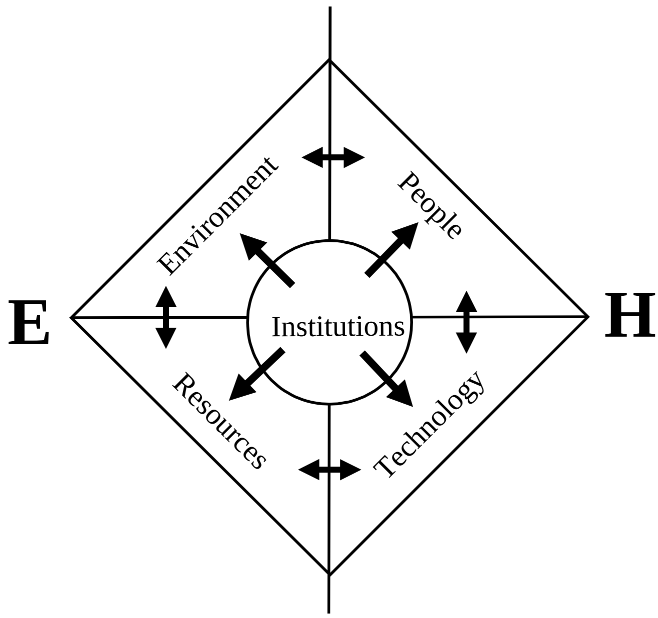

Figure 1. Schematic representation of the FAO sustainability framework
Source: Garcia and Staples (in press)

It can be noted that such a framework addresses the two main concerns of sustainable development: environmental well-being (E, through both the environment and the resource *sensu stricto*) and human well-being (H, through the people, the technology and institutions). A number of indicators, each of which may integrate more than one variable, would be needed to track: a) the resource endowment, including its abundance, diversity and resilience; b) the environment, for example by reference to its pristine condition; c) the technology in terms of capacity as well as environmental impact; d) the institutions (e.g. fishing rights, enforcement

[2] This Annex draws heavily on Garcia, S.M. and Staples, D. (in press). Sustainability reference systems and indicators for responsible marine capture fisheries: a review of concepts and elements for a set of guidelines. Paper prepared for the Australian-FAO Technical Consultation on Sustainability Indicators for Marine Capture Fisheries, Sydney, Australia, 18-22 January 1999. *Marine Fisheries Research.*

system); and e) the human aspects including benefits (food, employment, income), the economics of exploitation (costs, revenues, prices) and the social context (social cohesion, participation, compliance). However, the FAO definition is a broad one, applicable to all development sectors and does not give prescriptive details to identify specific targets, criteria and indicators. The FAO Code of Conduct for Responsible Fisheries fills that gap.

2. The Code of Conduct for Responsible Fisheries

The Code of Conduct for Responsible Fisheries was adopted by FAO Member Governments in 1995 and is considered by fishing and coastal nations as the practical foundation on which to establish sustainable fisheries in the future. It offers a different but related sustainability framework and its system structure has an operational focus. Instead of showing the balance between the well-being of the environment and human well-being, it is subdivided into a number of operational Articles: i) fishing operations, ii) fisheries management, iii) integration of fisheries into coastal area management, iv) post-harvest practices and trade, v) aquaculture development, and vi) fisheries research. This structure is optimized for "implementation" (as opposed to "reporting") and its different components correspond roughly to different groups of stakeholders (fishermen, managers, processors, traders, fish farmers and scientists).

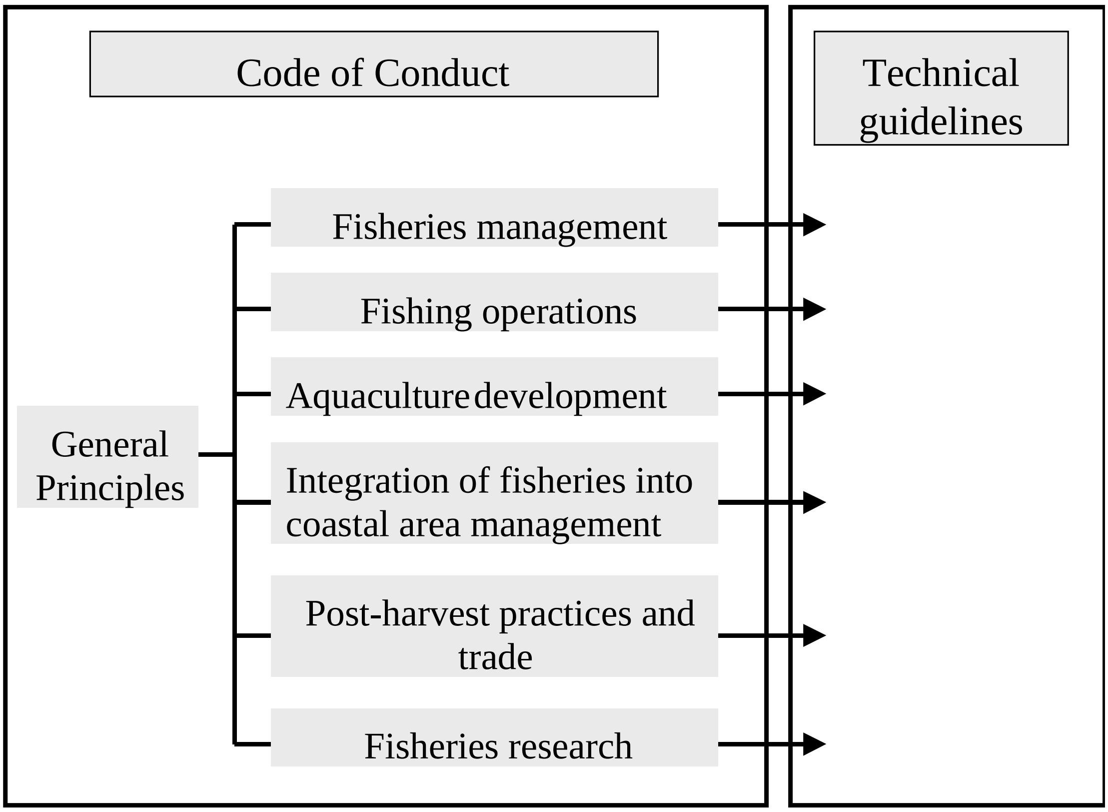

Figure 2. The framework of the FAO Code of Conduct for Responsible Fisheries
Source: Garcia and Staples, in press

This formal (and voluntary) framework is completed by a series of technical guidelines produced by FAO in support of its implementation, the list of which remains open-ended. Such guidelines could be complemented as required by specific technical protocols. Each of these Articles (and guidelines) contains a number of provisions (and approaches and options) that call, explicitly or implicitly, for a number of specific targets, criteria and indicators.

The close relationship between the numerous and detailed prescriptions of the Code of Conduct and the FAO definition of sustainable development has been highlighted by Garcia (in press)[3] who distinguished, in the FAO definition, three main elements: i) conservation (and sustainability) of the multiple resource in its environment; ii) satisfaction of the social and economic needs of human beings; and iii) management of the required changes in institutions and technology. Garcia developed principles or objectives for each of these elements, which may form the basis for the selection and development of specific indicators. For each principle and sub-principle he also identified the relevant specific provisions of the Code of Conduct (not reproduced here) as well as the criteria and indicators necessary to monitor the effectiveness of its implementation.

3. The general framework for sustainable development

The general framework for sustainable development is less detailed than the Code of Conduct because it has been designed for general application and has the advantage of explicitly identifying the two domains of well-being (the environment and the human subsystems) and how they relate to one another (see Figure 3).

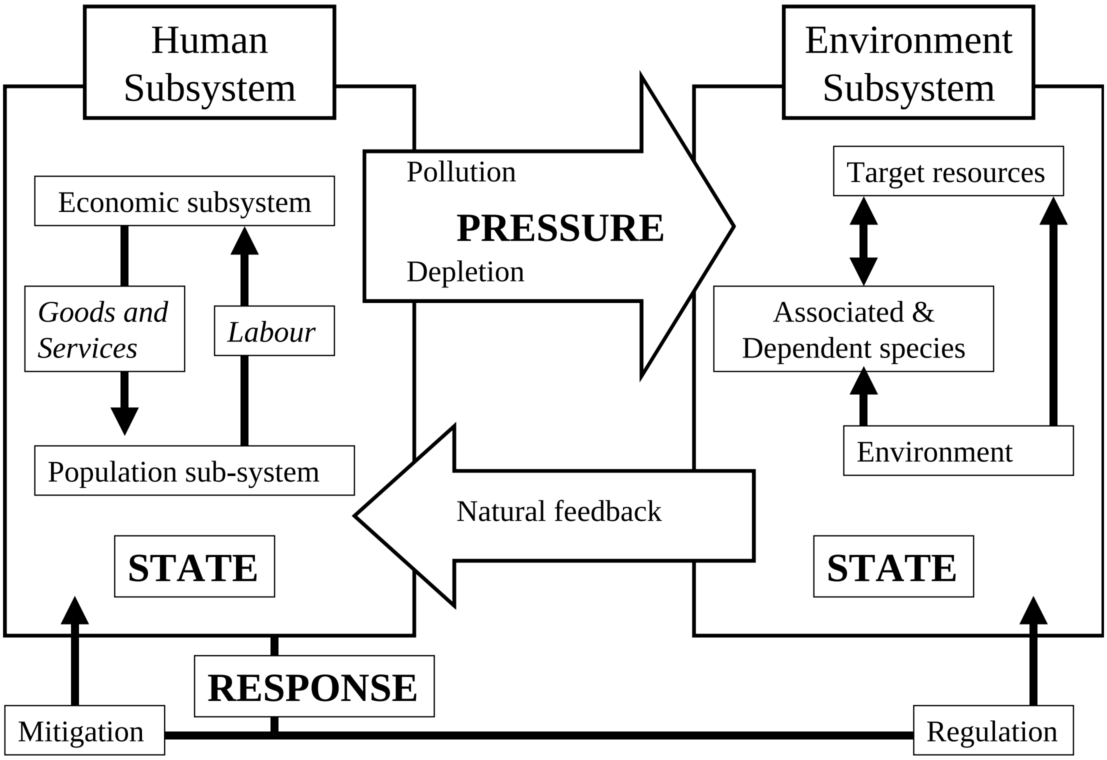

Figure 3. The general framework for sustainable development
Source: Garcia and Staples, in press, modified from UNEP/EAP, 1995

[3] Garcia, S.M. (in press). The FAO definition of sustainable development and the Code of Conduct for Responsible Fisheries: An analysis of the related principles, criteria and indicators. Paper prepared for the Australian-FAO Technical Consultation on Sustainability Indicators for Marine Capture Fisheries, Sydney, Australia, 18-22 January 1999. *Marine Fisheries Research.*

The human subsystem exerts a complex pressure on the environmental subsystem through, for instance, pollution and depletion and receives feedback signals from it. The two subsystems can themselves be subdivided into smaller components and their relationships shown. For instance, the economic and population components of the human subsystem exchange goods and services, and labour.

4. The pressure-state-response (PSR) framework and its variants

The pressure-state-response framework (represented in Figure 4), developed by the Organization for Economic Cooperation and Development (OECD) and other international bodies, provides a variation on the general sustainability framework, with its dichotomic representation of sustainability, superimposing on it the state of the two system components as well as the processes that affect these states and in particular the pressure exerted on the environmental subsystem and the responses made by society that affect both subsystems.

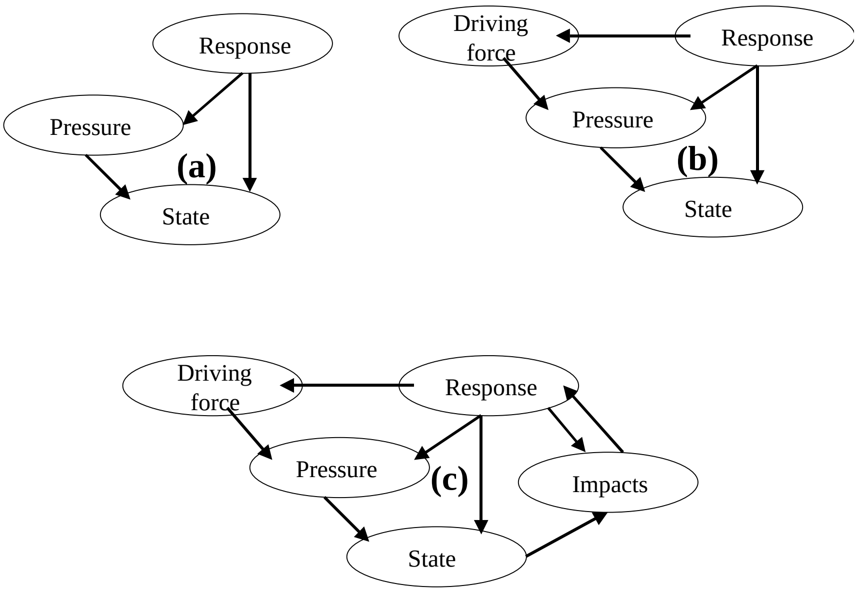

Figure 4. The PSR (a), DPSR (b), and DPSIR (c) frameworks
Source: Garcia and Staples, in press

The PSR framework defines three types of indicator:

Pressure - These indicators tell us about the pressure that is being applied on some aspect of the fisheries sustainability system. It can be difficult to determine whether a level of pressure is acceptable or whether it is too high, unless information is also available on the state of the environment. Therefore these indicators generally need to be read alongside the state indicators. However, variations in pressure indicators can be early warnings of problems before they cause a change in the state indicators.

State - These indicators report on the current state of some aspect of the fisheries sustainability system. They provide information on where the system stands at the moment it is observed. The observation of a time series of one indicator indicates trends in the state of the system.

> **Response** - These indicators report on what action decision-makers and managers are taking in response to signals they receive on the state of the fisheries sustainability system or, very often, in response to pressures from stakeholders. If indicators suggest that the state of the system is satisfactory then no action may be required. These indicators form an important part of the feedback loop into the management system.

To be meaningfully interpreted, the three types of indicator should be directly related. For instance the indicator of pressure (e.g. fishing rate) should be accompanied by a measure of impact of such pressure (i.e. stock level) and a measure of response to such pressure (regulation of fishing pressure or removals). Ideally, a model should be available on how the three are related. PSR indicators should be developed that are dynamic and therefore capture both the direction and rate of change as well as static measures of the system. For ease of presentation and understanding, indicators could be presented in a sustainability "scorecard" or "dashboard" format at some appropriate periodicity, perhaps annually.

Any sustainability system for fisheries comprises four main dimensions which are: i) ecological (the ecosystem, including biological resources and their environment); ii) social; iii) economic, and iv) related to the institutions and governance systems in which the fishery operates. The indicators chosen for the PSR approach must reflect the state, changes and structural characteristics of the components.

Examples of PSR indicators for fisheries are given below. Many of these indicators can be applied to more than one of the scales identified - global, regional, national, sub-national and local. Some indicators can also serve as more than one of the three types of indicator – catch, for instance, could serve as both a pressure and a state indicator.

The driving force-pressure-state-response framework (DPSR) is a variant of the PSR framework in which the *driving forces* (DF) are distinguished from the *pressure* (P) they generate (see Figure 5). Similarly, it has sometimes been suggested that state (S) be split into impact (I), effect (E) and stock (ST), leading to more complicated framework structures.

The driving force-pressure-state-impact-response framework (DPSIR) (Figure 5) is an example of such an expansion of the PSR framework in which it is considered that "driving forces" reflect more accurately the economic, social and institutional dimensions of sustainable development. In this expanded framework, human driving forces (e.g. demand for food, and revenues fuelled by economic and demographic forces) exert pressure on the environment (*sensu lato*, including use of natural resources, impact on habitat, emission of waste). These pressures result in changes in the state of the components of the system and its environment (such as a decrease in resource biomass or in revenues to coastal communities) and may have an immediate impact on the functioning of the system (such as collapse of fisheries, social unrest, decline in compliance). Societies, possibly through their management authorities, provide a response to these changes of state and their impact (e.g. legal, institutional, and/or financial measures, changes in development strategies or tenure systems) with a view to modify the pressure (through management) or to mitigate its impacts (rehabilitation or contingency plans, insurance schemes, etc.).

The relationships between driving forces, pressures, states, impacts and responses may not always be simple and responses to a pressure can become a pressure on another system or part of the system. Catches are an indicator of the level of extraction and therefore are proxy indicators of fishing pressure. With some assumptions, however, they are also often used as indicators of the state of the resource. Moreover, a subsidy established to provide relief in case of exceptionally low yields may become an incentive to increase capacity and fishing pressure. In addition, the demarcation between impacts and states is not always straightforward and the debate on the usefulness of the "expanded" framework is ongoing.

Dimensions	Pressure	State	Response
Ecosystem (resource and environment)	Total catch Total area fished Catch/ sustainable yield *% resources > target* Total effluent discharge	B/Target B F/ Target F E/Target E *% TR > target* *% NTR > target* Biodiversity index Community structure Trophic structure Area of critical habitat	TAC/sustainable yield % depleted stocks rebuilding Reduction of land-based pollution User rights established User fees established
Social	Fishing effort Number of vessels Growth rate of number of fishers Unemployment rate Immigration rate Social unrest	Number of fishers Demography Number of associations % below poverty line Income and asset distribution	Unemployment assistance Support to associations Resources allocation decision
Economic	Sector unemployment Subsidies Excess fishing capacity Resource rent potential	Profitability Wages and salaries Sector employment	Economic incentives & disincentives (e.g. subsidies, taxes, buy-back) Command & control measures
Institutions/ governance	Employment policies Absence of use of property rights	% resources assessed % with management plans % managt. cost recovery Rate of compliance % resources co-managed	% resources assessed Job conversion programmes Retraining programmes Number of compliance operations

Notes: B = Biomass, F = Fishing mortality, E = Exploitation rate, TR = Target resources, NTR = Non-target resources.

Integrated indicators are shown in italics

Table 1. Examples of PSR indicators

5. The ecologically sustainable development framework

Chesson and Clayton (1998) have proposed a variant of the general sustainable development framework, known in Australia as the ecologically sustainable development (ESD) framework, to assist in determining how well the management requirements for sustainability are met, and how performance progresses over time. The top dichotomic structure is similar to that of the general framework for sustainable development above, reflecting the environmental and human components. The effects of fishing are subdivided into the *effects on humans* and *the effects on the environment* (*sensu lato*, including the *effects on the resource*). The subdivision recognizes that while all effects ultimately influence the quality of human life, some act directly whereas others act indirectly through the environment. The ESD framework establishes, in addition, a hierarchy of elements at progressively higher levels of detail (see Figure 5). The authors stress that the value of some elements of the structure could be negative. For instance, incomes could be negative when the fishery is in deficit (particularly when taking subsidies and management and other costs into consideration). Similarly, lifestyles could be “negative” when the situation imposes dangerous or otherwise undesirable conditions on individuals.

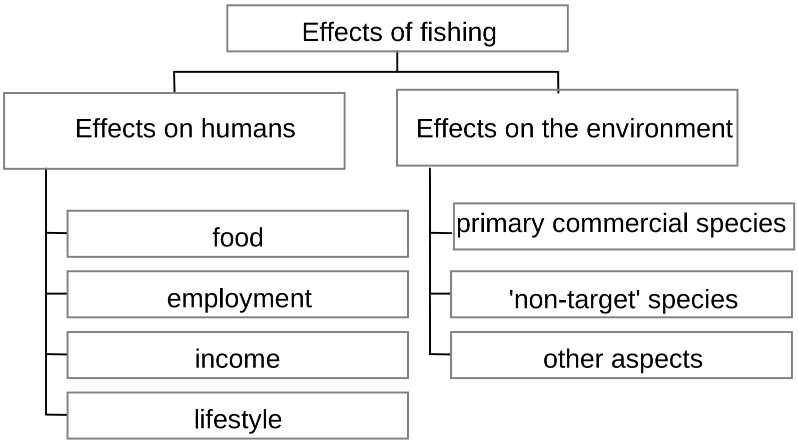

Figure 5. Hierarchical subdivision of a sustainable development framework
Source: Chesson and Clayton, 1998[4]

The elements within the framework can of course be subdivided further. For instance, the effects on non-target species could be subdivided into indirect and direct effects, and the latter could be further subdivided into the effects of i) normal fishing operations and ii) other fishing operations, such as ghost fishing.

While the two main elements of Figure 5 (effects on humans and the environment) are often likely to be adopted as the two major ones for any fishery or fishery subsector, the lower levels may be changed or subdivided according to local conditions. For each cell of the framework, an objective (and reference point) must be specified (e.g. a figure for total expected revenue) and the related indicators can be easily determined (e.g. actual revenues). In addition, different weights can be given to different cells depending on the policy and the prioritization of objectives. These weights will be used in combining the values of the indicators from the lower level of the ESD tree.

[4] Chesson, J. and Clayton, H. (1998). A framework for assessing fisheries with respect to ecologically sustainable development. Bureau of Resources Sciences. Fisheries Resources Branch, Australia. 19 p.

Annex 4: Selected criteria and indicators for ecological, economic, social and institutional/governance dimensions of fisheries

This section describes selected ecological, economic, social and governance/institutional criteria that can be used to assess the sustainable development of fisheries. The criteria are presented in no special order, and their degree of relevance will vary among fisheries. Appendices A and B give examples of criteria and indicators in the institutional/governance and economic dimensions respectively, at the various scales at which they may apply, from local to global level. Appendix C details some of the data requirements for ecological criteria and indicators.

1. Ecological criteria

Catch structure

The catch structure refers to the size of fish, species composition and numbers, and the trophic level of each species in the catch. Shifts in the catch structure are strong signals of potential non-sustainability in the fishery. Shifts in catch structure may reflect a "fishing-down the food chain" process in which excessive pressure is exerted on individual stocks (of high value predators) leading to a shift of fishing pressure to less-preferred species or size classes (e.g. of lower value preys). Changes in catch structure that would signal non-sustainability may be hidden unless the data is gathered at sufficiently fine scales of spatial and temporal resolution to show the patterns of change in catch structure within the subunits of each fishery.

Information on catch structure should be gathered from fishers and, where species composition is complex, supported by observer programmes and taxonomic identification aids to verify species identities. The data on catch structure should be captured in the finest space and time scales that are achievable in each fishery.

Area and quality of important or critical habitats

Vegetated habitats (such as seagrasses, algal beds, mangroves and marshes), estuaries, coral reefs, offshore canyons and seamounts, and trawlable soft-bottom habitats are fundamental elements of marine ecosystems. For specific fisheries these can be considered as very important or even critical, e.g. as spawning and feeding areas as well as trawling grounds. Critical habitats provide critical and direct support for fisheries production, such as seagrass or mangrove systems through which all recruits to a fishery may have to pass, or reefs that may be the main source of larvae for a large reef complex. Both would also be important for biodiversity in general as well as source of food for exploited species. Change in the area of habitat, as measured using habitat inventory tools, can indicate changing conditions in the environment that could be caused by fishing, or might affect fishing activities. Loss of seagrass beds caused by pollution can affect fisheries, while trawling or dredging in seagrasses can destroy many types of seagrass habitat. The quality of habitats, as measured by the extent of coral cover or ratio of live to dead coral on coral reefs, for example, or by faunal composition in seagrass beds, is closely related to the value of habitats for fisheries purposes. Changes in habitat quality signal changes in ecosystems that can have very important ramifications for fisheries, irrespective of their causes. All fisheries need to be aware of the extent to which critical and important habitats support the fishery, and the nature and extent of any changes that might be occurring, irrespective of the causes.

Fishing pressure - fished vs unfished areas

Not all areas within any given fishing grounds are fished with equal intensity. Some locations may be difficult to reach, or may only be fishable in certain weather conditions. For some types of fishing, such as trawling or seining, fishing grounds often contain areas that cannot be safely fished because of risk to gear (posed, for example, by reefs, canyons, pinnacles or other obstructions). Moreover, fishing grounds are not usually considered to be homogeneously productive, so some areas will be more intensively fished because of a greater perceived return or catch rate. In addition, reserves and other forms of closure are used to protect spawning stocks, or sensitive young life stages from harvesting or other detrimental effects.

This means that there may be substantial areas, even within designated fishing grounds, where fishing does not occur, or occurs only very infrequently. These areas may be considered to be natural refuges where samples of habitats and ecosystems are, to some extent, immune from the effects of fishing. They may also contribute to the maintenance of target stocks, by providing recruits for the fishery, or feeding grounds for stocks fished in other places.

Monitoring of the extent of fished and unfished areas is a useful proxy for the extent of protection and refuge provided for local sedentary species and samples of habitats. To measure and document this proxy, detailed information is required on fishing locations, the type of gear used and the frequency of fishing activities. Data on this indicator could be gathered in cooperation with fishers and recorded in the form of maps or GIS-compatible spatial records.

Identifying the extent of fished and unfished areas and tracking changes provides crucial information that can be used to evaluate the extent to which fishing management practices provide support for the conservation of non-target species. The extent and location of fished areas provides key information on the spatial patterns of fishing effort and any exploitation patterns that could be unsustainable.

2. Economic criteria

Profitability

In the absence of major market distortions such as extensive subsidies or the existence of price controls, profitability is the single most important economic criteria. Low or negative profitability usually indicates that fish stocks are exploited in an economic wasteful manner and fishing capacity and effort are excessive on both economic and biological grounds. Only in rare instances would low profitability result from an unfavourable combination of relatively low fish prices and high fishing costs. Most commercial fish stocks can yield high or satisfactory returns on investment with present fishing technologies and when subjected to effective fisheries management. In a theoretically perfect market economy, profit would be equal to resource rent as all inputs and outputs are correctly priced at their opportunity cost or willingness to pay level.

Value of fishing entitlements

Where management is done through transferable entitlements such as individual transferable quotas (ITQs), the resource rent becomes capitalized in the value of the entitlement. In theory, the entitlement is worth the sum of the discounted stream of future profits or rent (i.e. the net present value). In the absence of speculative trading, a change in the market price of quota entitlement, thus, reflects a change in the, by market participants, estimated profit potential of the fishery. Such a change can occur, for example, as a result of a decline in stock abundance, a drop in fish prices or an increase in fishing costs. Second generation holders of fishing entitlements may realize only low or zero profit because of the capital cost incurred when purchasing the entitlement.

Subsidies

Apart from failing to effectively regulate access to the fishery, the single most important cause for economic waste and overfishing is the provision of subsidies for fishing inputs such as for fuel and for the construction and purchase of fishing vessels and gear. The extent of such subsidies does not only provide an indication of the poor economic performance of the fishery or fisheries but also of the likely large political difficulties of attaining effective fisheries manage. These difficulties relate to the large overcapacities prevailing in heavily subsidized fisheries and the consequent need to reduce excess capacity and employment. Such adjustments might only be politically feasible when accompanied with compensatory measures such as buy-backs and temporary re-training and income support for displaced fishermen.

3. Social criteria

Employment

Work in the fisheries sector, especially fishing, is often regarded as employment of last resort in many countries, because of the limited training and educational requirements. Typically, there are many more fishermen than fisheries can absorb and maintain because of the high fishing pressure this can bring to bear on fish stocks. Changes in the total amount of paid labour or employment in a fishery can be a useful indicator of both the condition of a fishery and its value to the local populations that may be dependent on fisheries for their livelihood.

Protein consumption

Fish provides more than two-thirds of the animal protein consumption of the population of many developing countries, especially in coastal communities. However in recent years the per capita availability of fish has been falling in an increasing number of countries because of declining catches and the export of highly valued catch for overseas consumption. As demands for production increase, so does the risk of unsustainable practices to produce more catch for more lucrative markets at the expense of local consumption. Change in per capita fish consumption, and fish consumption as a proportion of total protein consumption, are important criteria that relate to the significance of the contribution of fisheries to the livelihood of coastal communities, and can be related to the community pressure for sustainable development of fisheries.

Tradition and culture

Local knowledge derived from oral traditions passed between generations can be an important aspect of fisheries management in many countries, both developing and developed. These traditions establish the “do’s and don’ts” of fishing, and in some countries cultural taboos are established and maintained. The loss of traditional practices can indicate substantial changes in fishing practices, and may signal the loss of traditional fisheries management systems and reduced controls in loosely organized and subsistence fisheries. Information on the prevalence of traditional fisheries practices can be obtained by consulting fishers and local community leaders.

4. Governance/institutional criteria

Capacity to manage

The capacity to manage fisheries depends on available human and financial resources as well as on the existence of competent institutions. Fisheries management requires an investment of time and resources to collect the needed information, develop and agree on a management regime, and enforce the regulations, monitoring the state of the system. An economically sound fishery should make acceptable returns on investments after the costs of management are accounted for. In many fisheries, however, returns are marginal or negative and, as a consequence, the costs of management are considered to be an extra burden that may provide long-term benefits but at the price of an unacceptable (or unaffordable) reduction of short-term returns.

Fisheries management also requires an adequate institutional base, including a set of regulations and a system to generate and enforce them. In subsistence fisheries, management institutions and plans need to rely more on traditional power structures and culture than on formal management plans. In more industrial fisheries, where conventional management plans are required to ensure sustainable development, the capacity to develop and implement them is often very limited.

Compliance regime

The management of fisheries to achieve specific goals and objectives requires the development and application of a set of rules that govern the behaviour of fishers permitted to enter a fishery and the gear they use. Rules also govern the behaviour of those not permitted in the fishery, and those without rights of access to certain parts of a fishery. For these rules to be effective a regime to evaluate compliance with them needs to be in place, together with appropriate methods to provide decision-makers with feedback. Compliance regimes assess the extent to which the rules designed to keep fisheries sustainable are applied in practice. The existence and effectiveness of compliance assessment regimes can be evaluated by examination of fisheries management plans and, in subsistence fisheries, examination of traditional practices.

Transparency and participation

Fisheries managed by exclusively “top-down” approaches (rules or legislation imposed without consultation with the affected fishers) are increasingly found to be at high risk of non-sustainability. This is typically because fishers feel excluded from decision-making processes that affect their livelihood, and have no “ownership” of decision outcomes. The lack of participation in decision making predisposes fishers and others with an interest in fishing to ignore rules designed to maintain a sustainable fishery. Poaching is a problem that typically results from a lack of transparency and participation in decision making. Transparency and participation do not guarantee sustainability, but fisheries are unlikely to achieve sustainability without them. The extent of transparency and participation can be evaluated by assessment of the management plan for a fishery, and in particular the structural and functional elements that permit effective participation of fishers in the decision-making process.

Appendix A: Examples of governance criteria and indicators

Criteria	Indicators
Global	
Compliance regime	Incentives to comply with the global agreements The existence of outstanding disagreements
Property rights	Compatibility with sustainability goals Acceptance by major stakeholders
Transparency and participation	Participation in the global agreements Incentives for participation in global agreements Involvement of major stakeholders in making and applying rules of the game Effective communication between stakeholders Capacity to elicit, receive, and use information from all stakeholders
Capacity to manage	Existence of a global management regime
Regional	
Compliance regime	Incentives to comply with the regional agreement The existence of a compliance regime Effectiveness of the regime The existence of outstanding disagreements Integration of global rules
Property rights	Existence of well defined and recognized property rights Compatibility with sustainability goals Acceptance by major stakeholders
Transparency and participation	Participation in the regional agreement Incentives for participation in regional agreements Involvement of major stakeholders in making and applying rules of the game Effective communication between stakeholders Capacity to elicit, receive, and use information from all stakeholders
Capacity to manage	Existence of a regional body with competence to manage Terms of regional agreements implemented Degree to which the regional agreement meets sustainable development objectives Existence of an effective dispute resolution process Resources availability at all levels
National	
Compliance regime	The existence of a compliance regime Effectiveness of the regime The existence of outstanding disagreements Integration of global rules Compatibility between local and higher level enforcement
Property rights	Existence of well defined and recognized property rights Compatibility with sustainability goals Acceptance by major stakeholders Incentives for cooperative behaviour

Transparency	Involvement of major stakeholders in making and applying rules of the game Effective communication between stakeholders Capacity to elicit, receive, and use information from all stakeholders
Capacity to manage	Resources availability at all levels Compatibility between formal and informal governance structures Higher level authorities facilitating lower levels of management Co-management
Fishery	
Compliance regime	The existence of a compliance regime Effectiveness of the regime The existence of outstanding disagreements Integration of global rules Compatibility between local and higher level enforcement
Property rights	Existence of well defined and recognized property rights Compatibility with sustainability goals Acceptance by major stakeholders
Transparency and participation	The transparency of fisheries management Involvement of major stakeholders in making and applying rules of the game Effective communication between stakeholders Capacity to elicit, receive, and use information from all stakeholders
Capacity to manage	Resources availability at all levels Compatibility between formal and informal governance structures Higher level authorities facilitating lower levels of management Co-management
Local	
Compliance regime	The existence of a compliance regime Effectiveness of the regime The existence of outstanding disagreements Integration of global rules Compatibility between local and higher level enforcement
Property rights	Existence of well defined and recognized property rights Compatibility with sustainability goals Acceptance by major stakeholders
Transparency and participation	The transparency of fisheries management Involvement of major stakeholders in making and applying rules of the game Effective communication between stakeholders Capacity to elicit, receive, and use information from all stakeholders
Capacity to manage	Resources availability at all levels Compatibility between formal and informal governance structures Higher level authorities facilitating lower levels of management Community-based management

Appendix B: Examples of economic criteria and indicators

The following table which unfortunately could not be fully discussed at the meeting contains examples of indicators and their criteria that would be needed for reporting purposes in an SDRS. Not all of these indicators will apply in a particular jurisdiction or circumstance and others may be needed depending on the particular objectives set for each scale, which will reflect regional, national and fishery priorities and policies.

Criteria[5]	Example of Indicator[6,7,8]	Structure	Reference Point
Harvest	▪ landing ▪ by-catch	▪ by species; age groups[7] ▪ by area ▪ by fishery sub-sector	▪ MSY[9] ▪ historical level ▪ policy target level
Harvest capacity	▪ GT (decked vessels) ▪ No of boats (undecked ves.) ▪ total effort (see below)	▪ by fleet type ▪ by fishery segment ▪ age composition of vessels ▪ fishing mortality/species[10]	▪ capacity or effort of MSY ▪ policy target level
Harvest value (in constant prices)	▪ total deflated value (landed price)	▪ by species groups ▪ by sub-sector & fishery	▪ Selected historical level
Subsidies	▪ Tax rebates ▪ Grants	▪ by sub-sector ▪ by fleets/fishery	▪ historical level ▪ zero level ▪ target level
Contrib. to GDP[11]	▪ Fisheries GDP/Nat. GDP	▪ by species groups	▪ historical level
Exports	▪ Export/Harvest value	▪ by species groups ▪ by fishery segment	▪ historical level
Investments	▪ Market or replacement value ▪ Depreciation ▪ Fleet age composition	▪ by fleet type ▪ by fishery	▪ historical level
Employment	▪ Total employment[12]	▪ sub-sector ▪ fleet/fishery	▪ historical level (?) ▪ realistic policy target
Net returns	▪ (profit + rent)[13] ▪ net return/investment ▪ value of entitlements[14]	▪ by sub-sector ▪ by fishery	▪ historical level ▪ MEY
Effort (mainly at fishery level)	▪ No of vessels; Fishing time ▪ Amount of gear used ▪ Employment[15]	▪ By fishery segment ▪ In physical or monetary terms	

[5] Criteria tend to be scale-independent and relevant from local to global level
[6] Indicators tend to be more scale-specific and careful selection will be needed
[7] Can be expressed as a ratio with the reference point
[8] Change can be described by trend and direction in relation to the reference point
[9] Hard to define and unstable at aggregated level (whether national, regional or global)
[10] Only at fishery level
[11] Gross Domestic Product
[12] The extent to which employment in forward and backward industries (e.g. in fish processing or boat-building is included needs to be specified.
[13] In practice data may be only sufficient to calculate "gross profit", e.g. including returns to capital, owner's labour, and rent. Subsidies would need to be included.
[14] in case fishing rights are transferable and tradable (e.g. ITQs)
[15] A proxy for "effort" in non-market fisheries or at small-scale community level.

Appendix C: Fishery data requirements for ecological criteria and indicators

In order to be usable for assessing the status and trends of exploited ecosystems, fishery data would need to relate to habitats and ecosystems but they usually do not. For instance, information on catch (weight and composition) is currently available for many countries, often by type of fisheries, or sub-sectors, but generally with no breakdown by exploited ecosystems and habitat.

In measuring and reporting on habitats and ecosystems of importance to fisheries, standard approaches are required so that indicators can effectively be developed and are and consistent in time and comparable within and across spatial scales. As a consequence, data need to be maintained in standard formats that facilitate access, analysis, synthesis and interpretation. To this end, the data collection should be organised following agreed guidelines providing for a breakdown of by habitats and major ecosystems in appropriate space and time scales. Some elements of potential use for such guidelines are offered below:

Taxonomic resolution

Relevant fishery data (e.g. catch weight) should be recorded by species or other recognisable taxon and by relevant unit area of a fishery. For comparison purposes, they might be expressed on a per-area basis (e.g. in tonnes/km$^{2)}$. Important habitats, exploited or otherwise (such as larval habitats) could usefully be defined into the following taxonomic ecological classes:

- Relevant freshwater systems (e.g. rivers for anadrome fish)
- beaches;
- mangroves;
- coral reefs (including reef flats seagrass beds);
- rock reefs;
- seagrass beds (not on reef flats); coastal lagoons;
- other estuaries; other intertidal habitats; near-shore (down to 10 m depth);
- trawlable grounds (non-upwelling, upwelling, seasonal upwelling, 10 to 50m depth, 50 to 100m depth, greater than 100 m);
- untrawlable grounds (non-upwelling, upwelling, seasonal upwelling, 10 to 50m depth, 50 to 100m depth, greater than 100 m);
- guyots and other seamounts;
- Pelagic domain (non-upwelling, upwelling, seasonal upwelling, 10 to 50m depth, 50 to 100m depth, greater than 100 m).

Spatial scales

Whenever possible (and particularly for large scale fisheries for which log-books may be available), relevant fishery data, such as catch weight, should be recorded in spatial sub-units of the overall fishing grounds. These units might be best identified using ecological sub-divisions (e.g. bays, bathymetric ranges) or fishing localities. For the purpose of analysing changes, ecosystem and habitat indicators should refer preferably to the same spatial units used for recording catch.

Temporal scales

The relevant fishery data (e.g. catch weight) may be collected using log books or other formal recording processes, on time scales that ranging from a few hours (e.g. in case of fisheries reporting on a haul-by-haul or set-by-set basis), to a week on months (e.g. for fisheries reporting on a trip-by-trip basis). For habitats and ecosystems measurements, however, the relevant frequency with which changes should be measured depends on the rate at which they can be degraded or rebuilt. This depends on their nature and location, as well as on the nature and intensity of the threats to their integrity, in terms of extension and quality. Inshore systems (seagrass beds) will therefore require more frequent measurements than deeper and more offshore habitats (such as seamounts).

In order to ensure that all ecosystems are properly monitored, comprehensive monitoring and reporting would be needed, of fishing activities within the EEZs (with details by ecological sub-areas), as well as in the high seas. The information could then be collated according to ecosystems (as defined by Longhurst, 1998)[16], including Large Marine Ecosystems (LMEs) and by type of habitat as described above.

Rapid appraisal

The need for data needs on ecosystems health may easily appear daunting. However, the quality and extent of coastal habitats can be rapidly appraised, generally, e.g. using rapid assessment surveys with various levels of taxonomic, spatial and temporal resolution; aerial photography; diver surveys; or in some circumstances traditional knowledge. In deeper waters, habitats may need to be monitored and assessed using more sophisticated technologies such as remote video or acoustics, and perhaps even more remote proxies (such as using simply fishing effort as a measure of disturbance). Using such techniques, both habitat quality and extent can be assessed using, for instance, a standardised performance scale with 6 graduations corresponding to habitat being: (1) destroyed; (2) severely disturbed; (3) moderately disturbed; (5) practically undisturbed or pristine; and (6) in an unknown state.

[16] Longhurst Alan R., 1998. Ecological geography of the sea. Academic Press: 398 p.

Annex 5: Typical reference points used in conventional fisheries management

MSY	Maximum Sustainable Yield
MCY	Maximum Constant Yield
MEY	Maximum Economic Yield
LTAY	Long-term Average Yield
F_{MSY}	F (fishing mortality) at MSY
F_{MCY}	F at MCY
F_{LTAY}	F at LTAY
F_{MEY}	F at MEY
$F_{0.1}$	F at which the slope of the Y/R curve = 10% of the slope near the origin
F_{AY}	Fishing mortality at Average Yield (Undetermined)
F_{MAX}	Fishing mortality at the level of maximum yield-per-recruit
F_{low}	F corresponding to a SSB/R = 10% (percentile) of observed R/SSB
F_{med}	F corresponding to a SSB/R = 50% (percentile) of observed R/SSB
F_{high}	F corresponding to a SSB/R = 90% (percentile) of observed R/SSB
$2/3F_{MSY}$	F corresponding to 2/3 of F_{MSY}
$F_{30\%SPR}$	F corresponding to SSB/R = 30% of SSB/R when F=0 (Virgin stock)
F_{crash}	F at recruitment failure (= slope of the tangent to the origin of the SRR)
F_{loss}	F corresponding to SSB/R=1/(R/SSB) at Lowest Observed Spawning Stock
Z_{mbp}.	Total Mortality corresponding to Maximum Biological Production of stock
MBAL	Minimum Biological Acceptable Limit (SSB below which R may decrease)
$0.3B_v$	Biomass corresponding to 30% of the virgin biomass (When F=0)
B_{MSY}	Biomass when the stock is fished at $F=F_{MSY}$
B_{MCY}	Biomass when the stock is fished at $F=F_{MCY}$
$B_{50\%R}$	SSB (spawning stock biomass) at which R (recruitment) = 50% Rmax
$B_{90\%R}$	SSB at which R= 90% Rmax

Notes:
SSB/R = Spawning Stock Biomass per Recruit
R/SSB = Recruitment per Spawning Stock Biomass
SRR = Stock-Recruitment Relationship

Annex 6: Example of a methodology sheet for indicators related to the maximum sustainable yield (MSY)

The following document is based on a United Nations document entitled *Indicators of Sustainable Development: Framework and Methodologies* (United Nations, 1996, pp. 238-243) modified to account, in particular, for differences in the vocabulary used in this document and by the Technical Consultation. The document has been further edited to better suit the purpose of the meeting.

1. Potential indicators

i Ratio of current effort to that at MSY: (f_t/f_{MSY});
ii Ratio of current fishing mortality rate to that at MSY: (F_t/F_{MSY});
iii Ratio of current population biomass or spawning biomass to that at MSY: B_t/B_{MSY});
iv Ratio of current biomass (or spawning biomass) to virgin biomass (or spawning biomass) (i.e. before fishing began): (B_t/B_v).

Meaning: Indicators (i) and (ii) measure the current fishing pressure (or rate of exploitation) relative to the fishing pressure corresponding to the maximum sustainable yield. Indicators (iii) and (iv) measure the stock abundance relative to the level of abundance at which the stock can produce its maximum sustainable yield.

Unit of measurement: The indicators could be expressed as a value or as a percentage.

2. Relation to selected indicator frameworks

Agenda 21: The indicators refer to Chapter 17: Protection of the Ocean, all Kinds of Seas, including Enclosed and Semi-enclosed Seas, and Coastal Areas; and the Protection, Rational Use and Development of their Living Resources.

Pressure-state-response: (i) and (ii) are indicators of pressure; (iii) and (iv) are indicators of state.

Sustainable development: Indicator (i) is an economic and technological indicator of the human component. Indicators (ii), (iii), and (iv) relate to the resource in the environment.

3. Significance (policy relevance)

Purpose: These indicators express the state of the fishery resource and/or its level of exploitation, in relation to either the MSY, or to virgin stock size (or spawning stock size). They reflect how the fishery is performing in relation to the MSY reference point enshrined in the 1982 United Nations Convention on the Law of the Sea.

Relevance to sustainable/unsustainable development: If a resource biomass is at or below that believed to correspond to MSY conditions, or if the fishing effort or fishing mortality is at or above that believed to correspond to the same conditions, there must be serious concern that the resource may currently be overexploited. This is not only because MSY conditions imply a level of fishing effort that is generally in excess of economically optimal harvesting and has other biological impacts on target and associated species, but because the precision with which the underlying quantities used in these indices are measured may be relatively low. Estimates of population biomass or size of a year class of fish, even in developed country fisheries, are rarely more precise than ±20%. This implies a significant probability that fishing may be more intensive than is apparently measured by the indices, and a risk that sustainable development options are being compromised. Other more conservative and sophisticated reference points may be appropriate in particular circumstances (see Caddy and Mahon, 1995; Garcia, 1996).

Linkages to other indicators: The indicator of fishing effort (i) is closely related to a number of other indicators of a more social and economic nature such as yield, employment or investment. Indicators (ii) to (iv) are closely related to the state of the exploited ecosystem.

Targets and limits: Indicators are used and interpreted in relation to reference points that serve as benchmarks. Given the great uncertainty about stock size and condition of stocks, especially in the open marine environment, two types of management benchmark are now proposed (Caddy and Mahon, 1995; Garcia, 1996). These are *Target Reference Points* (TRPs), which reflect the classical objectives of fisheries management, and *Limit Reference Points* (LRPs), which represent upper limits to the rate of fishing or fishing effort level (or lower limits to the population biomass or spawning biomass) that should not be passed. When LRPs are approached, action should be taken to ensure they are not exceeded.

International Conventions and Agreements: The *Draft Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea* of 10 December 1982 relating to the *Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks* (Doc A/CONF 164/33), particularly Annex II, and of course the *1982 Convention* itself, are of immediate relevance. The other significant draft agreement is the FAO *Code of Conduct for Responsible Fisheries,* which applies to all marine and freshwater fisheries, and whose Article 6 also recommends the use of LRPs and TRPs.

4. Methodological description and underlying definitions

Indicators and reference points should be estimated using the "best scientific information available" as provided for in UNCLOS. A precautionary approach should be adopted where justified by the level of uncertainty in the available information. In the case of straddling, highly migratory, or transboundary stocks, such indicators and reference points should be developed with other states sharing the same stock and should relate to jointly agreed objectives.

Underlying definitions and concepts: The methods used to provide the ratio indicators listed above are well known, and described in a number of texts on fisheries assessment and population dynamics. The approach is usually based on the application of general production models, by fitting the relationship between yield and fishing effort for a historical series of catch and effort data. However, roughly equivalent indicators can be obtained from size- or age-based methods of analysis.

It is felt that using only one reference point (MSY) is not sufficient to ensure sustainability and fishing at the MSY level is now often seen to be incautious. More empirical reference points may sometimes be more appropriate. For instance, they could reflect specific management or development planning objectives. They could also reflect empirical evidence of spawning biomass levels below which the reproductive capacity of stocks seems to be impaired (such as 30 percent of the virgin spawning biomass). Similarly, other customized indicators may be developed for particular fisheries to better reflect the characteristics of their resources as well as the methodologies used for their scientific assessment.

Where MSY estimates are available, it should be possible to determine whether the fishing effort level corresponding to MSY (f_{MSY}), or the corresponding fishing mortality rate (F_{MSY}), is currently being exceeded or not. Depending on the fisheries management approach used in a country, it may be possible, as an alternative, to say if the current biomass or spawning biomass of a particular stock has fallen below that corresponding to MSY (B_{MSY}).

An alternative reference point commonly used to measure the state of the marine fisheries resources, which could be used instead of MSY-related indicators where these do not exist, is current biomass, or spawning biomass, expressed as a percentage of the virgin biomass (the biomass of the stock before fishing began). This can be determined by scientific surveys (such as trawl or acoustic surveys) or calculated using mathematical models.

The above indicators are given as ratios - they are pure numbers, as are the current rates of fishing mortality. It is generally possible to cross-reference these indicators making certain assumptions, so that the apparent diversity of indices simply provides a choice that allows for the different information sources available under different fishery management regimes. In all cases, the indicator could be expressed as a ratio, and its component numerical values.

Measurement methods: The measurement methods for each of the alternative indicators are described below:

f_t/f_{MSY}: The current effort level (f_t) given in standard units, adjusted for changes in fleet fishing power over time, is expressed as a ratio or percentage of the effort level under MSY conditions.

F_t/f_{MSY}: The current rate of fishing mortality (F), is defined by the ratio of the natural logarithm of numbers for fully exploited cohorts now in the fishery at the beginning of the year (N_t), and its end (N_{t+1}), allowing for the present rate of mortality due to natural causes (M).

$$\mathbf{F = \ln[N_t/N_{t+1}] - M.}$$

B_t/B_{MSY}: The biomass (or spawning biomass of mature animals) is determined for the most current year (for example, by trawl surveys) and compared with that level of biomass (or spawning biomass) when MSY conditions were believed to have applied.

B_t/B_v: The biomass (or spawning biomass of mature animals) is determined for the most current year (for example, by trawl surveys) and compared with the level of biomass (or spawning biomass) before commercial exploitation began. Under a commonly used population logistics (or surplus production) model, MSY conditions occur when the stock size is reduced to 50 percent of the virgin stock size: that is, when this indicator shows values of 0.5.

MSY and biomass are usually specified in metric tonnes. Fishing effort is often expressed in standard number of days-at-sea fishing, per unit of time (usually the year) or any other measure of fishing activity (e.g. total number of hours of bottom trawling). In data-poor situations, fishing effort is sometimes expressed by the total horsepower or gross registered tonnage (GRT) of the fleet.

Limitations of the indicator: The major defect of the MSY concept, and of these indicators, is that MSY, as it is usually determined, does not always fully reflect processes of birth and death, effects of exploitation on non-target species, or inter-species interactions. Nor does it reflect changes in fishing methods or fishing efficiency resulting from technological improvements. To improve management, it is important that countries collect ancillary data (for example, on size and age composition of catches and populations) that can be used to produce more refined indicators of greater value for the management of the resource, as their research funds and skilled manpower allow.

5. Assessment of the availability of data from international and national sources

For many countries, suitable data to calculate these indicators are scarce and often deficient or unreliable. For example, there are serious deficiencies in data series for annual catch owing to poor statistical design, failure to estimate catches by small-scale fleets or illegal fishing, local consumption, or other forms of misreporting. In such cases, corrected estimates by qualified scientists may have to be used.

Data needed: In order to generate the above indicators and reference points, data are required for annual catch, fishing effort, fishing mortality rates, biomass estimates, and stock size and age. Other supplementary data needs may include mean size or age of the catch (which fall as fishing pressure rises), the percentage of mature fish in the catch, the overall current mortality rate and the proportion of long-lived fish in the catch (for a multispecies fishery).

Data availability: Most countries collect data on annual catch. Not many countries maintain data on fishing effort by national fleets; still fewer standardize effort levels by different fleets and arrive at an annual total. Unless size and age compositions are collected and/or estimated from properly sampled catches in landing places, fishing mortality rates will not be estimated. The latter require a cadre of trained fisheries scientists working in an equipped fisheries or marine science laboratory. Regular biomass estimates will require regular fisheries surveys using standard vessels and procedures with trained observers/fisheries biologists on board.

Data sources: National statistical offices often collect data on catches and fleet size, but often require assistance in distinguishing species in the catch. At present, effort and mortality estimates are nearly always made by national marine resource institutes or universities, who usually supply the other biological information used to develop the indicators mentioned above.

6. Agencies involved in the development of the indicator

Lead agency: At international level, the lead agency for the development of these reference points and indicators is FAO. At regional levels, the work is usually conducted by competent working groups of the regional fishery bodies. At national level, they are developed by the fishery research agency in close collaboration with the Fisheries Department.

Other competent organizations: The fisheries laboratories of the North Atlantic countries, particularly the United Kingdom, Canada and the United States, and International Fisheries Commissions, notably the Inter-American Tropical Tuna Commission and the International Commission for Northwest Atlantic Fisheries (now defunct) have sponsored the earliest applications of these indicators. The work of the International Center for Living Aquatic Resources Management (ICLARM), Manila has been aimed at applying these concepts in tropical fisheries.

7. Further information

For more detailed information about the reference points and the indicators the reader could usefully refer to:

Caddy, J.F. and R. Mahon, 1995. Reference Points for Fishery Management. *FAO Fisheries Technical Paper* 347.

Garcia, S.M., 1996. The precautionary approach to fisheries and its implications for fishery research, technology, and management: an updated review. In *FAO Fisheries Technical Paper* 350.2:1-75

Gulland, J.A., 1983. *Fish Stock Assessment.* Volume 1, FAO/Wiley Series on Food and Agriculture.

Hilborn, R. and C.J. Walters, 1992. *Quantitative Fisheries Stock Assessment.* Routledge, Chapman and Hall.

Annex 7: Example of questionnaires relating to the management system (governance)

	Factor 1 – Management regime	Response
1	Are management objectives clearly stated, with relative weightings specified?	
2	Are the rules and regulations of the management system clearly documented and available?	
3	Has the management system documented a definition of “stakeholders" in the fishery?	
4	Is the management system sufficiently inclusive of fishing operators as stakeholders to encourage “responsible” resource stewardship?	
5	Is there a dispute resolution mechanism (e.g. an appeals council) to address issues of procedural & outcome equity?	
6	Is the fishery subject to outstanding disputes, e.g. over allocation issues?	
7	Is research to answer ecological questions being supported (e.g. on ecosystem effects of fishing; on sea bed damage; on cetacean by-catch)?	
8	Is research to investigate the management and decision-making processes supported?	
…		
Additional remarks		
To what extent is the management regime structured so as to ensure precautionary and sustainable management? **<u>OVERALL RATING</u>: GOOD (), ACCEPTABLE (), MARGINAL (), UNACCEPTABLE()**		

	Factor 2 - Decision making	Response
1	Are management decisions, and their rationale, clearly documented and made available?	
2	Has scientific advice on stock conservation been overridden without overt justification (concerning e.g. social objectives)?	
3	Are there examples of innovative or experimental management procedures being implemented and monitored (e.g. adaptive management regimes)?	
4	…	
Additional remarks		
To what extent is the decision-making process structured so as to ensure precautionary and sustainable management? **<u>OVERALL RATING</u>: GOOD (), ACCEPTABLE (), MARGINAL (), UNACCEPTABLE()**		

	Factor 3 – Assessment	Response
1	Are the available data (commercial and research) considered to be of sufficient standard (e.g. large scale, unknown misreporting occurs)?	
2	Are assessments carried out by a formally constituted scientific body, which utilizes all information?	
3	Are assessments conducted as part of a clearly structured advisory framework (e.g. assessments produce BRPs with error estimates and stock status estimates with errors, which are used within a formal mechanism to determine appropriate fishing rates or catch levels)?	
4	Are there any identified, outstanding issues of concern about assessments (e.g. data quality, uncertainty in model structure etc.)?	
5	…	
Additional remarks		
To what extent is the data collection and assessment process structured so as to ensure precautionary and sustainable management? **<u>OVERALL RATING</u>: GOOD (), ACCEPTABLE (), MARGINAL (), UNACCEPTABLE()**		

	Factor 4 – Regulation	Response
	Do the precautionary management plans specify:	
1a	Data, including a specification of precision, to be collected & used for stock assessments?	
1b	Decision rules, including risk levels, to be used in determining catch or fishing rate limits?	
2	Are thresholds defined which trigger pre-agreed action if the stock or the environment approach or enter a critical state?	
3	Does legislation exist to discourage wasteful practices such as sea dumping of discards?	
4	Where applicable, are allowable by-catch percentages set?	
…		
Additional remarks		
To what extent are regulations implemented which ensure precautionary and sustainable management? **<u>OVERALL RATING</u>: GOOD (), ACCEPTABLE (), MARGINAL (), UNACCEPTABLE()**		

	Factor 5 – Enforcement	Response
1	Is there an identifiable enforcement agency or agencies?	
2	How many cases were brought against operators in each of the last 5 years?	
3	Do operators perceive a real risk of cheating being detected?	
4	…	
Additional remarks		
To what extent are regulations enforced so as to ensure precautionary and sustainable management? **<u>OVERALL RATING</u>: GOOD (), ACCEPTABLE (), MARGINAL (), UNACCEPTABLE()**		

	Overall assessment	Rating	Multiplier	Score
1	Management regime			
2	Decision-making process			
3	Assessment			
4	Regulation			
5	Enforcement			
	TOTAL			

OVERALL ASSESSMENT OF RESPONSIBLE AND SUSTAINABLE MANAGEMENT:

The guidelines provide general information on the issue of sustainable development of fisheries in order to clarify why a system of indicators is needed to monitor the contribution of fisheries to sustainable development. They are complementary to the *Guidelines on fisheries management* but provide the broader perspective needed for a sectoral and holistic approach to sustainability in fisheries. All dimensions of sustainability (ecological, economic, social and institutional) are considered as well as the key aspects of the socio-economic environment in which fisheries operate. The guidelines also provide information on the type of indicators and related reference points needed. They highlight the various frameworks that have been identified and can be used to organize the indicators and reference points, reflecting the objectives, constraints and state of the different elements of the system in a coherent picture. They include some graphical and other representations that may be of use in conveying the information to policy-makers and to a wider audience. Finally, they outline the process of establishment of a Sustainable Development Reference System (SDRS) and address a number of related operational issues.

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