ISSN 1020-5292

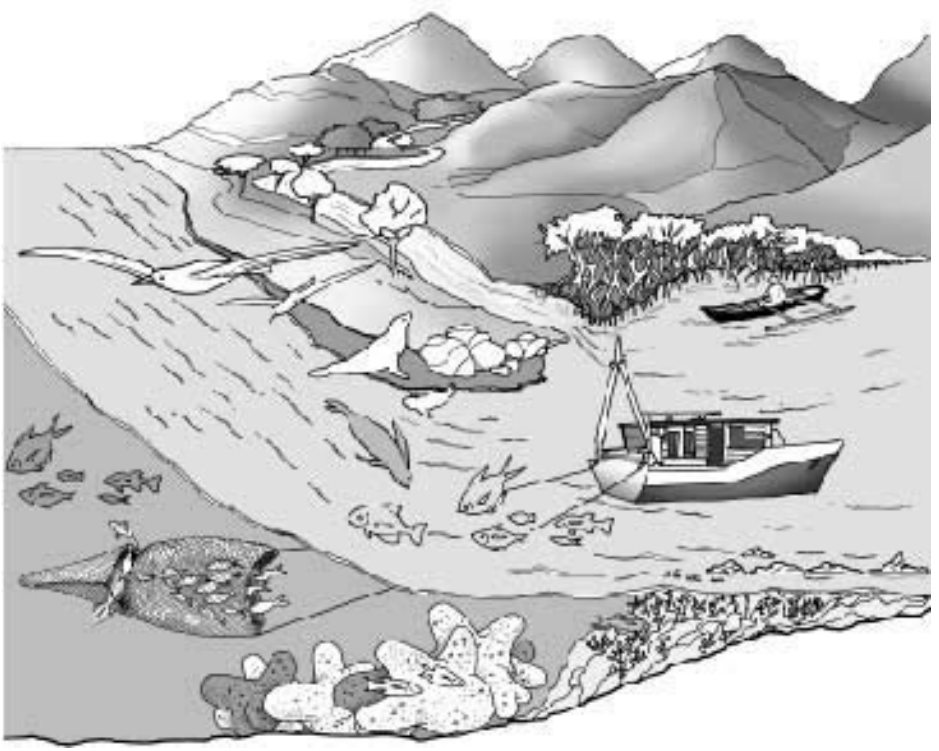
FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES

4

Suppl. 2

FISHERIES MANAGEMENT

2. The ecosystem approach to fisheries



FAO
TECHNICAL
GUIDELINES FOR
RESPONSIBLE
FISHERIES

4

Suppl. 2

FISHERIES MANAGEMENT

2. The ecosystem approach to fisheries

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2003

ISBN 92-5-104897-5

Preparation of this document

These guidelines have been finalized by the FAO Fishery Resources Division (FIR) based on the draft developed during the Expert Consultation on Ecosystem-based Fisheries Management, Reykjavik, Iceland, 16–19 September 2002.

Experts contributing to the original draft included Johann Bell, Doug Butterworth, Kevern Cochrane, Robin Cook, Philippe Cury, Serge Garcia, Henrik Gislason, Sebastian Mathew, Carlos Moreno, Hiroshi Okamura, Jake Rice, Keith Sainsbury (Chair), Birane Samb, Jóhann Sigurjónsson, Michael Sissenwine, Derek Staples, Gunnar Stefánsson, Keven Stokes, Sergi Tudela, John Willy Valdemarsen and Rolf Willman. Final editing and compilation were undertaken by Derek Staples with assistance from Kevern Cochrane and Serge Garcia.

It must be stressed that these Guidelines have no formal legal status. They are intended to provide support for the implementation of the Code of Conduct for Responsible Fisheries. Furthermore, in order to present the management process in all its complexity and diversity, the wording and structure of these Guidelines do not strictly follow the language and the structure of the Code. Therefore, any eventual differences in the terminology employed should not be understood as an intention to reinterpret the Code. At the time of writing, there was little practical experience in implementing EAF anywhere in the world. These guidelines, therefore, should be considered as preliminary, to be revised regularly in the light of practical experience as it becomes available.

Distribution
All FAO Members and Associate Members
Interested Nations and International Organizations
FAO Fisheries Department
FAO Fisheries Officers in FAO Regional Offices
Interested Non-governmental Organizations

FAO Fisheries Department.
The ecosystem approach to fisheries.
FAO Technical Guidelines for Responsible Fisheries.
No. 4, Suppl. 2. Rome, FAO. 2003. 112 p.

Abstract

These guidelines have been produced to supplement the FAO Code of Conduct for Responsible Fisheries. The Code and many international agreements and conferences highlight the many benefits that can be achieved by adopting an ecosystem approach to fisheries (EAF) and elaborate a number of agreed principles and concepts relating to EAF.

These guidelines attempt to make EAF operational by recognizing that this approach is a way to implement many of the provisions of the Code and achieve sustainable development in a fisheries context. They provide guidance on how to translate the economic, social and ecological policy goals and aspirations of sustainable development into operational objectives, indicators and performance measures. They are not seen as a replacement for, but rather an extension of, current fisheries management practices that need to be broadened to take into account the biotic, abiotic and human components of ecosystems in which fisheries operate.

EAF will require that current fisheries management processes include a broader range of users of marine ecosystems (including both extractive and non-extractive users) in deliberations and decision-making and, through improved participatory processes, broader assessment and consensus among users, whose objectives frequently compete. The process will need to take into account more effectively the interactions between fisheries and ecosystems, and the fact that both are affected by natural long-term variability as well as by other, non-fishery uses. Most importunately, the approach aims to ensure that future generations will benefit from the full range of goods and services that ecosystems can provide by dealing with issues in a much more holistic way, rather than by focusing on only certain target species or species groups, as has often been the case until now.

These guidelines also examine other aspects of current fisheries management approaches that will need to be broadened to implement EAF. They include the measures and incentives available to managers to assist in meeting operational objectives. They are a re-assessment of the legal and institutional infrastructure associated with fisheries management at regional and national levels, as well as ways to improve data collection, research and analyses.

Although there are many gaps in our current knowledge of ecosystems and how they function, these guidelines stress that uncertainty should not prevent the development of operational objectives aimed at improving human well-being as well as protecting and improving the status of marine coastal ecosystems. The guidelines recognize the differences in current capacity and knowledge that exist among different countries and attempt to provide a practical approach to implementing EAF by considering these differences.

The guidelines outline a certain number of impediments that may prevent achieving the significant longer-term benefits to be gained from adopting EAF. These impediments include a lack of investment in the management process, lack of adequate training and education, gaps in knowledge and lack of participation by the main stakeholders. As experience grows and as solutions to these major challenges become available, they will be published in subsequent editions of these guidelines.

Contents

List of Boxes, Figures and Tables

Abbreviations and acronyms

1982 Convention
United Nations Convention on the Law of the Sea of 10 December 1982

BRD
by-catch reduction device

C&C
command and control measures

CBD
1992 Convention on Biological Diversity (see http://www.biodiv.org/doc/legal/cbd-en.pdf)

CCAMLR
Commission for the Conservation of Antarctic Marine Living Resources

Code of Conduct
FAO Code of Conduct for Responsible Fisheries

COP
Conference of the Parties

cpue
catch per unit effort

EAF
ecosystem approach to fisheries

EBFM
ecosystem-based fisheries management

EEZ
exclusive economic zone

ESD
ecologically sustainable development

FAO
Food and Agriculture Organization of the United Nations

FM
fisheries management

FSA
Agreement for the Implementation 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)

GEF
Global Environment Facility

GMO
genetically modified organism

ITQ
individual transferable quota

LME
large marine ecosystem

MARPOL
International Convention for the Prevention of Pollution from Ships

MCS
monitoring, control and surveillance

MPA
marine protected area

MSY
maximum sustainable yield

NAFO
International Commission for the Northwest Atlantic Fisheries

NGO
non-governmental organization

PIA
prior impact assessment

SEEA
system of environmental and economic accounts

SNA
system of national accounts

TAC
total allowable catch

TED
turtle exclusion device

TEV
total economic value

TROM
target resource-orientated management

TURFs
territorial use rights in fishing

UNCED
United Nations Conference on Environmental Development

VITQs
value-based individual transferable quotas

WCED
World Commission on Environment and Development (1984-87)

WHAT
World Humanities Action Trust

WSSD
World Summit on Sustainable Development, Johannesburg, South Africa, 2002

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 living 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 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 the areas of their national jurisdiction, 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 many 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 over-exploitation 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 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 affect 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 appropriate technical guidelines in support of the implementation of the Code in collaboration with members and interested relevant organizations.

The concepts and principles of an EAF are not new, as they are contained in a number of international instruments, agreements and conference that have already been negotiated, adopted or are in the process of being implemented. These include:

- the 1972 World Conference on Human Environment;
- the 1982 United Nations Law of the Sea Convention;
- the 1992 United Nations Conference on Environment and Development and its Agenda 21;
- the 1992 Convention on Biological Diversity;
- the 1995 United Nations Fish Stocks Agreement; and
- the 1995 FAO Code of Conduct for Responsible Fisheries.

A summary of the content of these instruments is given in Annex 1.

More specifically, the Reykjavik Declaration (2001) requested that FAO prepare

> "…guidelines for best practices with regard to introducing ecosystem considerations into fisheries management."

Even more recently, the World Summit on Sustainable Development (WSSD, Johannesburg, South Africa, 2002) adopted a Political Declaration and a Plan of Implementation in relation to capture fisheries. In the Declaration, the Heads of States agreed to:

> develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive practices, the establishment of marine protected areas ... and the integration of marine and coastal areas into key sectors (31c).

Although the concepts underpinning EAF are not new, there has been little experience in attempting to implement them. These guidelines attempt to translate the requests for an ecosystem approach to fisheries into operational guidelines that can be applied to marine capture fisheries. While recognizing that EAF is relevant to fisheries development, trade, research, aquaculture, inland and marine capture fisheries, the current document focuses on marine capture fisheries. It should be read as a supplement to the FAO Technical Guidelines for Responsible Fisheries (No. 4, ROme, 1997, 82 pp.), hereafter referred to as the FM Guidelines.

Executive summary

The broad principles and approach for effective and responsible fisheries management are contained in the FAO Code of Conduct for Responsible Fisheries, many of which relate to an ecosystem approach to fisheries (EAF). EAF is, in effect, a means of implementing many of the provisions of the Code and provides a way to achieve sustainable development in a fisheries context. The principles pertaining to EAF are not new. They are already included in a number of international agreements and conference documents, including the 1972 World Conference on Human Environment; the 1982 United Nations Law of the Sea Convention (LOS); the 1992 United Nations Conference on Environment and Development (UNCED) and its Agenda 21; the 1992 Convention on Biological Diversity; the 1995 United Nations Fish Stocks Agreement; the 1995 FAO Code of Conduct for Responsible Fisheries; the 2001 Reykjavik Declaration; and the 2002 World Summit on Sustainable Development (WSSD). However, although the principles are not new, there has been little prior practical experience in implementing them. The guidelines, therefore, attempt to translate these higher-level principles into operational objectives and measures capable of delivering on EAF in a broad range of social and economic settings, particularly in developing countries.

There have been increasing demands for a practical set of guidelines for implementing EAF as a result of heightened awareness of the importance of interactions among fishery resources, and between fishery resources and the ecosystems within which they exist. A further incentive has been the recognition of the multiple objectives and values of fishery resources and marine ecosystems within the context of sustainable development. In addition, it is considered essential to disseminate information about the poor state of many the world's fisheries along with recent advances in science that highlight both knowledge and uncertainties about the functional value of ecosystems (i.e. the goods and services they are capable of providing).

In developing the guidelines, a comparison was made between what was needed to implement EAF with what is already required under current fisheries management practices. These comparisons focused on the dominant management paradigm in many medium- to large-scale commercial fisheries, namely to maintain the target resource base by controlling the size and operations of the fishing

activity (referred to as a target-oriented approach to management (TROM)). This focus does not, however, ignore the fact that many small-scale, multi-species fisheries in both developing and developed countries are often undertaken with little intervention beyond development support, or are based on more traditional management methods.

The guidelines recognize that there is a need to improve current fisheries management. The interactions that occur between fisheries and ecosystems, and the fact that both are affected by natural long-term variability as well as by other, non-fishery uses, must be more effectively taken into consideration. The purpose of an ecosystem approach to fisheries, therefore *is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystem.*

From this purpose, the definition of EAF follows. *An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries.*

Both the purpose and the definition recognize that EAF is a means to implement sustainable development concepts into fisheries by addressing both human and ecological well-being. They merge two related but potentially converging paradigms. The first is ecosystem management that focuses on protecting and conserving ecosystem structure and functions by managing the biophysical components of ecosystem (e.g. introducing marine protected areas (MPAs)), and the second is fisheries management that focuses on providing food and income/livelihoods for humans by managing fisheries activities. EAF recognizes the broader uses and users of the marine environment (including fishing) and the need to accommodate and reconcile the many objectives of these users so that future generations can also derive the full range of goods and services provided by the ecosystem. This approach also recognizes that man is an essential component of the ecosystem in which fishing takes place, and it focuses on the interactions within the system. EAF attempts to deal with issues in a holistic way, a feature often lacking in current fishery management practices that focus on individual species or species groups.

The ecosystem is a functional unit comprising dynamic complexes of plants, animals (including humans), micro-organisms and the non-living environment. Ecosystems exist on many scales, which are frequently defined in terms of the

question being asked. However for ecosystems to be a functional management unit they need to be geographically-based with ecologically meaningful boundaries.

EAF is neither inconsistent with, nor a replacement for current fisheries management approaches (e.g. as described in the FM Guidelines), and is likely to be adopted as an incremental extension of current fisheries management approaches. To provide continuity between current fisheries management practices and EAF, this publication use the FM Guidelines as a template, reinforcing those sections most pertinent to EAF and adding to them as appropriate to ensure that they give due attention to the extra dimensions required by EAF. The structure of these EAF Guidelines therefore follows that of the FM Guidelines.

The guidelines initially focus on the need for broader sets of data and information to support EAF. While recognizing that the availability of relevant information will vary widely among countries, considerable relevant information is nonetheless available. Some of this data comes from outside the conventional fisheries area, frequently from fishers and local people especially in developing countries where traditional knowledge of ecosystems and the fishery should be collected and made available for use by others. Many of the measures available to managers to implement EAF are based on those currently used for TROM fisheries management, but have been broadened to include a greater use of economic incentives and ecosystem manipulations. Current measures such as effort, catch, technical gear and area-based controls must be broadened to address a wider range of issues than simply management of the target species of the fishery.

These guidelines describe how the current management process would change under EAF. Although the EAF management process uses essentially the same cycle of planning, implementation and evaluation, there is a need to provide for better consultation with a broader range of stakeholders, and for a more rigorous setting of operational objectives, decision rules and evaluation of management performance. The approach described here encourages the participation of all relevant stakeholders, translating high-level policy goals into day-to-day management activities. Competing goals and aspirations should be debated to promote consensus. Participatory processes that allow consultation and input from an initial group of stakeholders must be developed in order to:

- identify the fishery, area and all relevant stakeholders;
- identify broad social, economic and ecological (including the fisheries resource) issues for the fishery, based on the broad international and national policy goals and aspirations;
- set broad objectives for these issues;

- break down broad issues into issues specific enough to be addressed by an identified management measure(s);
- rank the issues based on the risk they pose to the fishery;
- set agreed operational objectives for the high-priority social, economic and ecological issues identified in step 5 and develop linked indicators and performance measures;
- formulate management decision rules; and
- monitor the fishery using the selected indicators, and regularly evaluate the performance of management in meeting operational objectives – by inference, because of the linkages developed between policy goals and operational objectives, this will provide an assessment on how well management is achieving the broader policy goals.

Moving from high-level policy goals to operational objectives is a major challenge in areas where the goals deal with concepts such as ecosystem integrity, ecosystem health and biodiversity. It must be stressed, however, that operational objectives such as protection of critical habitats must be developed, or EAF will fail. Although there is lack of knowledge concerning ecosystem functioning and structure, uncertainty must not prevent the development of operational goals based on the best available knowledge. The process moves from higher-level goals to operational objectives whether applied to data-poor fisheries with low scientific and management capacity, or to fisheries rich in data and capacity.

In examining the legal and institutional aspects of EAF, the guidelines point out that, although the basic guiding principles and concepts are largely contained in already agreed international instruments and conference documents, the detailed requirement for operational EAF are not well covered in binding international fisheries law at present. They are mainly reflected in voluntary instruments such as the Code of Conduct. As a result, few regional fisheries bodies and arrangements make explicit recognition of EAF in their conventions. Similarly, EAF is not frequently an integral part of national fisheries policy and legislation. For EAF to be implemented, legislation will need to be reviewed and improved as appropriate. EAF may require more complex sets of rules or regulations that recognize and cater for the impacts of fisheries on other sectors and the impact of those sectors on fisheries.

EAF requires adherence to the same principles of transparent and participatory management that already guide many current management practices.

Given the broader stakeholder base under EAF, there will frequently be a need for institutions to coordinate better consultation, cooperation and joint decision-making between fisheries operating in the same geographical area, and between the fisheries and other sectors that interact with them. For example, where one fishery causes a decline in one or more prey species of a predator targeted by another fishery, there must be an institution or arrangement to coordinate the management actions of both fisheries, including the reconciliation of the different objectives of the two. This recognizes the true nature and extent of access and allocation of resources within an ecosystem, often neglected or ignored in fisheries management practices.

A transition to EAF will be greatly facilitated if adequate attention is given to the education and training of all those involved, including fishers, the management agency officials and staff and other stakeholders. The administrative structures and functions, including monitoring, control and surveillance, will have to be adapted as necessary.

A start should be made now in the implementation of EAF, where it has not already begun, based on existing knowledge. However, implementation and effectiveness will undoubtedly benefit from reducing important uncertainties, and further research is needed for this purpose. These guidelines identify a number of essential areas for further research, including better understanding of ecosystem structure and function and how fisheries affect them; integrating social, economic and ecological considerations into decision-making; improving the management measures available to implement EAF; understanding the management process better; and improving monitoring and assessments.

While it is generally recognized that EAF will generate important benefits, there are a number of major threats to smooth implementation of EAF. A lack of investment in the process will certainly hinder progress and could mean failure in the end. It will also take considerable resources to reconcile the often competing objectives of the different stakeholders, possibly aggravated by the difficulties of ensuring effective participation of all stakeholders in the development and implementation of EAF. Insufficient biological and ecological knowledge will continue to be a constraint, as will insufficient education and awareness, because these affect the ability of all stakeholders, including the fishery management agencies, to exercise their responsibilities. Equity issues will always be difficult to resolve in relation to responsibility for ecosystem degradation between fisheries

and other economic activities such as agriculture (including forestry), chemical industries, urban and coastal development, energy and tourism.

These issues will need to be addressed, and as more practical experience becomes available, solutions can be incorporated into future editions of the EAF Guidelines.

1 Introduction

1.1 The need for and benefits of an ecosystem approach to fisheries

The term ecosystem approach to fisheries (EAF) has been adopted in these guidelines to reflect the merging of two different but related and - it is hoped - converging paradigms. The first is that of ecosystem management, which aims to meet its goal of conserving the structure, diversity and functioning of ecosystems through management actions that focus on the biophysical components of ecosystems (e.g. introduction of protected areas). The second is that of fisheries management, which aims to meet the goals of satisfying societal and human needs for food and economic benefits through management actions that focus on the fishing activity and the target resource.

Up until recently, these two paradigms have tended to diverge into two different perspectives, but the concept of sustainable development[1] requires them to converge towards a more holistic approach that balances both human well-being and ecological well-being. EAF is, in effect, a way to implement sustainable development in a fisheries context. It builds on current fisheries management practices and more explicitly recognizes the interdependence between human well-being and ecosystem well-being. EAF emphasizes the need to maintain or improve ecosystem health and productivity to maintain or increase fisheries production for both present and future generations. Of special relevance to these guidelines is the recognition that, in contributing to a convergence of the two paradigms, EAF will be assisting in implementing many of the provisions contained in the FAO Code of Conduct for Responsible Fisheries.

Fishing activities normally target one or several species, known to provide food for consumers and income/livelihood to the fishers. During the past 50 years at least, the dominant fisheries management paradigm has been to maintain the target resource base through various controls on the size and operations of the fishing activity. In these guidelines, we will adopt the term "target resources-oriented management" (TROM) for this paradigm, recognizing that it has been

[1] "Meeting the needs of the present without compromising the ability of future generations to meet their own needs", Brundtland Report, *Our common future*, World Commission on Environment and Development, 1987.

adopted mainly for medium- to large-scale commercial fisheries. In most developing countries (with notable exceptions) and in many developed ones, the activities of the small-scale, multi-species fisheries are undertaken with little intervention beyond development support, or are based on more traditional management systems. The term "current fishery management practices" refers to this global situation, in which TROM is a part.

The depleted state of many of the world's fisheries and the degraded nature of many marine ecosystems have been well documented. Because fisheries have not been managed in a way that contributes positively to sustainable development, the impact on the world's economies and societies will be enormous both now, and probably even more importantly, well into the future. This situation will inevitably contribute to increased poverty, increased inequities and lack of opportunities for many of the world's fishers to make a decent livelihood. Poor management is depriving many regions and states of the potential social and economic benefits of fishing (currently estimated to employ 12.5 million people with about US$40 billion per annum in international trade). Approximately 80–90 million people, most of them in developing countries, depend on fish for their main daily source of protein. The need to reduce the alarming trend of depletion and degradation has been recognized in many international fora, most recently at the World Summit for Sustainable Development (Johannesburg, 2002), which pledged to:

> maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015.[2]

There is obviously a need to improve the approach used in fisheries management so that potential social and economic benefits can be achieved. Conflicts between competing users must be reduced, and fisheries must be accepted by society as responsible users of the marine environment.

1.2 What is an ecosystem approach to fisheries?

Interest in an ecosystem approach to fisheries (EAF) has been motivated by:

---

[2] Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August–4 September 2002, Chapter 1.2, Plan of implementation of the WSSD (www.Johannesburgsummit.org).

- heightened awareness of the importance of interactions among fishery resources and between fishery resources and the ecosystems within which they exist;
- recognition of the wide range of societal objectives for, and values of, fishery resources and marine ecosystems within the context of sustainable development;
- poor performance of current management approaches as witnessed by the poor state of many the world's fisheries; and
- recent advances in science, which highlight knowledge and uncertainties about the functional value of ecosystems to humans (i.e. the goods and services they are capable of providing).

Overall, there is a deeper and broader sense of stewardship in response to increased awareness of the importance of resources and about the current status of fisheries (such as the common occurrence of overfishing, economic waste and adverse impacts on habitat).

In both large- and small-scale fisheries, fishing activities usually affect other components of the ecosystem in which the harvesting is occurring; for example, there is often by-catch of non-targeted species, physical damage to habitats, food-chain effects, or changes to biodiversity. In the context of sustainable development, responsible fisheries management must consider the broader impact of fisheries on the ecosystem as a whole, taking biodiversity into account. The objective is the sustainable use of the whole system, not just a targeted species.

The need for a wider consideration of environmental and ecosystem issues in fisheries has also been acknowledged in many fora, and the principles and aspirations for EAF have been well documented. Although full implementation of agreed principles and aspirations might be difficult at this time, the status quo is not an acceptable option in the light of growing understanding of ecosystems and their uses by society. Progress in implementing EAF is possible, whatever the current approach to managing various types of fisheries. This document elaborates the benefits of EAF and provides practical guidelines for making the changes necessary for an ecosystem approach to marine capture fisheries.

In theory, all aspects of responsible fisheries, as outlined in the FAO Code of Conduct for Responsible Fisheries, can be addressed through EAF. However, the focus of these guidelines is on fisheries management (Article 7) with some coverage of research (Article 11), integration of fisheries into coastal area management (Article 10) and special requirements of developing countries (Article 5). The need to prevent pollution from fishing activities and the impact of polluters on fishing is also included, but was not fully elaborated.

The purpose of EAF can be inferred from many international instruments, reports and scientific publications (see discussion of principles and concepts, below). Generally speaking, *the purpose of an ecosystem approach to fisheries is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems.*

To fulfil this purpose, an EAF should address components of ecosystems within a geographic area in a more holistic manner than is used in the current TROM approach. Doing so will require identifying exploited ecosystems (in their geographic context); their complex nature must be recognized and addressed. An EAF also requires the recognition of many (sometimes competing) societal interests in fisheries and marine ecosystems. Accordingly, this definition follows: *an ecosystem approach to fisheries (EAF) strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries*.

EAF is neither inconsistent with, nor a replacement for, current fisheries management approaches (e.g. as described in the FM Guidelines). Rigorously applying TROM approaches (with appropriate emphasis on the precautionary approach and rights-based allocation) would begin to help solve some of the current fisheries problems. Such action in the past could have prevented a large number of present ecosystem problems. Thus, in practice, EAF in the foreseeable future is likely to be developed as an incremental extension of current fisheries management practices.

1.2.1 Principles and concepts

EAF addresses a number of concepts, sometimes referred to as "principles" that have been expressed in various instruments and conventions, and in particular in the Code of Conduct for Responsible Fisheries. These principles generally underpin the high-level policy goals assigned to fishery management at a national or regional scale. In brief (see Annex 2 for more details), recognizing that fisheries have the potential to alter the structure, biodiversity and productivity of marine ecosystems, and that natural resources should not be allowed to decrease below their level of maximum productivity, fisheries management under EAF should respect the following principles:

- fisheries should be managed to limit their impact on the ecosystem to the extent possible;
- ecological relationships between harvested, dependent and associated species should be maintained;
- management measures should be compatible across the entire distribution of the resource (across jurisdictions and management plans);
- the precautionary approach should be applied because the knowledge on ecosystems is incomplete; and
- governance should ensure both human and ecosystem well-being and equity.

1.3 Making EAF operational

There is considerable agreement on the underlying principles of EAF, and on their implications for policy. There is also consensus among academics, scientists, fishery advisers and many non-governmental organizations (NGOs) on the essential elements of an ecosystem approach to fisheries. However, to implement EAF it is necessary to translate the principles into operational objectives and action (see Box 1).

Translation of principles into high-level policy goals is relatively simple in terms of wording and definitions. Policy goals will usually reflect the overarching principles outlined in relevant domestic legislation, regional agreements and international agreements of various kinds (see Annexes 1 and 2). There should also be some societal agreement on the degree to which it is acceptable for fisheries and other users to alter these "characteristics".

Translation of policy into action is more important, but it is probably the most difficult step in the implementation of principles. At the outset, all stakeholders must recognize the existence of a hierarchy of issues[3] together with related objectives, indicators and performance measures. Without this recognition, EAF will simply remain an important concept, but will not really be useful in day-to-day fisheries management.

The aim of these guidelines is to translate the high-level policy goals into action by:

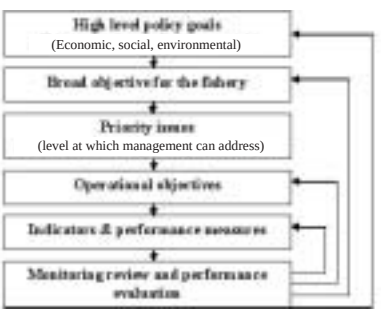
[3] Issues are referred to as "criteria" in the FAO Guidelines on the development of indicators for sustainable development of marine capture fisheries. FAO Fisheries Resources Division, *Indicators for sustainable development of marine capture fisheries*, FAO Technical Guidelines for Responsible Fisheries, No. 8, 1999, 73 pp.

Box 1
Making EAF operational

Available international agreements and instruments along with work already undertaken at the national level in some countries reflect a wide consensus on the need for the incorporation of an ecosystem approach to fisheries (EAF). However, to make EAF operational, the principles underpinning this approach need to be "translated" first into policy goals and then into operational objectives that can be achieved by applying management measures. Without this translation, EAF will remain an important, but largely unachievable, concept.

From principles to policy goals. The principles underpinning EAF cover the full spectrum of economic, social and ecological considerations of sustainable development. Many of the "characteristics" of ecosystems, such as ecosystem health, integrity, resilience, energy flows and the like are relatively abstract concepts that are not fully understood. However, even with our current state of knowledge, higher-level policy goals can be set, such as conserving biodiversity, maintaining fishery habitats, protecting important food chain functioning and so on.

From policy goals to implementation. These higher-level policy goals then need to be broken down into more specific issues, each with its own operational objective that can be achieved by applying a management measure. These need to be at a practical operational level for stocks, habitat, by-catch, protected species, income and social aspirations of the fishers, for example. The chart below shows the step-wise process to be adopted to facilitate implementation (see Chapter 4 for more detail).



Indicators and performance measures for each operational objective provide a framework for monitoring, review and evaluation of the performance of management in achieving both the operational objective, and because of the linkages, the higher-level policy goals.

- identifying broad objectives relevant to the fishery (or area) in question;
- further breaking these objectives down into smaller priority issues and sub-issues that can be addressed by management measures;
- setting operational objectives;
- developing indicators and reference points;
- developing decision rules on how the management measures are to be applied; and
- monitoring and evaluating performance.

It is not possible to be prescriptive on these sub-issues because they will obviously vary among fisheries. However, it is important to consider all the economic, social and environmental aspects of fisheries so that an important issue or sub-issue is not overlooked.

Any advice or guidelines then need to take into consideration the differences between developed and developing countries or types of jurisdiction, the availability of handbooks and manuals as well as technical protocols (e.g. to develop indicators), training of scientists and managers, etc. The process elaborated in Chapter 4, if applied in the context of the relevant country or jurisdiction, will provide a method for implementing EAF.

1.4 Moving towards EAF management

In this section, the topics covered in the FM Guidelines are considered sequentially in terms of the limitations of current fisheries management practice (referred to hereafter as current management practice)[4] and what would be required to fully implement EAF, noting that current management practice frequently falls short of TROM requirements and paradigms. As applied in the FM Guidelines, it is useful to categorize the different aspects of EAF into (i) the fisheries management process, (ii) the biological and environmental concepts and constraints, (iii) technological considerations, (iv) the social and economic dimensions, (v) institutional concepts and functions, (vi) time scales in the fisheries management process and (vii) the precautionary approach. Based on the increased emphasis of the importance of fish and fisheries to developing countries, a further category, (viii) special requirements of developing countries, has been added.

[4] This acknowledges the wide diversity of current practices, some of which are more advanced towards EAF than others, and of which TROM is a subset.

The main limitation of most current fisheries management is that it fails to effectively take into account the interactions that occur between fisheries and ecosystems and the fact that both are affected by natural long-term variability as well as non-fishery extractive and polluting activities.

1.4.1 The fisheries management process

The current fisheries management practice of planning, setting objectives, implementing strategies and measures to meet the objectives, as well as monitoring and assessing performance, if conducted to a satisfactory standard, will still provide a sound basis for implementing EAF. However, recognizing the broader economic and social interests of stakeholders under EAF, the setting of economic and social objectives will need a broader consideration of ecological values and constraints than is currently the case. This will require a broader stakeholder base, increased participation and improved linkages of fisheries management with coastal/ocean planning and integrated coastal zone management activities (see Chapter 4).

1.4.2 Biological and environmental concepts and constraints

Marine capture fisheries affect the environment directly (e.g. removal of target and non-target species, habitat change) and indirectly (e.g. changing biological interactions). Similarly, changes in the environment (e.g. climate, agricultural practices and pollution) affect fisheries.

TROM is based on the paradigm that the productivity of marine systems and the level of harvest for any target are limited. It may refer to non-target species, associated and dependent species but, in general, it does not sufficiently recognize the potential direct and indirect effects of fishing on the dynamics of the ecosystem, the conditions under which its productivity can be maintained and the existence of other societal values and uses. TROM is often based on a management unit (e.g. species, gear and jurisdiction) that takes little account of the ecosystem structure or boundaries in which it is operating.

EAF is based on the same "paradigm of limits" as TROM. It recognizes that our ability to predict ecosystem behaviour is inadequate, and accepts that all ecosystems have limits that, when exceeded, can result in major ecosystem change – possibly irreversibly. Maintaining biological diversity is regarded as being of major importance to ecosystem functioning and productive fisheries, as well as providing flexibility for future uses. Current management practices tend to give insufficient recognition to the fact that many components are intrinsically linked in the system in a complex flow of material, energy and information.

There have been many attempts to define an ecosystem. A fundamental principle is that ecosystems are one in a hierarchy of biological organizations in which the integrated whole is more than the sum of the parts (e.g. cells, organisms, ecosystems and biosphere) and are comprised of both living plants and animals (including man) as well as non-living or abiotic structures. They can be defined at many scales, for example from a boulder on a reef to an entire ocean. They can, therefore, overlap or be nested together. Ecosystems are usually spatially defined (i.e. they are sufficiently different from adjacent areas to be recognized as a functional unit) but most of them have no fixed boundaries, especially within the marine environment, and they exchange matter and information with neighbouring ecosystems. However to be able to implement EAF at an operational level, delineation of the "boundaries" is required and can be achieved by a sensible consensus based on proposed EAF objectives (see 4.1).

1.4.3 Technological considerations

EAF seeks to build on conventional fishery management measures to regulate fishing mortality through the use of input controls, output controls and technical measures (including spatial measures) by broadening the approaches to include other measures such as modifying populations by restocking or culling, where appropriate and effective. Similarly, habitat restoration and MPAs will need to be considered both in the context of facilitating fishing activity or enhancing the populations of target species as well as protecting biodiversity and providing broader benefits to the system as a whole (see Chapter 3).

Gear modifications, such as those used to selectively harvest the target species and minimize unwanted by-catch, including protected species, for example turtle exclusion devices (TEDs) and by-catch reduction devices (BRDs), will take on increasing importance as ecological objectives are broadened within the context of EAF. The impact of some fishing gear and methods on the bottom habitat (biotic and abiotic) can often have a negative effect on the ecosystem. There is limited knowledge about this impact, however, and more research is required to examine the extent of the impact of various gear. For gear known to produce serious impacts, the introduction of restrictions may be necessary and, where possible, new technologies that mitigate any negative impact will need to be developed.

Fishing operations may also cause other negative impacts to the environment, such as continued fishing by lost gear ("ghost fishing"), emission of exhaust gas with dangerous substances to the atmosphere and pollution from oily waste, litter and fish waste. Minimizing such impacts will require development and successful introduction of alternative cost-effective technologies and fishing practices.

Many ecosystems, especially those in coastal waters, are impacted not only by fisheries, but also by other users, including upstream land-based activities. In these cases, many of the broader measures will be the responsibility of other agencies. Fisheries managers will need to take a proactive approach so that the appropriate authorities recognize fisheries as an important stakeholder in these ecosystems.

1.4.4 Social and economic dimensions

Current fisheries management often focuses on a limited set of societal goals and objectives for achieving economic and social benefits from fishing. However, as the overarching goal of EAF is to implement sustainable development, the shift to EAF will entail the recognition of the wider economic, social and cultural benefits that can be derived from fisheries resources and the ecosystems in which they occur. The identification of the various direct and indirect uses and users of these resources and ecosystems is a necessary first step to attain a good understanding of the full range of potential benefits. While many of these benefits may be amenable to quantitative assessments, some are not, and their value can be described only in qualitative terms. Multi-criteria decision-making techniques may be applied to create aggregate indices that encapsulate both quantitative and qualitative ecological, economic, social and cultural considerations.

The quantitative valuation of marine ecosystem goods and services can be based on the concept of total economic value (i.e. use and non-use value). Many ecosystem goods and services are not traded, and therefore need to be valued through means other than market prices. While various approaches have been developed to undertake such valuations (see Annex 3), they pose particular difficulties in the measurement of non-use values, especially current or future (potential) values associated with resources which rely merely on continued existence of the resource and are unrelated to use (e.g. conservation of some endangered species). The relative weights given to use and non-use values by different groups, not just within countries but also between countries, can give rise to diverging views on whether specific fishing practices should be modified or cease entirely.

The consideration of a broader range of ecosystem goods and services necessarily implies the need of addressing a wider range of trade-offs between different uses, non-uses, and user groups. In view of the higher complexity of EAF and limited ability to predict changes in the future flow of ecosystem goods and services, valuation has to take uncertainties and risks explicitly into account.

Ecosystem considerations have been part of the fishery perspective of many

traditional fishing communities for long periods in different parts of the world. Nevertheless, overcapacity, overfishing and destructive practices have also occurred in many small-scale fisheries. EAF provides a framework within which traditional fisheries management practices can be recognized and strengthened to address some of these problems. EAF is better suited than TROM to handle impacts arising from destructive fishing practices, habitat degradation and pollution, and to use traditional ecological knowledge about fish and their habitats. EAF must, however, take into account the dependence of artisanal and small-scale fishing communities on fishing for their life, livelihoods and food security.

1.4.5 Institutional concepts and functions

One of the implications of implementing EAF is an expansion of stakeholder groups and sectoral linkages. This may have substantial impact on institutional structure and process, in terms either of creating new structures or strengthening existing institutional collaboration. Division of responsibilities within governments and differing priorities among different economic sectors are impediments to be overcome in order to implement an ecosystem approach to fisheries. An effective ecosystem approach will depend on better institutional coordination (e.g. between ministries). This will require clarification of roles and responsibilities, improved coordination and integration across government and other users and more accountability across all stakeholder groups. A greater emphasis on planning at a range of geographical levels that involves all relevant stakeholders will be required and will involve a much more collaborative approach and sharing of information. The magnitude of this task should not be underestimated, and a global acceptance of the benefits of this approach is needed for it to succeed.

In many cases, fisheries are currently managed by an agency with narrow legislation and objectives pertaining to the harvesting of only the target species without due regard to other uses/users in the area of the fishery or its impact on the ecosystem. Many laws and regulations may need to be changed to incorporate EAF. Management units may need to be redefined geographically or, at the very least, coordinated within a larger-scale planning process. This will be particularly important where natural and operational boundaries straddle jurisdictions and management plans, and where the indirect effects of fisheries are manifested elsewhere.

In most countries, EAF will require considerable capacity building. This will include improving understanding of ecosystem structures and functions; training

managers and regulators to deal with a broader range of options and trade-offs, conflicts, rights and regulations; and enhancing stakeholder capacity to participate. This may be achieved, at least in part, by mobilizing and linking with existing institutions.

1.4.6 Time scales

The FM Guidelines recognize three time scales of immediate relevance to the fisheries management process – a policy cycle of about 5 years, a fishery management planning and strategy cycle of 3–5 years and a shorter cycle of management implementation and review at an operational level, usually occurring annually. These will also apply to EAF, although the coordination necessary to achieve EAF may mean that progress is slower in some more complicated areas. Longer time scales will need to be considered when dealing with issues such as climate change or the well-being of future fisheries generations.

1.4.7 Precautionary approach

Under EAF, the precautionary approach gains even greater significance, because it is expected that uncertainty will be much greater than under TROM. Application of the principle specified in the FAO Technical guidelines on the precautionary approach to capture fisheries and species introductions that "where there are threats of serious irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation"[5] should result in conservative management action being taken until more is known about ecosystem structures and functions. Under EAF, as outlined in the above-mentioned publication, the principle is much broader than just environmental degradation, and applies to any undesirable outcome (ecological, social or economic); it should also be applied in all stages of the management process.

1.4.8 Special requirements of developing countries

The challenge to implement improved fisheries management is stretching national systems and capacity in most countries, and especially in the developing world. Implementing EAF could add a significant additional burden, and the challenge

[5] United Nations Conference on Environment and Development; and elaborated further in a fishery context in *The precautionary approach to capture fisheries and species introductions*, FAO Technical Guidelines for Responsible Fisheries, No. 2.

may be particularly formidable in small-scale fisheries, where the difficulty and costs of the transition to effective management may outweigh the available capacity and short-term economic benefits derived from it. Particular problems are likely to be encountered in regions where poverty is widespread, alternatives to fishing are scarce or non-existent, and where the traditional systems have broken down. In such situations, the short-term economic necessities, at both national and local levels, may be too overwhelming for serious consideration of change even when the long-term benefits are apparent.

The particular problems being faced by developing countries in implementing the Code of Conduct and EAF, and the role of the international community in assisting them, have already been recognized in major international instruments. In particular, Article 5 of the Code of Conduct, Special Requirements of Developing Countries, states:

> In order to achieve the objectives of this Code and to support its effective implementation, countries, relevant international organizations, whether governmental or non-governmental, and financial institutions should give full recognition to the special circumstances and requirements of developing countries, including in particular the least-developed among them, and small island developing countries ... especially in the areas of financial and technical assistance, technology transfer, training and scientific cooperation and in enhancing their ability to develop their own fisheries as well as to participate in high seas fisheries, including access to such fisheries (para. 5.2).

Paragraph 30c of the Plan of Implementation of the World Summit on Sustainable Development drew attention to Article 5 of the Code of Conduct, and the 2001 Reykjavik Declaration affirmed:

> Our determination to strengthen international cooperation with the aim of supporting developing countries in incorporating ecosystem considerations into fisheries management, in particular in building their expertise through education and training for collecting and processing the biological, oceanographic, ecological and fisheries data needed for designing, implementing and upgrading management strategies.

Greater attention needs to be given to fulfilling these requirements if the developing countries as a whole are to be able to make progress in implementing the growing number of agreements and instruments aimed at fisheries and fishery resources, as these countries simultaneously struggle with pressing fundamental

socio-economic issues such as food security, health and access to other basic necessities.

To mobilize more national resources, every opportunity should be taken to raise awareness and facilitate the use of EAF in all relevant cases. To justify using public financial resources, the many benefits that can be derived from the approach, not just those for the fishery sector, need to be highlighted. Emphasis also has to be placed on the existence of potentially high returns from improved management in order to mobilize support from international financial institutions.

The following issues are will need to be addressed to assist the implementation of EAF in developing countries:

- *Adaptation to capacity-poor situations*. Efforts are needed to tailor EAF to the capacity available in developing countries and small-scale fisheries, focusing on data-poor situations and providing appropriate models and methods for such situations. In addition, participatory and adaptive approaches will need to be developed, drawing on existing traditional rights and management systems whenever possible. There may also be advantages in integrating fisheries management into coastal area management where it could benefit from economies of scale and the existing networks for participation.
- *Financial policies*. International financial agencies and mechanisms as well as national development banks will need to facilitate and contribute to the finances necessary to take action on EAF. In appropriate cases, mechanisms could be established to recoup this funding through proper capture of the economic rent generated by better management (including payments for rights). Investing in disinvestment should also be seriously considered in suitable cases.
- *Aid and technical assistance*. Fish are a global commodity needed in the rich areas of the world as well as in the poorest, and building up a long-term national and regional institutional capacity to manage resources sustainably should be considered a global "duty". International financial institutions should adopt measures to assist developing countries to restore and manage their fisheries to facilitate food security and livelihood opportunities for impoverished coastal communities. Priority should be given to the least developed and food-deficit countries.

2 Ecosystem approach to fisheries data and information requirements and use

Data and information are the basis of good management. They underpin all stages in the EAF management process including formulating policy, developing management plans, and evaluating progress and updating policy and plans to provide for continuous improvement (see Chapter 4 and Figure 1 for details on this overall management process). As pointed out in FM Guidelines, although the data and information required for each of these stages overlap, the processes are distinct, occur on different time scales and require information at different levels of detail and aggregation. The guidelines in this Supplement do not re-iterate many of the important points concerning data collection and analyses already stated in the FM Guidelines, but attempt to show instead where EAF will require a broadening of data, analyses and information provision.

Because EAF is a broadening of current fisheries management practices, the data and information needs will by necessity be broader. However, it is important to stress that immediate action should be based, as much as possible, on data and information that already exist. In some countries, much of the information will already be available in reports and statistics from various research institutes, agencies and ministries. In others, EAF will have to be based on comparatively fewer data. However, in these cases there is often extensive traditional knowledge about the ecosystem and the fishery, which can be extremely useful if collected and validated from interviews with local fishermen and other stakeholders. In all cases, information about the local situation should be complemented by information from ecologically similar situations elsewhere.

2.1 Policy formulation

Policy development will be informed by broad information on the role that fisheries play in terms of the regional, national and local economy and social setting. As in TROM and other fishery management responses, information should be collected about the stakeholders, economic factors related to the fishery, details on costs and benefits, role in providing employment or livelihood, alternative sources of employment and livelihoods, status of access to or

ownership of the resource, institutions currently involved in planning and decision-making, along with a historical perspective of the fishery and its stakeholders. Under EAF, similar knowledge of alternative uses and users of the resources within the ecosystem will be required, and a better understanding of the many interactions that occur within the system is fundamental. A fishery will often affect species whose distribution extends beyond the distribution area of the fishery. Other users should also be informed by the fishery sector on the role fisheries play in the broader social and economical setting and on how any actions may affect other stakeholders.

2.2 Developing management plans

Formulating management plans is an important component of implementing EAF (see Chapter 4). To the extent possible, plans must be based on an understanding of a broad background of knowledge, although a lack of data or uncertainty about the impact of the fishery should not be used as an argument for delaying the formulation of an EAF management plan. Only in situations where the existing information is insufficient to decide whether a potentially important impact does actually take place will it be necessary to collect and analyse additional data (rapid assessment techniques, for example).

As described in the FM Guidelines, the information that feeds into a fishery management plan should include:

- the area of operation of the fishery and its jurisdiction;
- the various stakeholders;
- the gear and vessel types to be employed in the fishery;
- the history, management and socio-economic importance of the fishery;
- if possible, the distribution area of the most important commercial species in the catch (preferably as a map);
- relevant information about the life histories of these species;
- the effects of the fishery on the recruitment, abundance, spatial distribution and age or size structure of the target species, as far as possible;
- any available monitoring data; and
- any management procedures already in place, with descriptions and a performance evaluation.

In addition to these TROM requirements, the potential direct and indirect effects of the fishery on species and habitats will also need to be described.

Ideally, the information should consider the following, but if this is not possible, at least a comment about the following should be included:

- the critical habitats that may be affected and the potential direct and indirect impacts of the fishery on these habitats;
- the species composition of both the retained and non-retained by-catch and the potential effects of additional fisheries-generated mortality on affected populations;
- the likely amounts of discards produced by the fishery and the importance of these discards for potential scavengers;
- the potential amounts of litter produced by the fishery and the possible effects of lost or abandoned gear on fish and other biota;
- the ecosystem within which the fishery takes place including the impact of other anthropogenic activities such as releases of nutrients and contaminants;
- the major biological interactions in which the harvested species participate and the potential effects of fisheries on these interactions. Particular efforts should be made to identify possible interactions with critical species, with forage species important for transfer of energy in the food chain, and with habitat structuring species such as coral;
- the impact of fishing on life history traits, such as age and size of first maturity and possible effects of the fishery on the genetic diversity of affected populations;
- the legal framework and extent to which the effects generated by the fishery would comply with national regulations and with international law and agreements related to nature conservation with consideration for endangered species; and
- the possible management measures to reduce adverse environmental impacts (see Chapter 3).

The guidelines stress the need to translate policy goals and broad fishery objectives into operational objectives in order to implement EAF. The process also needs to be informed by the best available scientific advice so that, firstly, all the issues relevant to a particular fishery have been covered and secondly, that all alternative objectives, indicators and reference points can be assessed.

2.3 Monitoring, implementing and performance reviews

The setting of operational objectives and indicators will identify what information will need to be routinely collected in order to feed into the decision-making

process, as well as the short-term (annual) and long-term (3–5years) reviews and assessments of management performance. As will be pointed out in Chapter 4, the indicators that are developed may vary from fishery to fishery, depending on the main issues identified for a particular fishery. However, many fisheries will have a basic set of common issues, objectives, indicators for which data and information will be required. These will cover the ecological (including the fisheries resources), economic and social dimensions of sustainable development. A hypothetical example is given in Annex 4, which sets out some possible operational objectives, examples of indicators linked to these objectives and the data that are needed in order to calculate values for the various indictors. This example is by necessity a simplification of what might be normally required in a complex fishery working in an EAF planning and decision-making environment, but serves to demonstrate how data should be to collected to fit in with the management process.

2.4 Uncertainty and the role of research

Given the complexity of the ecosystems in which fisheries operate and the dynamic nature of the myriad of interactions that can occur, science (in its broadest sense word including biologists, mathematicians, sociologists, economists and technologists working in collaboration with stakeholders) cannot possibly hope to deliver on all the information required. Critical research to reduce some of this uncertainty will be presented in Chapter 5. There is an obvious need for more ecosystem information, for better information on social and ecological implications, for an understanding of the management process itself (including the provision of information in decision support systems) and for monitoring and assessment methods.

3 Management measures and approaches

3.1 Introduction

The measures available to managers to adopt an EAF will, at least in the short term, be an extension of those conventionally used in TROM. Thus the range of input and output controls and technical measures (including spatial measures) used to regulate fishing mortality remain highly relevant; but these controls will need to be considered in a broader context. This means recognizing that the range of measures chosen should not only address a series of target species concerns, but should also enhance ecosystem health and integrity. Managers should consider as far as possible a coherent mix of approaches that takes account of the interdependencies and functioning of the ecosystem. Apart from managing the direct effects of fishing activity, fishery managers will need to be aware of other measures that are available for managing populations (e.g. restocking and culling). Similarly, habitats may be modified to enhance the populations of target species or to restore degraded areas.

While population and habitat manipulation may lie partly within the remit of fishery management bodies, there are many other issues, generally within the competence of other agencies, that concern fisheries managers. These may be highly relevant in an EAF context; they include such issues as the impact associated with human activities on land and sea leading to habitat destruction, eutrophication, contaminants, CO_2 emissions, litter, accidental introduction of exotic species through ballast water, etc. Fishery managers should be proactive in these circumstances to ensure that the appropriate authorities include all those involved in fisheries as important stakeholders in management planning and decision-making.

3.2 Options to manage fishing

3.2.1 Technical measures

3.2.1.1 Gear modifications that improve selectivity

Most fishing gear affects marine life in one way or another. One major impact is that gear is used to remove the larger fish from a population and thus to change the size composition of the targeted species. In many fisheries, the gear also has an impact on non-target organisms. They are captured as well, and this by-catch

is frequently discarded because of its low economic value, prohibitions on landing or space limitations on board the vessel. The consequences for the ecosystem can be severe. For example, discarding by-catch can often change the trophic structure of entire ecosystems with the encouragement of scavengers, as is seen in many shrimp fisheries around the world. Size selective harvesting can, under some circumstances, lead to genetic changes in affected populations, such as changes in growth and in size and age at first maturity. Under EAF, these effects need to be considered more seriously.

Size selectivity of target species

Mesh size restrictions can be a useful measure to avoid capturing individuals of target species in the immature stages, but they have limitations in multi-species fisheries. When organisms of different shapes and sizes occur on the same fishing ground, immature individuals of a co-occurring larger species might still be captured.

When considering introduction of mesh size regulation in a trawl fishery, it is also important to consider the survival rate of the organisms that escape through codend meshes. If mortality is high, the anticipated benefit of larger meshes may not be achieved. Selectivity can be improved through a variety of methods other than mesh size, including the use of square mesh, sorting grids and other devices which enable the unwanted portion of the catch to escape.

Non-target species selectivity

Tools that reduce capture of non-target species in fisheries are known as by-catch reduction devices. Some successful examples include:

- turtle excluder devices (TEDs);
- sorting grids that assist in allowing unwanted by-catch to escape;
- circle hooks and blue dye baits that reduce incidental capture of turtles in longline fishing;
- scaring lines positioned above a longline gear during setting, thawed bait, night setting with minimum ship light, weighting the line, underwater setting, prohibition of dumping offal during setting to reduce catching seabirds;
- acoustic pingers to distract marine mammals from becoming entangled in gillnets; and
- modified operational methods and gear modifications that avoid capture of dolphin while purse seining for tuna.

All of these measures have proved to be very effective in different fisheries around the world and there are several examples where there have been economic benefits as well as large ecological benefits, e.g. in the Caribbean trap fisheries, in the Alaskan ground fish fishery and in tropical shrimp fisheries in Australia.

3.2.1.2 Other gear issues

When fishing gear like gillnets and traps/pots are lost during fishing operations, they may continue to capture fish for several weeks, months or even years, depending on the depth and prevailing environmental conditions (light level, temperature, current speed, etc). This "ghost fishing" can be partially limited by using biodegradable materials or some means to disable the gear, through increased effort to avoid losing them, or by facilitating the quick recovery of lost nets. In some areas, active campaigns are undertaken to "sweep" periodically for lost nets in known gillnet fishing grounds.

3.2.1.3 Spatial and temporal controls on fishing

Fishing mortality can be modified by restricting fishing activity to certain times or seasons, or by restricting fishing in particular areas. Such measures can be used to reduce the mortality rate of individuals of either target or non-target species in vulnerable life stages. Where stocks are shared by more than one country, the closures – like other management measures – must be coordinated.

The selective reduction of fishing mortality rate on both target and non-target species generally reduces both the direct and indirect effects of fishing on the ecosystem. Closures may be used to protect critical habitats where fishing activity would otherwise cause damage to the physical structures supporting the ecosystem. They may also help to reduce mechanical disturbance to the benthos and facilitate the establishment of more stable and structured communities.

One form of closure is that of marine protected areas (MPA)s. MPAs range from "no take" to planned "multiple-use" areas. MPAs are often designated for non-fishery objectives, but they can produce considerable benefits for fisheries. MPAs can protect sedentary species, allow a proportion of the stock to remain free of the genetic selective effects of fishing, and may act as refuges for the accumulation of spawning biomass from which replenishment of surrounding fished areas can occur, either through out-migration of fish or dispersal of juveniles. This latter benefit has yet to be demonstrated unequivocally for a range of locations, and may be site-specific.

Commonly, spatial and temporal closures have been established in the context of specific target stocks or fisheries, and it is not unusual for a very large variety of such ad hoc measures to occur in a single ecosystem. While such an approach may have its benefits, there may be advantages in a more systematic scheme where consideration is given to a coordinated attempt to protect a range of habitats and species on a scale which is relevant to the ecosystem concerned. This requires a synthesis of the current understanding of the important elements of ecosystems and an evaluation of the potential benefits (see Chapters 2 and 4.1.3).

It is important to include an evaluation of the overall effect of a closure based on the biology of the species concerned and the nature of the fishery. The success of spatial and temporal closures can be limited if their effect is merely to displace fishing activity and increase mortality of other species or life stages elsewhere. Species that are mobile and move between the protected and non-protected areas may, in fact, gain little protection.

Area closures that permit some fishing may require a large enforcement effort and can therefore be costly. Allowing certain categories of fishing activity can also create loopholes which undermine the intentions of the closure. Management authorities need to consider the likely degree of compliance and enforcement costs in establishing closures, although the advent of vessel monitoring systems (VMS) makes area-based management more enforceable in some regions of the world.

3.2.1.4 Control of the impact from fishing gear on habitats

Fishing gear that touches or scrapes the bottom during fishing operations is likely to produce negative impact on the biotic and abiotic habitats. Because only limited knowledge exists about the long-term effect of such impact, a precautionary approach is recommended in the use of high-impact fishing methods in critical habitats. Use of towed gear with reduced bottom contact is a technical option in such areas. Prohibition of certain gear in some habitats is another, e.g. trawling in coral reef and seagrass areas. A third option is to replace a high-impact fishing method with one with less impact on the bottom, e.g. trapping, longlining or gillnetting.

3.2.1.5 Energy efficiency and pollution

Many modern fishing vessels use fossil fuel for propulsion, for operating the fishing gear and for the preservation and processing of the catch. The impact of exhaust gas emission of dangerous substances, including CO_2, has been fully recognized, and technological innovations that reduce such emissions are encouraged. Energy optimization can be achieved through improved efficiency

of fishing gear as well as through improved management that lead to less fishing effort being required.

3.2.2 Input (effort) and output (catch) control

3.2.2.1 Controlling overall fishing mortality

The direct effects of fisheries on marine ecosystems are to increase fishing mortality rate among target and non-target species and to affect habitat. The fishery management methods that are used to control fishing mortality are often referred to as input and output controls. Input controls apply to *capacity* (which is closely related to the fishing mortality a fishing fleet could generate if the entire fleet were to fish full time) and *effort* (which is the actual amount of fishing activity). Output controls apply to the catch that results from the fishing effort. Well-known fisheries models are used to relate both catch and fishing effort to fishing mortality.

Capacity limitation seeks to restrict the total size of the fleet, thus reducing both fishing mortality and the pressures on decision-makers to allow higher fishing mortality. Capacity controls have the potential to reduce fishing mortality on entire species complexes in exactly the same manner as effort or spatial/temporal access limitations.

Effort limitation seeks to restrict the fishing activity of fleets and hence reduce fishing mortality. Because this operates at the fleet level, there will be a reduction in mortality among all species involved in the fishery, and this may be advantageous when dealing with multi-species fisheries. Although there is a considerable difference in the likely social and economic effects of different effort limitation regimes, the net effect of reducing the amount of fishing will produce benefits for the ecosystem, provided the continual improvement in efficiency ("effort creep") does not cancel out the effect over time.

In current fisheries practices, the main limitations of any of these controls are that they do not directly constrain the fleet from targeting and depleting an individual stock. From an EAF viewpoint, these input controls have the virtue of restricting the overall pressure on the ecosystem, thus offering the potential of limiting negative impacts. However, there is also considerable danger that fishing mortality will steadily increase if increasing efficiency is not monitored and controlled. While increases in efficiency, if unchecked, will increase the fishing mortality in the target and by-catch species, some technological progress such as development of echo-sounders and satellite navigation may also enable fishermen to direct more of their effort towards the target species and thus diminish the impact on non-target species.

3.2.2.2 Catch controls

Catch controls in the form of catch limitations are aimed at directly reducing fishing mortality on target species. If complemented with by-catch controls (such as quotas) they have the potential to protect associated species. They have proven successful in some cases, including in multi-species fisheries, but have sometimes also led to undesirable outcomes (high-grading, increased discarding, etc.). In terms of an EAF, however, in a mixed-species fishery, consideration needs to be given to the different vulnerabilities and productivity of the various species. It will be necessary to implement a set of consistent catch limits across the range of target and by-catch species to reflect these differences and addresse desired ecosystem related objectives (such as maintaining food webs). Catch limits for target species may need to be modified to control catches of more vulnerable species.

3.2.3 Ecosystem manipulation

In some situations, technology and understanding of marine ecosystems have advanced to the point where ecosystems may be manipulated to achieve societal objectives that include conservation and restoration. Such manipulation (in the form of, for example, stock enhancement, culling or habitat restoration) may be an attractive option to mitigate negative impact from the past (like overfishing or habitat destruction). However, mitigation is rarely completely effective, carries with it some risk of unexpected consequences; it may also be costly. There is still little experience with successful ecosystem manipulation, and knowledge is insufficient to allow for sound prognoses. Avoiding the causes of the problem in the first place is a much more desirable approach.

3.2.3.1 Habitat modifications

Preventing habitat degradation. Habitat preservation in marine fisheries is the key to EAF, because it underpins the health of exploited ecosystems. Managers need measures to prevent damage to habitats, to restore damage where it has occurred and to increase habitat where required. Such measures must be in harmony with other ecosystem functions. Various types of fishing pose threats to the integrity of the habitats that support fisheries resources and other components of the ecosystem. Apart from notorious practices such as using dynamite and fishing with poison, already widely outlawed, several other practices may result in physical and biological damage to the seafloor. The different measures needed to reduce such impacts include:

- prohibition of destructive fishing methods in ecologically sensitive habitats (such as seagrass beds);
- prohibition of intentional cleaning of the seafloor to facilitate fishing; and
- reduction of the intensity of fishing in some fishing grounds to ensure that non-target, habitat-forming species are not reduced below acceptable levels.

Providing additional habitat. In situations were it is evident that insufficient habitat is available to support species of interest or concern, additional habitat can be created in two ways. The first measure applies where habitat has been damaged or lost and involves re-establishing mangroves, seagrasses and coral reefs. Such rehabilitation programmes should not be implemented unless the problems causing the damage in the first place have been adequately addressed. The primary objective is to re-create the physical structure needed to provide shelter for animals and a substrate for forage organisms. Ideally, rehabilitation programmes should aim to increase biodiversity, so they should aim to be multi-species rather than monospecific enhancements. In some cases, simply providing the conditions necessary for survival of propagules (coral larvae, seagrass seeds) arriving from nearby areas of habitat will result in restoration of habitats. Because many species of fish use different habitats as a continuum during their development, restoring only some habitats may not achieve the full potential of a rehabilitation programme to improve productivity or biodiversity.

The second method is to construct artificial habitat. Well-designed and -located artificial habitats have the potential to improve production by increasing the settlement success of juveniles in years of abundant seed supply (e.g. larvae). Artificial habitats may also play an integral part in a restocking or stock enhancement programme by permitting a larger number of animals to be released (see below). However, care needs to taken to ensure that the new habitat does not redistribute fish in a way that makes them more vulnerable to overfishing. Artificial habitats may also become a navigation hazard, pollute the ecosystem or disrupt its structure and function. Problems can also occur when the artificial habitats are not robust enough to prevent them from breaking up during storms and littering the seashore.

Decisions to increase the amount of structural habitat will involve choices about the relative value of different components of the ecosystem (habitats and species), because creation of one habitat will be at the expense of another. Artificial habitats are also expensive to construct and it may be more effective to protect the existing natural and renewable forms of fish shelters, such as seagrass beds.

3.2.3.2 Population manipulation

Restocking and stock enhancement

Target species that have been heavily over-exploited in some fisheries ecosystems can potentially be restored by releasing cultured juveniles to rebuild the spawning biomass, and then protecting the released animals, the remnant wild stock and the progeny until the population increases to the desired level. This process is known as restocking, and differs from stock enhancement (see below). The former aims to rebuild the stock back up to viable levels, while the latter supplies additional stock to harvest. However, as there are often high costs involved in restocking programmes, careful analysis is needed to determine whether the goals of rebuilding stocks can be achieved by other management measures. In general, restocking should be considered only when other forms of management are incapable of restoring populations to acceptable levels, and it should be coupled with controlled fishing capacity and reduced overfishing. If restocking is needed, and the species is part of a mixed fishery that need not otherwise be closed, restocking can be carried out in MPAs.

To reduce the risks of adverse effects on remnant wild individuals of the same species or other species in the ecosystem, restocking programmes must incorporate: (i) hatchery procedures that prevent loss of genetic diversity by guarding against inbreeding and selective breeding and (ii) quarantine protocols that prevent the transfer of pathogens from cultured animals to the wild.

Where managers wish to increase the yields of particular species from ecosystems, release of cultured juveniles in "stock enhancement" can sometimes be used to manipulate population levels. This process aims to overcome recruitment limitation, which occurs when the natural supply of juveniles falls short of the ability of the habitat to support the desired stock level. As with restocking programmes, careless hatchery practices could also result in the release of individuals unfit for survival in the wild, modification of genetic diversity and the introduction of diseases.

Factors to be considered in determining the benefits and costs of stock enhancement programmes include: (i) the need to minimize production of hatchery-reared juveniles by optimizing the scope for natural replenishment by wild stocks, (ii) the abundance of predators and prey at proposed release sites, and (iii) the need for independent assessments to determine whether the enhancement programme is achieving its goals and whether it is having adverse effects on the ecosystem. It may also be necessary to provide additional habitat to support the increased numbers of enhanced species.

Culling. This measure usually aims to reduce the abundance of predators or species that compete for the same trophic resources, in order to increase the yields of target species or to maintain the balance of the trophic structure. However, such food-web manipulation needs to be carried out with caution to ensure that it produces only the desired effect and does not result in unwanted changes in abundance of other important components of the ecosystem or threaten the survival of the species culled. An adaptive approach is needed, which may benefit from planned experimentation in some cases. Consideration should first be given to the rebuilding of target species populations through other, more conventional, fisheries management measures. Large-scale culling should be conducted only after the full implications of the manipulation have been thoroughly investigated.

Intentional introductions. Although new fisheries can be created by introducing species, there is a high risk of causing detrimental changes in coastal ecosystems. A precautionary approach is needed here, but this does not mean that the measure should never be considered. Some introductions of marine species have resulted in social and economic benefits with no apparent impacts on other components of the ecosystem. Fisheries for trochus in the Pacific and scallops in China are good examples.

A comprehensive risk assessment should be undertaken before considering the creation of new fisheries based on introduced species so as to understand the benefits and consequences of such measures. Steps to be undertaken in a risk assessment should include a detailed understanding of issues such as the trophic level of the species, reproductive potential and requirements, interactions with other species, introduction of pathogens and parasites, and effects on demand for and supply of other species.

3.2.4 Rights-based management approaches

The dangers and consequences of allowing open access to fisheries are now well understood (see Section 3.2, FM Guidelines), where the different options for limiting access and their properties are also described. The Code of Conduct stipulates:

> "States should develop, as appropriate, institutional and legal frameworks in order to ... govern access to them (coastal resources) taking into account the rights of coastal fishing communities" (para.10.1.3).

A well-defined and appropriate system of access rights in a fishery produces many essential benefits, most importantly ensuring that fishing effort is commensurate with the productivity of the resource and providing the fishers

and fishing communities with longer-term security that enables and encourages them to view the fishery resources as an asset to be conserved and treated responsibly.

There are several different types of use rights. Territorial use rights (TURFs) assign rights to fish to individuals or groups in certain localities. Limited-entry systems allow only a certain number of individuals or vessels to take part in a fishery, with entry being granted by way of a license or other form of permit. Alternatively, entry may be regulated through a system of effort rights (input rights) or by setting catch controls (output rights), where the total allowable catch (TAC) is split into quotas and the quotas allocated to authorized users.

Each type of use right has its own properties, advantages and disadvantages, and the ecological, social, economic and political environment varies from place to place and fishery to fishery. Therefore, no single system of use rights will work under all circumstances. It is necessary to devise the system that best suits the general objectives and context for each case, and this system may well include two or more types of use rights within a single fishery or geographic area. For example, a fishery that includes artisanal and commercial fishers could make use of TURFs, effort quotas and catch quotas to regulate access in the different sectors in a way that suits the nature of each, and gives due attention to the productivity of the resources. By way of example, *A fishery manager's guidebook* by FAO tentatively suggests:

- TURFs may be particularly suitable for the management of sedentary resources;
- effort rights may be more effective and practical than catch rights where there are no reliable estimates of biomass or where good monitoring of catches may be impractical (or where species diversity is high);
- catch rights may best facilitate the management of highly migratory and transboundary stocks where the allowable catch must be divided amongst the participating nations; and
- effort management may be more effective where a fishery uses primarily the same gear type, whereas in a fishery using many different gear types, catch rights may be preferable.[6]

EAF requires that all the uses and users of a fishery resource be considered and reconciled, and that interactions between different fisheries within the designated geographic area be taken into account. This will mean that the systems of access rights across different fisheries or different fishery sectors within the management area should be mutually compatible and, overall, that the total effort applied should be commensurate with the productivity of the ecosystem

and its component parts. While this may be a demanding and difficult task to implement, often with significant political implications, it is essential for sustainable use of ecosystems and, once in place, will greatly facilitate management of the fisheries and their operation.

3.3 Creating incentives for EAF

EAF may be easier to implement if the rules and regulations applied under a so-called control and command (C&C) form of management are supplemented, or even replaced to the extent possible, with more appropriate incentive measures to achieve EAF. The idea of incentives is to provide signals reflecting public objectives while leaving some room for individual and collective decision-making to respond to them (further elaboration is given in Annex 5).

Different kinds of incentives can be developed in isolation or in combination.

- Improve the institutional framework (definition of rights and participatory processes).
- Develop collective values (education, information, training).
- Create non-market economic incentives (taxes and subsidies).
- Establish market incentives (eco-labelling, and tradable property/access rights, as discussed above).

Incentives play indirectly through the determinants of individual/collective choices, such as the profit motive or normative values. Market or social forces can be very efficient vectors to force the global outcome of individual actions towards collectively set objectives.

Any of these instruments relies to some degree on command and control. Creating the conditions for an efficient market for property rights requires that these rights be legally set and effectively enforced. Similarly, creating a market-based incentive for environmentally-friendly production methods through product eco-labelling requires that certification standards be established and enforced. Incentives and command and control should be seen as complementary, having relative advantages or disadvantages depending on what they are supposed to achieve. Presently, the full range of available incentive instruments is probably underused, with a continuing bias towards command and control.

---

[6] A.T. Charles, Use rights and responsible fisheries: limiting access and harvesting through rights-based management, in *A fishery manager's guidebook – Management measures and their application*, K.L. Cochrane (ed.), FAO Fisheries Technical Paper, No. 424, pp. 131–157.

3.4 Assessing costs and benefits of EAF

3.4.1 EAF management costs and who pays

The shift to EAF may in most, if not all, cases imply higher management costs that include acquisition of additional information, planning and consultative decision-making processes involving a broader range of stakeholders/interest groups, and additional monitoring, control and surveillance. Although higher management costs may often be out-weighed by the long-term benefits of implementing EAF, the question of who pays becomes important. The idea of the fishing industry paying some of the fishery management costs is becoming increasingly accepted and adopted. However, the fact that EAF responds to wider societal needs requires an explicit policy on how the incremental management costs of EAF should be divided between benefits derived by those dependent on fishing for food, livelihood and employment, and benefits to society at large. Where countries are given the task of managing global ecosystem goods and services, consideration may have to be given to whether incremental management costs should be carried by the international community.[7]

In considering global ecosystem goods and services such as bio-diversity or conservation of endangered species, the issue arises whether valuation should be based on national or local preferences, or take into account preferences of the citizens of other countries or the international community at large. It also needs to take note of goals expressed in international conventions. On the other hand, valuation based on what the most affluent citizens of the globe are willing to pay could result in policy prescriptions that are unfavourable to poor producers and consumers in developing countries. This has given rise to the call for establishing equivalency standards that explicitly take into account differences in wealth and the ability to provide alternative employment and income opportunities.

3.4.2 EAF cost-benefit analysis

The appropriate tools to estimate the costs and benefits of EAF management measures include bio-economic and ecological-economic modelling of various sophistication and total economic valuation methods (see Annex 3). A useful cross-sectoral tool is integrated environmental and economic accounting. A system of integrated environmental and economic accounts (SEEA) provides a comprehensive framework to monitor and analyse the interactions between

[7] The idea of compensating countries for such incremental management costs underlies the Global Environmental Facility (GEF).

Box 2
System of environmental and economic accounts (SEEA)

One approach for making EAF more operational is to incorporate the role of the environment into economic accounts at the national level through a system of national accounts (SNA) and satellite accounts for the environment. SNA constitutes the primary source of information about the economy and is widely used for analysis and decision-making. However, SNA has had a number of well-known shortcomings regarding the treatment of the environment. In fisheries, for example, the SNA is used to record only the income from capture fishing, but not the changes in the abundance and value of fish stocks. This can be quite misleading when a fish stock is being overexploited: income from overexploitation is recorded, but not the corresponding depletion of the fish stocks. These and other shortcomings are being addressed through a system of environmental and economic accounts (SEEA).

As a satellite account, SEEA has a structure similar to that of SNA, recording stocks and flows of environmental goods and services. It provides a set of aggregate indicators to monitor environmental and economic performances at the sectoral and macroeconomic levels and to keep a detailed set of statistics to guide resource managers toward policy decisions that will, it is hoped, improve environmental-economic performance in the future.

There are two features that distinguish the SEEA from other databases about the environment. First, the SEEA directly links environmental data to the economic accounts through a shared structure, set of definitions and classifications. The advantage of this database is that it provides a tool to integrate environmental-economic analysis to overcome the tendency to divide issues along disciplinary lines, in which analyses of economic and environmental issues are carried out independently of one another.

Second, SEEA covers all the important environmental-economic interactions (including environmental manage-ment costs), a feature that makes it ideal for addressing cross-sectoral issues such as fisheries management. As an ecosystem-wide approach, it addresses threats to the health of fish habitat that result from changes in land use, pollution levels, forest cover, water flow and other environmental components. As satellite accounts to the SNA, the SEEA is linked to the full range of economic activities with a fairly comprehensive classification for environmental resources, including information about all critical environmental stocks and flows that may affect fisheries. A handbook on SEEA for fisheries is under development by FAO in cooperation with the United Nations Statistics Division.

different sectors of the economy and their individual and aggregate impacts on the environment (see Box 2).[8]

3.5 Other considerations

Many of the problems facing fisheries management in an EAF context fall outside the direct control of fisheries managers. Examples of such problems include:

- eutrophication of coastal waters resulting from excess nutrients from agriculture and sewage, which cause toxic algal blooms and affect the health of seagrass and coral reef habitats (by encouraging growth of epiphytes, for example);
- sediment loads from agriculture, forestry and construction of infrastructure in catchment that degrade coastal ecosystems, particularly the critical coral reefs and seagrass habitats;
- destruction of fish habitats through foreshore development;
- introduction of exotic species through ballast water and on the hulls of ships;
- contamination of fish products through chemical pollution from agriculture and industry;
- competing use of waterways from other sectors, including aquaculture; and
- effects of climate change on distribution of stocks and sea level rise on nursery habitats.

Fisheries managers need to ensure that they are recognized as important stakeholders in the process of integrated coastal management so that they can safeguard the function of the habitats that support fisheries ecosystems from adverse effects stemming from activities in other sectors.

[8] Under the umbrella of the United Nations Statistical Commission, the so-called London Group on Environmental Accounting has produced a handbook on the System of Integrated Environmental and Economic Accounts 2000 (SEEA 2000). The draft, as submitted to the UN Statistical Commission, can be found at: http://www4.statcan.ca/citygrp/london/publicrev/pubrev.htm

4 Management processes

4.1 Developing an EAF management plan

This chapter provides guidelines for the process to be followed to produce and revise management plans within EAF. They apply whether the fishery is new, moving from TROM (or other management systems) to EAF, or managed consistently with EAF but undergoing changes (from new gear, new areas of operation, etc.). Many of the steps included in these guidelines are already part of good practice in developing management plans in TROM.

As discussed in the FM Guidelines, an important basis for management is the formulation of a fisheries management plan. This should be a formal or informal arrangement between a fishery management authority and stakeholders (used synonymously here for "interested parties"). The plan should identify the background to the fishery, including all major stakeholders, agreed objectives (covering the economic, social and ecological components for the fishery) and specific rules and regulations that apply (for more detail see Box 3).

The process of developing and modifying an EAF management plan requires a series of iterative steps (see Figure 1) that include: defining the initial scope; gathering background information and analysis; setting objectives (broad objectives as well as operational objectives along with their associated indictors and performance measures); and the formulation of rules, and monitoring, assessment and review.

These guidelines are intended to be as complete as possible, and hence describe an ideal situation. In many cases, sufficient capacity and information will not be available to address all points. The processes outlined in the guidelines, however, are worth applying even in data-poor situations, and even when there is need for substantial capacity building. The output of the process will still provide guidance on how management can start implementing the policy goals outlined in the various international agreements [as summarized in the Background section and fully elaborated in Annex 1]. In practice, just applying the process will facilitate better fisheries management.

Because of the different time scales involved in the processes elaborated in Box 3, it may be necessary to have at least two components to the plan – for example, a higher-level plan that is in place for 3–5 years that states the broad

Box 3

Suggested elements for a fishery management plan under EAF

TITLE

BACKGROUND

Social and institutional aspects

Area of operation of the fishery, jurisdiction and *ecosystem "boundaries"*

History of fishing and management

Social and economic benefits, both now and in the future

Description of stakeholders and their interests

Description of other uses/users of the ecosystem, especially activities that could have major impacts and arrangements for coordination and consultation processes

Consultation process leading to the plan

Ongoing consultative arrangements

Details of decision-making process, including recognized participants

Descriptions of fishing activity, resources and the ecosystem

Description of resource (target species and by-product)

Description of the aquatic ecosystem in which the fishery occurs

Description of fleet types or fishing categories

Ecological issues and challenges

Details of critical environments, particularly sensitive areas

Details of bycatch concerns including threatened/protected species

Details of other environmental concerns, including biodiversity and trophic changes

OBJECTIVES

Objectives, reference points and performance measures for the fishery

- Resource
- Environment (including bycatch, habitats, prey protection, biodiversity, etc.)
- Social
- Economic

MANAGEMENT MEASURES

Agreed measures for the regulation of fishing to meet all objectives within agreed time frame, including by-catch, habitat protection, prey protection, etc.

DECISION RULES

Pre-agreed rules for applying management measures

ACCESS RIGHTS

Nature of rights granted in the fishery and details of those holding the rights

(Box 3, cont.)

EVALUATION OF MANAGEMENT

Most recent status of stocks including, critical by-catch species, based on risk and stock assessments using agreed indicators and performance measures

Status of the aquatic ecosystem, using agreed indicators relevant to essential and performance measures

Social and economic analyses using agreed indicators and performance measures

MONITORING, CONTROL AND SURVEILLANCE

Arrangements for ongoing monitoring, control, surveillance and enforcement

COMMUNICATION

Communication strategy

Details of any planned education and training of stakeholders

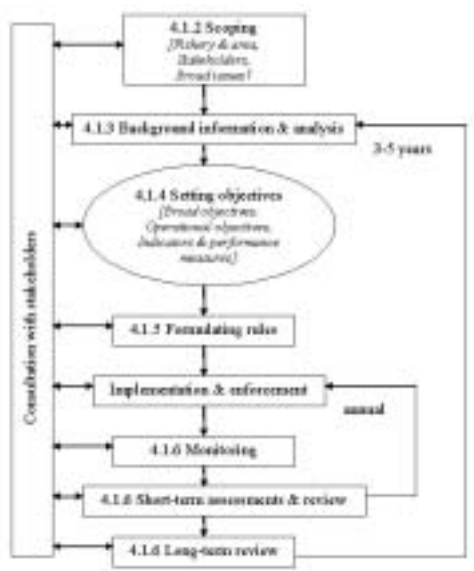
REVIEW

Date and nature of next review and audit of performance of management

Source: Adapted from FAO Fisheries Department, Fisheries management, *FAO Technical Guidelines for Responsible Fisheries*, No. 4, Rome, 1997. New elements are in italics.

Figure 1
Developing EAF

Diagrammatic representation of the process of developing, modifying and implementing an EAF management plan. Numbers refer to sections in the following text. Note that the steps shown in Box 1 are subsets of 4.1.4, Setting objectives.



management objectives and measures to achieve them, and another plan/report that reflects an annual cycle of setting and reviewing specific operational objectives, indicators and performance measures. Over time, as operational objectives become more stable, these latter could be formally included in the higher-level plan.

4.1.1 Consultation

For the stakeholders to obtain ownership of the plan and its implementation, they must be included in consultation and participation at all stages in the process. The range of interests, aspirations and numbers of stakeholders are likely to be greater than for TROM, and processes are needed to ensure that stakeholder involvement sufficiently represents the breadth of views, without the group becoming unmanageably large. Issues related to stakeholder capacity and commitment will also need to be carefully addressed, and formal, transparent and accountable processes set up to allow all parties to work cooperatively. In some cases, logistic constraints may mean that stakeholder inclusion is limited; in these cases, great care will be needed to maintain transparency, credibility and ownership in the outcomes.

4.1.2 Defining the scope of a fishery management plan under EAF

4.1.2.1 Identifying the fishery, area and stakeholders

The first step in developing an EAF management plan is to identify the fishery(ies) and geographic area to be addressed. For EAF, this is potentially much more difficult than for TROM, although in some cases the fishery(ies) to be covered by the Management Plan is(are) specified before the process begins. Ideally, the spatial coverage of the management plan would coincide with a clearly and precisely defined ecosystem. Ecosystems, however, are not clearly defined entities with unambiguous boundaries, and they may cross or be contained within fishery management areas. The final choice of fishery(ies) and geographic area for a management plan will depend on the issues identified in step 4.1.2.2, but a preliminary delineation of the area concerned is necessary, if only to allow identification of stakeholders. In practice, the preliminary steps are interactive, and initial choices can be adapted as subsequent steps reveal new information or concerns. From a practical perspective, EAF will need to recognize existing fisheries, management entities and jurisdictions and build incrementally on these. In some cases, this may require building additional elements into individual fishery management plans, while in others it will require coordination of additional measures across fisheries (see section 4.2).

4.1.2.2 Identifying broad issues for the fishery

The next step is for stakeholders included in the process to undertake an initial evaluation of issues associated with the fishery. The purpose of the evaluation should be to identify, as far as possible, all potential consequences of the identified fishery(ies) and the management tools and options that might be available.

This should cover economic, social and ecological components of sustainable development and be guided by the high-level policy goals set at the national or regional level. Ecological considerations would need to include:

- sustainable harvesting of the retained species (target and by-product species);
- managing the direct effects of fishing (especially on non-retained by-catch and habitat); and
- managing the indirect effects of the fishery on ecosystem structure and processes.

Several useful frameworks for guiding this process have been described in the FM Guidelines on indicators for sustainable development in marine capture fisheries.[9] These include a "pressure – state – response" approach and a "hierarchical tree" approach. A framework ensures that all relevant issues are included. In these guidelines, the hierarchical tree approach that has been adopted in Australia is used (see Figure 2).[10] The strength of this approach is that it deals explicitly with the hierarchy of issues and objectives inherent in fisheries management that are consistent with achieving sustainable development, linking them with higher-level goals. The hierarchical tree starts with the two main concerns of sustainable development, namely human and ecological well-being, and it includes management capacity by adding a third component related to the ability to achieve (includes governance and environmental impact on the fishery).

4.1.3 Background information compilation and analysis

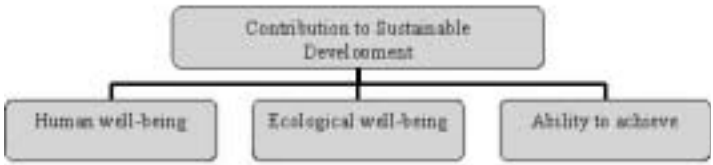
When the potentially important ecological and socio-economic issues have been agreed, relevant information must be compiled and analysed to allow formulation of more detailed objectives; this will normally be a desk study of available information.

---

[9] FAO Fisheries Resources Division, *Indicators for sustainable development of marine capture fisheries*, FAO Technical Guidelines for Responsible Fisheries, No. 8, 1999.

[10] www.fisheries-esd.com

Figure 2.
Hierarchical tree framework for identifying major issues in a fishery



In an EAF context, there should be greater emphasis on the analysis of the environmental impacts of the fishery in terms of effect on habitat and direct and indirect impact on biota other than the target species than has been the case with TROM (data and information requirements are described in Chapter 2).

4.1.4 Setting objectives

4.1.4.1 Setting the broad objectives for the fishery

The broad objectives for the fishery provide statements of the intended outcomes of the fishery management plan in addressing the set of issues identified in 4.1.2.2 above. These broad objectives provide a link between the principles, policy goals, major issues and what a particular fishery is trying to achieve.

For example, the broad management objectives for a given fishery might be to:

- keep harvested species within ecologically viable stock levels by avoiding overfishing and maintaining and optimizing long-term yields;
- maintain habitats and populations of non-retained (by-catch) species within ecologically viable levels;
- keep impact on the structure, processes and functions of the ecosystem at an acceptable level;
- maximize net revenues; and
- support regional employment.

It is important that those responsible for setting the broad objectives involve those responsible for implementing the relevant policies and agreements. In most situations, this will involve several levels of government and several major stakeholder groups.

4.1.4.2 Developing operational objectives from broad objectives

In order to implement EAF, the broad objectives must be translated into operational objectives with direct and practical meaning in the context of the fishery, and against which the performance of the fishery and its management can be evaluated. The process of developing operational objectives from the broad objectives should be transparent and participatory. This will enable interested parties to understand and contribute to the development and selection of the operational objectives, establish broad ownership and encourage compliance.

Fisheries and their ecosystems involve many potential issues, but there is a practical limit to how many operational objectives (and linked indicators) are useful for management decision-making. The process of identifying the operational objectives must thus also be able to screen large number of possibilities and choose only the most important and feasible ones. The detailed consultation and decision process for development of the operational objectives from the broad objectives will vary from one fishery to another. However, they will necessarily involve three steps:

- identify issues, at a practical level, relevant to the fishery under each of the broad objectives;
- prioritize the issues based on the risk they pose; and
- develop operational objectives for priority issues, and as necessary, a process for monitoring some lower priority issues.

Ideally, these steps will include participation of appropriate technical experts who will conduct an assessment process described in 4.1.6, below. These steps will both inform and be informed by the analysis and evaluation conducted by the assessment team. For example, the prioritization process might require exploratory analysis and the identification or specification of a potential operational objective and may involve several iterations that nominate and test possible options. At some point, and particularly in setting the operational objective, it may be decided that the information available is inadequate to address some important concern satisfactorily, and some data will have to be collected before there can be further progress in developing the EAF management plans. If such technical expertise or opportunity does not exist, it can still be informative and constructive to carry out the process in whatever way possible, using qualitative judgements, for example.

(i) Identify the issues under each of the broad objectives

This step is most easily carried out by starting with the broad objectives and further developing the hierarchical tree diagram to include all issues relevant to that objective for a given fishery. Constructing the branching of the tree is the process of moving from the high-level issue to an operational level, with as much branching as is necessary to specify the issue at a level that can be managed with one or more of the measures outlined in Chapter 2. An example of this process is shown in Figure 3.

In Figure 3, two specific issues relevant to the broad objective for retained species are identified:

- broad objective: manage the harvested species within ecologically viable stock levels by avoiding overfishing and maintaining and optimizing long-term yields;
- specific issue: spawning stock declining to a level that impairs recruitment; and
- specific issue: spawning stock declining to a level that does not maximize long-term yield allowing for the past pattern of recruitment variability.

By a similar process, other broad objectives might be translated into specific issues against which operational objectives can be set such as minimizing the

Figure 3

Identification of specific issues using the hierarchical framework approach

* Broad objective: provide high and sustainable yield from the target stock

** SLMTY = stock level that will provide maximum long-term yield

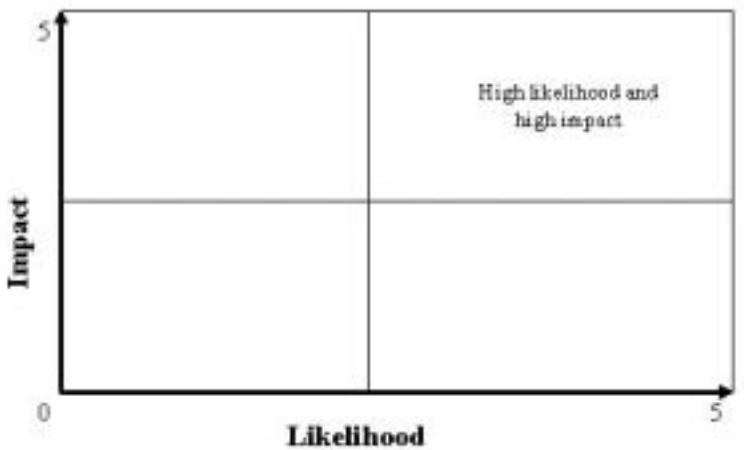
catch of selected vulnerable or endangered species, maintaining the unfished level of identified essential habitats, maintaining selected prey populations above 75 percent of the unfished biomass to allow for predator feeding, and achieving a net economic return on capital that is comparable to that for other nominated industries. These examples will all require further tree branching to more specific levels that will obviously vary from fishery to fishery (for instance, turtles may be of concern in one fishery and require specific objectives, while seabirds may be of concern in another).

In a process it will be necessary to provide operational interpretations for some concepts and intentions in the higher-level policy goals that are currently not well defined or understood – concepts such as biodiversity, ecosystem integrity and ecosystem function. This will require that judgements be made, but more importantly the process of successively elaborating the issue in increasingly operational terms both encourages explicit judgements and provides the argument by which they can be explained. For example, it may be concluded that ecosystem function is likely to be achieved by an operational objective that states that all target and by-catch species be managed at population levels implied by their long-term maximum sustainable yield (MSY), and that no major habitat types be reduced from their present level. On the other hand, it might be concluded that that ecosystem function is likely to be achieved by an operational objective that states that 40 percent of the area occupied by the ecological community containing the target species be placed within MPAs. As scientific understanding of ecosystems improves, there will be a stronger basis for selecting particular operational objectives to meet the policy goals relating to biodiversity and ecosystem function, but there is still a need to provide and explain the operational interpretations that are developed for the fishery.

(ii) Rank the issues

Many issues, often at very different scales of relevance, are likely to arise in the first stage of this process. The second stage is to prioritize the issues that occur at the bottom of the tree structure to identify those for which detailed operational objectives, indicators and reference points will be developed. One practical approach is to conduct a risk assessment. Risk assessments can be qualitative and opinion-based, or highly quantitative and data-based. The appropriate level will depend on the circumstances, but should always include the best possible practices given the information available to conduct and document at least a qualitative risk assessment and capacity evaluation. There are many clearly

Figure 4
A qualitative risk assessment to identify high priority issues



described processes for carrying out a qualitative risk assessment. One example would be to score both the likelihood and consequences of failure in relation to each issue on a scale of, say, 1 to 5. High-priority issues are those with high likelihood of occurrence and high impact (see Figure 4).

(iii) Develop operational objectives for priority issues, and as necessary, the process for monitoring of some lower priority issues.

Next, each issue can be dealt with in the management plan in a manner commensurate with the related risk. High-risk issues are elaborated into detailed operational objectives. Some medium-risk issues might require identification of a mechanism in the plan for ongoing review and some form of contingency plan. Low-risk issues might be noted in the plan, explaining why they are considered low risk. Following on from the target species example used above, an operational objective for the two specific issues relating to a target species might be to maintain the spawning stock above 40 percent of the estimated un-fished level.

In developing the operational objectives, the level of understanding and uncertainty about the issue under consideration is taken into account – particularly uncertainty about how well the operational objective reliably reflects the intent of the broad objective, and thus how the fishery will contribute to

sustainable development. The operational objective should become increasingly stringent as uncertainty increases, so that achieving the operational objective will achieve the corresponding broad objective at the same level of low risk, despite the uncertainty.

Some operational objectives may be contradictory because they represent contradictory policy goals and/or broad fishery objectives or contradictory interpretations of them. Unnecessary contradictions should be avoided, but the contradictions may also represent real competing demands that the fishery management process and plan seeks to balance. The process of reconciling these competing demands occurs interactively between the process of setting the operational objectives and the process of setting indicators and reference points (4.1.4.3), and is informed by the technical process described in 4.1.6. The various indicators and reference points will relate to a wide variety of aspects of the ecosystem and fishery system, and it may be difficult or impossible to simultaneously meet them all. Some combinations of targets, for a predator and a prey species for example, may not be possible because of their biological interactions.

4.1.4.3 Process for selecting indicators and reference points for each operational objective

The next step is to agree on indicators, reference points and performance measures (see Box 4). The setting of objectives and performance measures is now an accepted part of the management process under TROM, but must be broadened to include all ecological, social and economic operational objectives.

In EAF, the setting of target reference points may be more problematic than in TROM, especially in relation to less specific ecosystem properties. For example, it is clear that a meaningful target could be set for the amount of benthic habitat to be protected, but that it would be more difficult to set a target for the energy flow through a particular part of one trophic level. The difficulty arises from uncertainty about ecosystem processes, and the extremely dynamic and naturally variable nature of ecosystems. For practical purposes the indicator should be an ecosystem property that is thought to be modified by the fishery, so that at least there is a controllable fishery impact for which a target level of change is identified. If it is not appropriate to set a target reference point, then at least a limit reference point should be set.

The final selection of indicators and reference points should take the technical, management and operational issues of a given fishery into account. Ideally, indictors should reflect parameters that can be measured or estimated with a

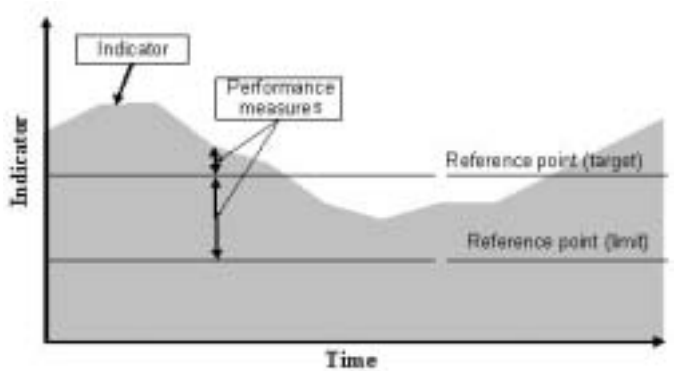
Box 4

Indicators, reference points and performance measures

The overall aim in setting indicators, reference points and performance measures is to provide a framework to evaluate the management rules, and to assess the performance of the fishery in achieving its objectives. An indicator tracks the key outcome identified in the operational objective and, when compared with agreed target and limit reference points, provides a measure on how well management is performing (performance measure). If the operational objectives are clear and measurable, the associated indictor is often self- evident (e.g. for an objective relating to the level of the spawning stock biomass, the indicator is obviously the spawning stock biomass), but the indicator may need to be modified to suit data availability and ease of communication with decision-makers and their ability to make appropriate changes in management.

The indicator and reference points define simple quantitative performance measures – the difference between the indicator value and its target or limit reference point in any year.

The target should be the desired state of the indicator, and the limit should be a boundary beyond which it is undesirable to be (including the possibility of both upper and/or lower limits). The target and limit can be quantitative (e.g. a target value where the value of the indicator should be or a specified limit where the value of the indicator should not exceed), or can reflect a trend (e.g. the indicator should increase over the period of the plan).



greater degree of certainty taking the dynamics of the target population and ecosystem into consideration, and should be able to estimate the indicators from data that have or could be collected. Selection would also depend upon what can be feasibly achieved from the management system and the fishery. At the end of the process, all stakeholders should feel confident that the indicators are both meaningful and workable. Consequently the selection of indicators and reference points necessarily involves an iterative process – suggesting possibilities and testing them – between all technical participants (discussed in 4.1.5) and stakeholders involved with development of the management plan.

Competing operational objectives can result in a conflicting set of targets and limits. The trade-offs involved in reconciling these differences would need to be identified and characterized by the evaluations described in 4.1.5, and refinements to the operational objectives, indicators and reference points agreed. Certain adjustments would mean that that some or all of the stakeholders would have to alter their expectations about the results to be obtained from the ecosystems and/or the fisheries, and any negotiation would have to be carried out by the stakeholders themselves for the plan to remain credible. As with the selection of operational objectives, there should be a clearly explained basis for selection of the indicator and reference point.

There are several sources for possible indicators and reference points in the fisheries literature and management plans that can act as a guide in the process, especially for target species. Indicators for objectives relating to the structure and function of the ecosystem and to various aspects of biodiversity are much less developed, but the ecological literature does provide several possible indicators that might be considered, provided that they can be linked to the operational objectives. (some examples are given in Annex 4). The scientific support for the chosen basis may differ in different circumstances, and can be expected to improve over time as the research and information needs of EAF are addressed. However, lack of scientific certainty should not prevent the selection of indicators and reference points that are considered important, or the clear explanation of a basis for selection.

4.1.5 Formulation of rules

Based upon the information compiled (see 4.1.3, above) and the setting of operational objectives (4.1.4) the next step is to choose a management measure or set of measures for achieving each objective. Thus, for example, catch controls might be advocated for one species, and effort limitation for another; closed

Box 5

Decision rules and EAF

The use of specific management measures should be accompanied by decision rules on how they are to be applied. The rules state what management action should be taken under different conditions, often determined by the value of an indicator in relation to a target or reference point (see Box 4). The decision rules should include how the management measure is to be determined, what data must be collected and how data will be used to determine the measure. Decision rules can be quantitative (e.g. setting catch limits for the species under consideration as pre-specified fractions of abundance, obtained from surveys, for instance) or qualitative (e.g. a certain value of an indicator triggers a decision to bring forward a review of management).

Decision rules based on an ecosystem approach are used in the sardine and anchovy fisheries in South Africa, managed primarily by total allowable catches (TACs). A TAC is set for each species, but because juvenile sardine are caught as by-catch in the anchovy fishery, the TAC for sardine needs to consider the likely by-catch that will be taken in the anchovy fishery. The rules that were used for setting the sardine TAC between 1994 and 1996 are presented here as an example. The data used in the decision rules are the abundance estimates of hydrocoustic surveys of sardine and anchovy undertaken each year: one in November to estimate adult biomass, and the second in the middle of the year to estimate that year's recruitment. An initial TAC is set at the start of the year based on the previous November biomass estimate, and this TAC is revised in the middle of the year when recruitment has been estimated.

The decision rules for the sardine TAC are:

Initial TAC

- Directed TAC = 10 percent of the adult biomass estimated the previous November;
- By-catch TAC = 7 500 tonnes + 6 percent of the Initial Anchovy TAC (as determined in a separate management procedure);

Mid-year revised TAC

- Directed TAC = unchanged from initial;
- By-catch TAC = 7 500 tonnes + *y* percent of the revised anchovy TAC (as determined in the separate management procedure), where *y* varies between 6 and 12 depending on the total recruitment for the year as estimated in the mid-year survey.

The decision rules are simple equations that can easily be applied once the survey results have been calculated. The initial by-catch TAC represents a minimum TAC, and can be increased only at the mid-year revision, reflecting the likelihood that the initial by-catch TAC will already have been caught by the time the TAC is revised in the middle of the year. The critical parameters of the equations were carefully selected on the basis of extensive testing of the sardine population dynamics and the fishery using a mathematical model. These parameter values were found to provide decision rules that came the closest to meeting the operational objectives for the sardine fishery.

areas might be proposed to meet targets in multi-species fisheries, or to meet habitat protection objectives. This process will need to take account of both the quality and the availability of the data, both current and that to be obtained through an enhanced monitoring programme.

The development of measures and decision rules (see Box 5) should ideally be underpinned by rigorous data analyses, including modelling the dynamics of the system or sub-system. However, as stressed throughout these guidelines, a lack of this capacity does not preclude the general approach. Even in data-poor situations, the best available information should be objectively analysed and considered. In such cases, an extrapolation based on better studied areas can be used to provide guidance on operational objectives and associated decision rules.

A number of analytical processes can be used to develop the decision rules. One approach would take the form of an expanded annual TROM approach, for which all the available data are used to make the best possible assessment of the productivity and abundance of a species. This approach has been used by CCAMLR, for example, which set precautionary catch limits on prey species to take account of predators.

Alternative approaches focus more on the longer term, and these might follow an expanded "management procedure" or "management strategy evaluation" approach (see Box 6). To date this approach has been applied mainly to TROM, but it could be usefully expanded to consider the greater dimensions of EAF. However, because the precise forms of interactions between species are usually not well known, the levels of uncertainty will probably become larger when interactions between species are taken into account.

Another approach is to use observed interaction between species in multispecies fishery (e.g. by-catch rate of species B when fishing for species A) to calculate a multispecies vector of allowable catches of target species so that the objectives for non-target species are achieved. The International Commission for the Northwest Atlantic Fisheries (now NAFO) applies linear programming to by-catch rates to optimize a multispecies vector of TACs.

4.1.6 Monitoring, assessment and review process

The EAF management plan should include the specification of regular reviews in which the success of the management measures in attaining the objectives is appraised. These reviews will benefit from data that has been collected by an effective and well-directed monitoring programme and analysed by appropriate technical experts. Such review should be carried out under guidance from, and

Box 6

Management strategy evaluation

Management strategy evaluation attempts to model and simulate the whole management process. It makes projections about the state of the fishery resources and other ecosystem parameters for a number of years into the future under a variety of decision-rule options. The management measure and rules that achieve the best results in terms of specified objectives can then selected and applied. This procedure greatly assists in identifying management strategies that are resilient to uncertainties in scientific understanding. Precautionary management measures and decision rules can be identified by testing the performance of the measure against a range of possible complexities that are likely to be operating in the fishery identified using a selection of appropriate reference points that include acceptable levels of risks. The output from such an evaluation is generally similar to that of a conventional risk assessment – the greater the uncertainty, the more conservative the management response will need to be to maintain risks at acceptable levels.

The procedure can take uncertainties into account through the use of a decision rule that evolves and improves through time, based on feedback on the outcome of past years. Management measures can also be automatically adjusted as time progresses to take further data into account as they become available; this will help to reduce the level of uncertainty.

To date, this procedure has been applied mainly to management of single stocks in which there is a model of the stock dynamics embedded in a model of the decision-making and management process. The approach needs to be expanded to take account of broad EAF objectives, the first step of which is the translation of EAF principles and policy goals into result-oriented operational objectives as described in the text.

making regular reports to, a designated stakeholder group. Both short-term and long-term reviews should be conducted.

Short-term reviews, for example as part of an annual cycle, should make assessments of species abundance and productivity in the case of targeted resources, assessments of impacts of the fishery for other broader ecological aspects and social and economic assessments. Because the process (as described in 4.1.4) requires setting out operational objectives, linked indicators and reference points, the performance measure should assess progress towards meeting the particular operational objective. In turn, because of the linkages between these

and the higher-level goals, an evaluation of whether the longer-term broader objectives are being achieved should also be provided. Appropriate management action can also be taken to keep the indicators on track, using the rules identified, as described above.

Should the exercise produce unexpected results, there should be mechanisms to bring forward the longer-term review detailed below. The review should also consider whether monitoring is achieving the quantity and quality of data collection required for the regular updating of management measures.

Longer-term reviews should be conducted on a regular basis. An interval in the range of three to five years may be appropriate, with the exact period being selected based upon the dynamics of the species concerned and the utilization and management systems. Slower rates of change may permit longer intervals between reviews. These reviews should include consideration of the full management arrangements including data collection/resource monitoring, comprehensive re-assessment, reappraisal of decision rules and progress towards meeting longer-term objectives.

Longer-term reviews may provide evidence that an objective set earlier (e.g. recovery to a certain target abundance level by a particular date) is no longer appropriate. Alternatively, societal objectives may have changed, or flaws may have become evident in the management system. To allow for such circumstances, provision should be made for the stakeholder group to provide revised and agreed operational objectives and associated indicators and reference points when required. A further purpose of the review procedure is to plan future research aimed at reducing the level of the most important uncertainties.

4.2 Legal and institutional aspects of EAF

4.2.1 Legal

Consistent with the FM Guidelines, legislation is used here in its broadest sense, encompassing all types of international instruments as well as national and local laws and regulations. The international instruments with provisions relevant to fisheries, and which need to be considered in implementing EAF, are described in Annex 1. These need to be reflected in national legislation and all associated fisheries regulations and practices.

EAF is not well covered in binding international law at present, either explicitly as EAF sensu stricto, or implicitly as sustainable development principles, but is reflected mainly in voluntary instruments such as the Rio Declaration, Agenda 21, the Code of Conduct for Responsible Fisheries and the Reykjavik Declaration.

As a result, few regional fisheries organizations and arrangements make explicit recognition of EAF in their instruments. Furthermore, EAF is not frequently an integral part of national fisheries policy and legislation. This leads to many deficiencies in current fishery management regimes, such as (i) weak cross-sectoral consultation and cooperation and (ii) the failure to consider, or a legal inability to act on external influences such as pollution and habitat deterioration. Such problems need to be addressed and corrected where required. Especially in the case of national policies and laws, EAF may require that existing legal instruments and the practices of other sectors that interact with or impact on fisheries need to be considered, and that adjustments to those instruments and practices pertaining to other sectors be made.

EAF is, therefore, likely to require more complex sets of rules or regulations that recognize the impacts of fisheries on other sectors and the impact of those sectors on fisheries. It may be desirable to regulate the major and more or less constant inter-sectoral interactions through the primary legislation. This could apply, for example, to laws controlling coastline development and coastal habitat protection, the establishment of permanent MPAs, and the creation of cross-sectoral institutions. However, many interactions between fisheries and other sectors will be dynamic, and in these cases, it may be desirable to strive for a more responsive and flexible mode of interaction than is usually possible through the primary legislation. In these cases, it would be preferable to rely instead on agreed rules. This is consistent with the advice in the FM Guidelines, namely that routine management control measures needing frequent revision should be included in subordinate legislation, rather than in the primary legislation (4.3.1. vi).

The FM Guidelines states that the primary legislation should specify the "functions, powers and responsibilities of government or other institutions involved in fisheries management" (4.3.1 iv). It also states that the jurisdiction should include the geographical area, the interested parties and the institutions involved in fisheries management (4.3.1 v). In addition, EAF requires that (i) the geographical jurisdiction should, as far as practical, coincide with natural ecological boundaries and (ii) that the legislation should specify the appropriate level of consultation and cooperation between the specific fishery agency and those institutions dealing with other fisheries or with other interacting sectors.

4.2.2 Institutional

Notwithstanding the addition of complexity and breadth at many levels and in many functions, the essential tasks and process of EAF are the same as those of

TROM, and are summarized in Figure 1 in Section 4.1. The institutional structures and processes for EAF must be able to deal with these tasks, including the added dimensions required, as discussed throughout this section.

Implied in EAF is a need for institutions to ensure coordination, consultation and cooperation, including joint decision-making, between fisheries operating in the same geographical area, and between the fishery and other sectors that interact with it. For example, where one fishery targets one or more prey species of a predator fished by another fishery, there must be an institution or arrangement to coordinate the management actions of both fisheries, including the reconciliation of the different objectives of the two fisheries.

The development and implementation of EAF policy and legislation will most naturally be undertaken by the national fisheries department or designated management agencies (at national level) and the fisheries management organizations (at regional level). A major problem in EAF development may stem from disparities between the ecosystem and jurisdictional boundaries and these disparities will need to be addressed as, for example, in the following.

- In coastal areas, the sea-use and land-use planning administrations need to cooperate in developing integrated systems of information and a governance capable of allocating resources and enforcing use rights. Zoning activities can be a means to allocate immobile resources. In many cases, the boundaries of the exclusive economic zones (EEZs) and the coastal ecosystems will not match, requiring bilateral (or multilateral) negotiations. At sub-national level, the decentralization of management responsibility to coastal communities will need to account for ecosystem boundaries and may require promoting inter-community coordination.
- In the open ocean, the jurisdictional boundaries of the fishery organizations may not properly match the ecosystem boundaries (e.g. the large marine ecosystem (LME) boundaries). In addition, the latter tend to be fuzzy, varying seasonally and inter-annually, requiring flexibility in agreements between relevant agencies.

In the context of TROM, conflicts frequently arise between different interest groups, and these conflicts often confound effective management of fisheries. The number of conflicts will inevitably increase under EAF as the number of stakeholders and objectives increase. This problem may be severe and, as under TROM, it will frequently not be possible to obtain voluntary compromise between competing stakeholders. Institutional arrangements need to be established "to reduce potential conflicts and to facilitate their resolution when they do occur"

(FM Guidelines, 4.3.1 xii). In some cases, this may require a political decision on the relative priorities of two or more conflicting uses.

EAF will require adherence to the same principles of transparent and participatory management as TROM (FM Guidelines, 3.3), such as:

- devolution of decision-making and management responsibility to organizations or groups lower than central national level (e.g. to coastal communities) where feasible, in order to improve compliance, improve the cost-effectiveness of management, make use of traditional management practices and other such means;
- building capacity at the devolved level to ensure that the body responsible for management is able to fulfil its responsibilities;
- appropriate participation of stakeholders in decision-making through, for example, opening of institutions, broader public debates, development of the capacity of the sector to participate;
- improved transparency and dissemination of more information; and
- establishment (or confirmation) of appropriate systems of user-rights.

While some level of devolution of responsibility and authority to the lowest levels (the local community) will be desirable, this decision must be reconciled with the need to ensure that management decisions and actions are coordinated and consistent at the higher levels required by EAF in each case. This will require effective institutional structuring to coordinate decisions and actions at the broader geographical and fishery scales required by EAF.

Limiting access and implementing appropriate systems of access rights are essential for successful and responsible fisheries under TROM (FM Guidelines, 3.2) and are expanded for EAF. Under EAF, it must be recognized that the access rights system will frequently need to encompass other uses in addition to the use of the target resources currently included in TROM. This may complicate the selection and implementation of equitable and effective systems of user rights. Examples of additional contenders for access rights under EAF include:

- explicit recognition of predator-prey relationships under EAF, requiring allocation of some of the potential yield of the prey species to the predator rather than all being allocated to the fishery or fisheries targeting the prey species; and
- management for a multitude of users – multiple fisheries, tourism, conservation, recreational fisheries and so on – will require appropriate allocation of resources and access to all the different user groups.

These allocation issues are not new, but have tended to be neglected in the past. Under EAF, issues of access and allocation of resources will need to be formally recognized. It may be necessary to consider allocating and controlling the rights to land-based activities that have a negative impact on fisheries – for example, pollution. This would obviously require that society completely change the way it deals with impacts such as pollution, but it would at least identify the issue and force people to think about linkages and implications.

4.2.3 Educating and informing stakeholders

Under TROM, the recognition that stakeholders must be involved in fisheries management has led to efforts to inform them about the need for, and principles of, fisheries management. In some cases, this has led to increasing awareness of and capacity to participate in fisheries management by stakeholder groups, but in many cases little progress has been made. Successful implementation of EAF will require that stakeholders (including management agencies) understand and accept the need for this more inclusive approach to fisheries management, and management agencies should actively promote such understanding and acceptance. Conversely, scientists and management authorities need to appreciate and use the knowledge of fishers themselves about the ecosystem, along with that of their representatives and communities. Without this interaction, stakeholders may be unwilling to participate in EAF. With the increasing number and broadening range of stakeholders under EAF, the potential disparities in capacity to participate in management will also increase. Management agencies will need to facilitate capacity building and empower all stakeholders to ensure equitable participation.

Implementation of EAF may involve changes in the tasks and priorities of agency staff. Effective and appropriate training may need to be provided to all staff having to deal with these changes. This training should include explanation of the rationale of the EAF approach, why it is necessary and what it is hoped will be achieved through EAF.

4.2.4 Effective administrative structure

Administrative structures under EAF will continue to reflect the variety of government systems that exist under TROM and related management approaches. However, they will have to be better integrated with more effective roles in auditing or oversight.

4.3 Effective monitoring, control and surveillance

The purpose of a monitoring, control and surveillance (MCS) system is to ensure that fishery policy in general, and the conservation and management arrangements for a specific fishery are implemented fully and expeditiously (FM Guidelines, 4.3.3 i). As with all other functions of the management agency, EAF may result in additional and broader tasks for the MCS arm of the agency. The specific tasks of the MCS arm will be related to the nature of the management measures used to achieve the objectives of MCS.

The control and surveillance functions of the agency will depend on a combination of the ecosystem components (species, habitat types, and so forth) under consideration, and the management measures that are implemented, as is the case under TROM. EAF will consider a wider range of ecosystem components and may also have to use a greater diversity of management measures. For example, EAF will commonly address a larger number of issues related to by-catch, discarded and endangered species. Enforcing regulations aimed at protecting these species will almost certainly require the routine use of effective observer schemes on fishing vessels. EAF may also require more common application of closed areas, including MPAs, and this will require the development and implementation of appropriate technology (e.g. vessel monitoring systems), provision of patrol and enforcement staff, or (where applicable) enforcement by local communities that benefit from the existence of the MPA. In the latter case, training and some logistic support may still be required. Management agencies will need to anticipate ongoing and possibly increased MCS costs under EAF.

In accordance with current awareness of the role and responsibilities of the stakeholders in responsible management, greater efforts are needed to create a social and political environment and management regime that encourages high levels of compliance and strong self-regulation. The transition to such systems is likely to be slow in many fisheries.

5 Research for an improved EAF

The process described in Chapter 4, if carried out successfully, will inevitably highlight areas of uncertainty and show where further research is needed. More importantly, from the fishery management perspective, it will identify the priority needs for the fishery and assist in guiding research investment. Some relevant areas of research that would lead to improved ability to implement effective EAF are listed below. The order does not reflect any particular priority.

5.1 Ecosystems and fishery impact assessments

1. Obtain better information on how ecosystems function, especially in terms of inter-species interactions, and how these lead to higher ecosystem properties.
2. Expand knowledge of how fishing impacts target stocks, especially genetic studies on stock identity as the basis for effective management units, assessment of the minimum levels of biomass compatible with the maintenance of the species' ecosystem function and the identification of spawning and nursery areas for effective management of these vulnerable stages of the life cycle.
3. Conduct research into the impact of fishing on non-target species through by-catch and discarding and what it is doing to food-web interactions, habitats and biodiversity. Habitats relevant to critical ecosystem processes (such as nursery grounds) will need to be identified, and 'gap analysis' strategies performed, to allow the identification of minimum sets of different critical habitats.
4. Develop appropriate multispecies bio-economic models, as well as extended ecological models that include the economic and social dimensions (private and societal returns, income distribution, employment, incidence of poverty and impact on food security).

5.2 Socio-economic considerations

5. Conduct research into the factors that influence the day-to-day behaviour of vessel operators/skippers, especially with regard to the choice of fishing gear and fishing ground, and levels of discarding.

6. Apply economic valuation methods, including the pros and cons of different methods in different circumstances.
7. Apply an integrated environmental and economic accounting framework to the assessment and analysis of the interaction between fisheries and other sectors of the economy.

5.3 Assessment of management measures

8. Conduct research and develop technology in the area of fishing gear and practices to improve gear selectivity and reduce the impact of gear on ecosystems.
9. Develop strategies/procedure to assess and integrate traditional ecosystem knowledge into management. This will apply not only to traditional fisheries, but also to the wide spectrum of fishing activities in which the knowledge of the people who spend their lives observing fishery resources and ecosystem could be more systematically utilized.
10. Identify the species (and ecosystems) that are suitable for restocking/stock enhancement programmes, and develop more adequate release strategies for them. Procedures will also have to be developed to assess the carrying capacity of the natural ecosystems with respect to the species to be restocked/stock enhanced.
11. The potential of MPAs (a biodiversity conservation measure) as a fisheries management measure needs to be better assessed, including research to clarify where MPAs will be most effective. Research will be needed on many aspects of MPAs, including whether propagules from MPAs replenish the surrounding areas that remain open to fishing, and whether any such replenishment result in an increase in catches great enough to offset catches lost from the closed area. Further questions include determining what proportion of the area occupied by a species needs to be dedicated as an MPA to optimize the trade-off between increased egg production and loss of catches; whether or not one MPA be used to manage several species simultaneously; and whether the life history patterns of species vary so much that MPAs of different sizes and different locations would be needed to achieve the desired goals for each species. It should be decided whether MPAs could include fishing activities, and how MPAs perform in relation to external impacts.

12. Artificial habitats are another area for research in terms of their usefulness and effectiveness for fisheries. Comparative studies involving case studies developed in different ecosystems are needed.
13. Culling is controversial topic requiring further research. A thorough review of global experiences would be informative.

5.4 Assessment and improving the management process

14. The many steps in the management process itself, as described in Chapter 4, could benefit from further research. For instance, research is needed on how better to compile data for management plans, how to evaluate management performance, and how to include uncertainty and risk assessments in the process.
15. Development of better participatory processes is critical, and sociological research on how to improve the consultation process with stakeholders will become increasingly important. Sociological research will also be required for assessing the impact of different management measures on the varied stakeholders and minimizing undesirable impacts. This will be especially important where alternative livelihoods and employment must be found to alleviate chronic overfishing and overcapacity.
16. Better ways of communicating the implications of different management strategies need to be developed. A broad range of decision-support systems is used in other natural resource management (e.g. "what if" computer modelling that allow user participation and analyses of trade-offs), but few are available in an EAF context.

5.5 Monitoring and assessments

17. The broadening of issues to be considered in the context of EAF will also require the development of simpler, more rapid appraisal methods, both in the field (to monitor and assess the state of the ecosystem) and at an analytical level (to evaluate decision rules and/or develop a generic "template" to form the basis for such evaluations). Development of adaptive management approaches to assist with data-poor situations will also be needed.
18. Develop several analytical techniques to underpin the decision-making process, including analyses to assist in setting reference points, and to evaluate potential decision rules. These techniques are continually being improved and are an important research topic in their own right.

19. Although specific objectives, indicators and reference points will vary among fisheries, a set of generic indicators needs to be identified. This must be a set of indicators common to most fisheries that are sufficiently general to be useful, at least as a starting point, and sufficiently specific to be meaningful. The set could be applied as a basis for starting EAF in relatively data-poor situations (an example is given in Appendix 4). The Scientific Committee on Oceanic Research-Intergovernmental Oceanographic Commission Working Group 119 (SCOR-IOC WG 119), entitled "Quantitative ecosystem indicators for fisheries management", is aimed at identifying appropriate framework and indicators to be used in EAF. The working group is reviewing and selecting existing indicators and developing new ones, when necessary, for the exploitation of marine ecosystems that take factors of environmental (climate change as well as habitat modification), ecological (species and size based, trophodynamics) and fisheries perspectives (integrated indicators) into consideration.[11] It is aimed at evaluating and selecting indicators and the different frameworks within which they can be used and applied.

[11] www.ecosystemindicators.org. The FAO Secretariat intends to review these guidelines to take account of this work when it is completed.

6 Threats to implementing EAF

The need to progress towards EAF has been widely recognized and was embedded to a large extent in the Code of Conduct for Responsible Fisheries. However, there are substantial obstacles to the effective implementation of EAF, as evidenced by the difficulties of countries in implementing the requirements of the Code. Key impediments to EAF include the following:

1. The mismatch between expectations and resources (both human and financial) will need to be carefully managed. EAF has much to offer, but lack of investment in the process will certainly slow progress and might mean failure in the end. The differing timetables of the political and the management process may also mean that insufficient commitment and resources are made available. EAF is a long-term commitment with long-term benefits, which may be difficult to present convincingly to governments, which normally work in shorter cycles, and especially when EAF competes with short-term socio-economic objectives.
2. Difficulty may be foreseen in reconciling competing objectives of the multiple stakeholders. In some, perhaps many, cases the participatory process may be insufficient for finding compromises that satisfy all stakeholders. Conflicts may then require higher-level intervention to determine the relative priorities and possibly, compensation. This is already a serious problem in many TROM fisheries, and will be exacerbated by EAF.
3. Insufficient or ineffective participation of stakeholders in the development and implementation of EAF may occur, even when competing objectives can be reconciled. This deficiency could be caused by a number of factors including:
   - an unwillingness of stakeholders to participate openly and transparently in the process or to make concessions, believing that they will fare better by non-cooperation than by cooperation;
   - inadequate and fuzzy user rights that fail to recognize long-term interests and responsibilities leading to poor stewardship;
   - a lack of access to necessary information;
   - inadequate consultation process or arrangements;

- insufficient resources being invested to improve fisheries and their management;
- a lack of capacity to participate effectively (e.g. knowledge, financial or other resources, geographical dispersion); and
- hidden agendas (e.g. expectations that are not transparent to all participants, leading to distorting behaviour and mistrust).

4. The time and cost required for effective consultation with a wide range of stakeholders could be substantial but, in many cases, a good start can be made with the resources already being used for TROM.
5. Insufficient knowledge will continue to be a constraint. Biological uncertainty is recognized as a substantial problem in management of fisheries under TROM, and the combined biological and ecological uncertainty under EAF will be even greater. One manifestation of this will be an inability in some instances to identify meaningful, cost-effective indicators for important objectives. The sum of these uncertainties will require robust and precautionary approaches that could cause substantial difficulties in some cases for certain stakeholders, both social and economic. A further source of uncertainty is a widespread lack of adequate knowledge of fleet and fisher behaviour and dynamics.
6. A lack of adequate capacity for informative compilation and analysis of the available information will often add to the uncertainty. In cases where there are or have been inadequate monitoring and data storage systems in place, the problems will be particularly acute.
7. Insufficient education and awareness will also be a problem. This will apply to all stakeholders in exercising their responsibilities, including the fishery management agencies and the public, who will need to be better educated on their roles in the process.
8. Equity issues will always be difficult to resolve in relation to responsibility for ecosystem degradation, between fisheries and other economic activities such as agriculture (including forestry), chemical industries, urban and coastal development, energy and tourism.
9. Aligning the boundaries of the ecosystems and of the jurisdictions of the management authorities (whether at regional, national or sub-national levels), as well as between jurisdictions of the different authorities responsible for competing sectors, will continue to be a challenge. Trans-boundary issues will require particular attention. As foreseen in the United Nations Fish Stock Agreement (FSA), EAF measures adopted by different

countries sharing an ecosystem will need to be compatible across the whole geographical range of the ecosystem.

10. Another impediment common to both TROM and EAF, which will continue to be a threat, is illegal stakeholder behaviour: illegal fishing, lack of implementation of flag state and port state responsibilities, and misreporting. While these types of practices continue, it is difficult to see how the principles and processes outlined in these guidelines can be implemented successfully, especially on the high seas. The Compliance Agreement and the International Plan of Action on Illegal, Unreported and Unregulated fishing should play a useful role in changing this situation for the future.
11. Poverty is a major threat to EAF. While poor coastal dwellers have few other options to derive livelihoods, fishing will continue to be the occupation of last resort for growing and displaced populations, resulting in excessive fishing effort, depletion of resources and ecosystem degradation. This will often occur in desperate circumstances where the incentive to care for the ecosystem is overshadowed by daily necessities.

Annex 1. Institutional foundation to the ecosystem approach to fisheries

The ecosystem approach to fisheries (EAF) is not a departure from the past fisheries management paradigms; it is, rather, a new phase in a process of continuous evolution. The concepts underlying EAF are already contained in many international and national legal instruments. This Annex contains a chronological list of some of the most prominent. They demonstrate the progressive building up of institutional strength in parallel with progress in the understanding of the ecosystem functioning and of human institutions created to conserve or use them. Some of the essential concepts and instruments of relevance to fisheries are examined briefly to illustrate that EAF is already well established in agreed broad policy and legal bases.

1 EAF and the concept of sustainable development

The EAF originates from two historical institutional processes directly related to the emergence of the concept of sustainable development.

1. The 1972 United Nations Conference on Human Environment (Stockholm, Sweden), which dealt with the environmental aspects of natural resources management, stressed the right of humankind "to modify the environment for its development and the dangers behind the huge capacity developed to do so". The Stockholm Conference highlighted concepts central to the ecosystem management concept in general and to EAF in particular: people's participation, resource limitation, environmental degradation, demography, planning and management, institutions, the role of science and technology, international collaboration and equity.
2. The 1982 United Nations Convention of the Law of the Sea (hereafter referred to as the 1982 Convention) – which came into force in 1994 – formulated the basis for conventional fisheries management and development. Its fisheries section refers to the maximum sustainable yield, corresponding to the level at which biological productivity (rate of growth and renewal capacity) is maximal, recognizing that it was influenced by environmental factors. Under Part V of the Convention, Article 61.3 states that resources conservation

measures "shall also be designed to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors … taking into account … the interdependence of stocks." Article 61.4 takes account of conservation measures in the exclusive economic zone (EEZ) by stating that "the coastal state shall take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened." Article 63 deals with the collaboration needed for shared populations of associated species. Article 119.1.b is similar to Article 61.4, but refers to resources in the high seas. Part XII of the Convention is dedicated to protection and preservation of the marine environment. Under Article 192, "states have the obligation to protect and preserve the marine environment". Under article 193, they "have the sovereign right to exploit their natural resources pursuant to their environmental policies and in accordance with their duty to protect and preserve the marine environment."

This dual origin of EAF can still be seen in the two main pillars of this approach in its various forms already adopted: (i) the elimination of overcapacity and overfishing, rebuilding of depleted stocks and protection of associated and dependent species; and (ii) the maintenance of ecosystem habitats, functional relations between components and productivity.

The link between sustainable development and EAF is illustrated by the definition of sustainable fishing adopted by the United States Committee on Ecosystem Management for Sustainable Marine Fisheries, which defined EAF as "fishing activities that do not cause or lead to undesirable changes in biological and economic productivity, biological diversity, or ecosystem structure and functioning from one human generation to the next. Fishing is sustainable when it can be conducted over the long term at an acceptable level of biological and economic productivity without leading to ecological changes that foreclose options for future generations" (United States National Research Council, 1999).

The related term of "ecologically sustainable development" (ESD) was adopted in the early 1990s in Australia to emphasize the importance of the environment to long-term human well-being, and to ensure that there would be a balanced approach in dealing with environmental, social and economic issues. ESD was defined as "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".[12] The ESD approach aims at three key objectives: (i) to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations; (ii) to provide for equity within and between generations; and (iii) to protect biological diversity and maintain essential ecological processes and life-support systems.

2 Institutional path to EAF

In addition to the 1972 United Nations Conference on Human Environment and the1982 Convention, a number of international events have contributed to the progressive emergence of the EAF paradigm.

1. The FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing (Rome, 1970), provided an early expression of the concern for the impact of land-based sources of pollution and degradation on fisheries.
2. The FAO Technical Conference on Fishery Management and Development (Vancouver, Canada, 1972) stressed both the problems of overfishing and of environmental degradation from non-fishery sources. It also called for new management approaches based on precaution and on addressing multispecies problems. It proposed to integrate the new fisheries management within the broader framework of ocean management.
3. The 1980 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) is usually considered a precursor of the ecosystem approach to fisheries. Its provisions require that any harvesting and associated activities must be conducted in accordance with the following principles of conservation: (i) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment, and for this purpose, size should not be allowed to fall below a level close to that which ensures the greatest net annual increment; (ii) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in (i) above; and (iii) prevention of changes or minimization of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect

[12] Commonwealth of Australia, National stratagy for ecologically sustainable development, Canberra, Australian Government Publishing Service, 1992.

impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources.

4. The World Commission on Environment and Development (WCED, 1984–87) and the resulting Brundtland Report (*Our common future*, WCED, 1987) further developed the concept of sustainable development. The report stressed, *inter alia*, the concepts of inter-generational equity, sustainable use, prior environmental assessments, prior consultation, precaution and liability, and cooperation on transboundary environmental problems and natural resources.
5. The United Nations Conference on Environment and Development (UNCED, 1992) completed this work and developed Agenda 21 as a basis for implementation. The Conference led to the adoption of a number of conventions and agreements of relevance to EAF, such as the Framework Convention on Climate Change, the Biodiversity Convention and the United Nations Fisheries Stock Agreement (FSA). The Rio Declaration puts human beings "at the centre of concerns" (Principle 1) and recognizes the sovereign rights to exploit resources (Principle 2), as well as the responsibility to do so without damaging the environment beyond the EEZ (Principle 2). It recognizes, *inter alia*, the need to: cater for future generations (Principle 3), integrate environmental protection in development (Principle 4), eliminate unsustainable patterns of production and consumption ((Principle 8), encourage public participation (Principle 10), widely apply the precautionary approach, internalize environmental costs (Principle 16 – "polluter-pays" principle), environmental impact assessment (Principle 17), the role of women (Principle 20) and indigenous communities (Principle 22) and peaceful conflict resolution (Principle 26).
6. Agenda 21 (UNCED, 1992) takes an ecosystem approach to ocean management. Chapter 17 calls for "new approaches to marine and coastal area management and development [which are] integrated in content and are precautionary and anticipatory in ambit". It recognizes that using marine resources and protecting the environment are inseparable, and that integrated management is necessary for both. It addresses in detail the integrated management and sustainable development of coastal areas (Programme A), marine environmental protection (Programme B), sustainable use and conservation of marine living resources in the high seas (Programme C) and

in areas under national jurisdiction (Programme D). It also addresses uncertainties related to natural variability of the marine environment and climate change (Program E). Programmes C and D are particularly relevant for fisheries. They provide for, *inter alia*, strengthening of conventional management (to eliminate overfishing) as well as multi-species management, associated and dependent species, relations between populations, restoration of depleted stocks, improvement of selectivity and reduction of discards, protection of endangered species and habitats, prohibition of destructive fishing, and the role of science.

7. The 1992 Convention on Biological Diversity (CBD) elaborates the core principles of multiple-use management of biodiversity. It emphasizes the conservation of biodiversity, the sustainable use of its components and the fair and equitable sharing of benefits. Under the Convention, parties have a right to exploit and use biological resources but also have an obligation to manage activities that may threaten biodiversity, regardless of where those effects may occur, and to collaborate where these effects occur on the high seas. In this respect, the CBD is compatible and convergent with the 1982 Convention, which it complements and reinforces, by ensuring that conservation and sustainable use goals apply to marine resources landward of the EEZ, where conservation obligations are not explicit under the 1982 Convention with respect to the 12-mile territorial sea, internal waters, or sedentary species of the continental shelf (CBD, Article 22.1). The CBD elaborates also on the 1982 Convention's content with respect to genetic resources and genetically modified organisms (GMOs). Furthermore, the CBD recommends establishing a system of marine protected areas (MPAs) as an essential measure for conserving biodiversity. According to the Convention, "biological diversity" means "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part" (Article 2). The CBD definition of biodiversity includes ecosystem diversity (the variety and frequency of occurrence of different ecosystems), species diversity (the frequency of occurrence of different species) and genetic diversity (the frequency of occurrence and diversity of different genes and/or genomes within species). Biodiversity is important from an EAF point of view, because it relates to "resilience", the capacity to resist an impact or return to original conditions after the impact has been removed. Therefore, it is of interest to fisheries to maintain and possibly enhance diversity both in exploited habitats

and among species, as "insurance" against the negative consequences of future changes.

8. The Jakarta Mandate on Marine and Coastal Biological Diversity (1995; COP 2, Decision II/10) elaborated further on the "ecosystem approach" adopted by the CBD focusing on protected areas, the precautionary approach, scientific knowledge, indigenous knowledge and stakeholders' participation. It aims, i*nter alia*, at integrated management, development of the ecosystem approach, valuation and effects of marine protected areas, assessment and minimization of mariculture impacts and the understanding of causes and impacts of the introduction of alien species.
9. The 1995 FSA aims at long-term conservation and sustainable use of marine living resources, recognizing from the onset "the need to avoid adverse impacts on the marine environment, preserve biodiversity, maintain the integrity of marine ecosystems and minimize the risk of long-term or irreversible effects of fishing operations" (p. 2). The FSA deals with the precautionary approach, protection of biodiversity, and sustainable use of fisheries resources. It calls on participating states to, *inter alia*: (i) protect biodiversity in the marine environment; (ii) adopt measures to ensure the long-term sustainability of the fish stocks and promote their optimum utilization; (iii) take account of environmental and economic factors; (iv) adopt an ecosystems approach, whereby dependent or associated species are taken into account; and (v) take measures to prevent or eliminate over-fishing and excess fishing capacity. It details, for the first time, the precautionary approach and how to apply it through the specification of precautionary reference points and the identification of management actions to be triggered in relation to these points. It promotes a principle of compatibility, according to which management measures taken in different jurisdictional areas must be compatible across the entire area of distribution of the stocks.
10. The 1995 Kyoto Declaration on the Sustainable Contribution of Fisheries to Food Security emphasizes the importance of fisheries as a food source for the world's population. It sets out a number of principles that focus on sustainable development of fishery resources related to maintaining food security. It contains the agreement to undertake immediate action to, i*nter alia*: "conduct…integrated assessments of fisheries in order to evaluate opportunities and strengthen the scientific basis for multispecies and ecosystem management…and to minimize post-harvest losses…".

11. The 2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem directly and specifically addressed the issue of introducing more ecosystem considerations into conventional fisheries management. Referring to the 1982 Convention, UNCED and the Code of Conduct, it recognizes the need to take "into account the impacts of fisheries on the marine ecosystem and the impacts of the marine ecosystem on fisheries" and confirms that "the objective of including ecosystem considerations in fisheries management is to contribute to long-term food security and to human development and to assure the effective conservation and sustainable use of the ecosystem and its resources". It recognizes "the complex inter-relationship between fisheries and other components of the marine ecosystems", but stresses that including ecosystem considerations in fisheries management would "enhance management performance". It calls for incorporation of ecosystem considerations, "such as predator-prey relationships" and for a better understanding of "the impact of human activities on the ecosystem". It emphasizes the role of science and the impact of non-fishery (usually land-based) activities. The Reykjavik Declaration calls for, *inter alia:* (i) immediate introduction of management plans with incentives for sustainable use of ecosystems, (ii) strengthening of governance, (iii) prevention of adverse effects of non-fisheries activities on the marine ecosystems and fisheries, (iv) advances in the scientific basis for incorporating ecosystem considerations in management (including the precautionary approach), (v) monitoring of interactions between fisheries and aquaculture, (vi) strengthening of international collaboration, (vii) technology transfer, (viii) removal of trade distortions, (ix) collection of information on management regimes and (x) development of guidelines.
12. The World Summit on Sustainable Development (WSSD, Johannesburg, South Africa, 2002) adopted a Political Declaration and a Plan of Implementation. In the Declaration, the Heads of States "agree to protect and restore the integrity of our planet's ecological system, with special emphasis on preserving biological diversity, the natural processes that sustain life on Earth ... The significant reduction in the rate of current bio-diversity loss at national and global levels is a priority to achieve sustainable livelihoods for all." The relevance to fisheries is obvious. The WSSD Plan of Implementation agreed to:
    - "encourage the application by 2010 of the ecosystem approach, noting the Reykjavik Declaration on Responsible Fisheries in the Marine Environment" (Article 30d).

- "maintain productivity and biodiversity of important and vulnerable marine and coastal areas, including areas within and beyond national jurisdiction" (Article 32a);
- "develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive practices, the establishment of marine protected areas ... and the integration of marine and coastal areas into key sectors" (Article 32c).

3 EAF elements in the Code of Conduct

The Code of Conduct is widely recognized as the most complete operational reference for fisheries management, combining many aspects of fisheries with environmental conventions and instruments. It contains a number of provisions which, when considered together, give a good indication of the ecosystem principles, concerns and policy guidance already available in the Code for the development of an ecosystem approach to fisheries. These are as follows:

1. Ecosystem and habitat protection: The Code refers to "with due respect" for the ecosystem (Introduction). Recognizing transboundary nature of ecosystems (6.4), it specifies that states should "conserve", "protect" and "safeguard" them (6.1, 6.6, 7.2.2d and 12.10), to keep their "integrity" (9.12), including from the impacts of aquaculture (9.2). It promotes their research (2.1), calling for an assessment of the impact of fishing, pollution, other habitat alterations and climate change (12.5). The Code deals with habitat protection (6.8; 7.2.2d) and the need to "safeguard" (12.10) critical habitats, requesting the rehabilitation of degraded ones (6.5; 7.6.10) and promoting research on the impact of their alteration on the ecosystem (12.5) as well as a prior assessment of the potential impact of new fisheries or introduction of new technologies (8.4.7 and 12.11).
2. Role of environmental factors: The Code states, in its Introduction, that it "takes account of" the environment. Its provisions promote its protection (2g, 6.5 and 8.7). It promotes research on environmental factors (2j) and requires that such factors be taken into account in the "best scientific information available" (6.4) even when the scientific information available is inadequate (6.5). It requires that fishing be conducted "with due regard" for the environment (8.4.1), which should be monitored for impacts (10.2.4). It recognizes, in line with the 1982 Convention, the qualifying role of environmental factors on the Maximum Sustainable Yield (7.2.1).

3. Environmental impacts of fisheries: The Code requires that the impact of fisheries activities (including aquaculture and artificial reefs) should be minimized (6.7, 6.19, 8.9d and 9.1.5) and recommends the development of research on such impacts (8.11) for their assessment (9.15) and monitoring (9.15). It aims at "ecologically sustainable" activities (9.1.3). It promotes a reduction of pollution and use of chemicals (9.4), environmentally sound processing, transport or storage (11.1.7), and calls for regulation of environmental impacts of post-harvest practices (11.1.2). The Code refers to the need for prior impact assessment and monitoring of gear impact (12.11), the prohibition of destructive practices (8.4.2) and the development of environmentally safe gear. The Code also considers, albeit very briefly, the problem of sound or optimal use of energy (8.6 and 11.8c).
4. Environmental impacts of other users and pollution: The Code also addresses other (non-fishery) users (1.2; 10.1.5) and acknowledges the impact of other human activities on fisheries. It recommends avoiding or settling conflicts (10.1.4 and 10.1.5). It also recognizes that other user's impacts should be assessed (7.2.3) and promotes the development of environmental research (8.4.8 and 12.10). It requires that the negative effects of natural environmental factors should not be exacerbated by fisheries (7.5.5) and calls for restoration of resources affected by other uses (7.6.10). It calls specifically for consultation with fisheries authorities before making decisions regarding the abandonment, in the aquatic ecosystem, of artificial structures (e.g. oil platforms). The Code contains also one article entirely dedicated to the integration of fisheries into coastal areas management (1.1, 1.3, 6.9, 8.11.3 and 10.2.4). The Code calls for a reduction of pollution (7.2.2) through the development of waste disposal systems (e.g. for oil, garbage, decommissioned gear) in harbours and landing places (8.7.4 and 8.9c). Dumping at sea from fishing vessels should follow the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) (8.7.4) for onboard incineration (8.7.2). Emissions into the atmosphere should be reduced (8.8) including emissions of exhaust gas (8.8.1), ozone emissions, phasing out of conventional cooling agents (chlorofluorocarbons) (8.8.3) and use of alternative refrigerants (8.8.4).
5. Biodiversity and endangered species conservation: The Code reflects "due respect" for biodiversity (Introduction). It promotes its maintenance (6.1), protection (7.2.2d), safeguard (12.10) and conservation (9.2.1), mentioning genetic diversity (9.2.1 and 9.1.2), the need to minimize fisheries impact on biodiversity (9.2.1) and to develop research about fishing gear impact. The

Code also recognizes the existence of endangered species that need to be protected (7.2.2), minimizing fisheries impacts on them (7.6.9).

6. Multispecies management: The Code distinguishes between exploited and non-exploited species belonging to the same ecosystem, the "target" species on the one hand and "non-target" species and "dependent or associated" species (in accordance with the 1982 Convention) on the other. Regarding the "dependent and associated" species, the Code promotes the study of their behaviour (12.10), their conservation (6.2 and 6.5), the absence of adequate scientific information (6.5, precautionary approach), accidental fishing mortality (7.2.5), the assessment (7.2.3) and the reduction/minimization of catches (7.2.2, 769 and 6.6) or fisheries impacts (6.6 and 7.2.2). The Code deals with conservation of populations structure (6.1), their rehabilitation in case of damage (6.3) and the analysis of the impacts on them of environmental factors (12). It also includes the need for the scientific study of the inter-relations between populations (7.3.3).
7. Coastal areas: The Code recognizes that these key geographical areas for an ecosystem approach to fisheries management. The Code requires that they should be protected (2g) and has one article entirely dedicated to the integration of fisheries into coastal areas management (1.1, 1.3, 6.9, 8.11.3 and 10.2.4).
8. Selectivity, ghost fishing, by-catch, discards and waste: Inadequate selectivity of fishing gear is a central ecological issue that impacts on target as well as non-target species, by-catch, discards and waste. The Code dedicates a whole section to the issue (8.5) and promotes the use of more selective gear (7.6.9 and 8.4.5) and calls for more international collaboration in better gear development (8.5.1 and 8.5.4), as well as for the agreement on gear research standards. The Code calls for minimizing discards (12.10) and waste (6.6, 7.2.2 and 7.6.9) including through reduction of dumping and loss of gear (7.2.2).
9. Risk, uncertainty and precaution: The Code, in line with the UNCED Rio Principle 15 and the 1995 FSA, deals with uncertainty, risk and precaution (7.5) and recommends the wide application of the precautionary approach to "preserve the aquatic environment" (6.5 and 7.5.1), taking into account various uncertainties (7.5.2 and 10.2.3), using reference points (7.5.3), adopting cautious measures for new fisheries (7.5.4) and avoiding to add pressure on a stock naturally affected by a negative environmental impact (7.5.5). The Code also recommends a scientific Prior Impact Assessment (PIA) before a new fishery is developed or a new technology is deployed (8.4.7 and 12.11).

Annex 2. Principles of relevance to an ecosystem approach to fisheries (EAF)

The various forms of an ecosystem approach or ecosystem-based management described in literature or adopted formally by states refer to a number of inter-related guiding concepts, principles or requirements. Many of these are accepted and agreed; some of the fundamental ones were established formally in the 1982 Convention. Others have been derived or expanded from that convention. While these may not be new or specific to EAF, they become more relevant under this approach. They are reviewed in the following sections.

Avoiding overfishing

Article 61.2 of the 1982 Convention requires that states "ensure that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation". This requirement is reflected in many of the agreements made to establish regional fishery management bodies and in most national fisheries legislation. For instance, the Australian ESD charter states that "a fishery must be conducted in a manner that does not lead to over-fishing". While overfishing is not always precisely defined, the related objective is to allow catch levels (or fleet sizes) that are compatible with the maintenance of ecologically viable stock at an agreed level or range of levels, with acceptable probability that it is viable.

The same requirement is expressed in the 1980 CCAMLR, which states that "exploited populations must not be allowed to fall below a level close to that which ensures their greatest net annual increase". This concept has also been central to fisheries management as established in the 1982 Convention which states that "measures shall also be designed to maintain … populations of harvested species at levels which can produce the maximum sustainable yield (MSY), as qualified by relevant environmental and economic factors" (Article 62.3). As above, the related objective is to allow catch levels (or fleet sizes) that maintain stock at or above the MSY level. The FSA has established that, for precautionary purposes, MSY should be considered as a "limit" to be avoided and not a target to be reached.

Ensuring reversibility and rebuilding

The 1980 CCAMLR Convention requires that "risks of changes to the marine ecosystem that are not potentially reversible over two or three decades must be minimized". The United States National Marine Fisheries Service Panel on ecosystem-based fisheries management (EBFM) also noted as a principle that "once thresholds and limits [of an ecosystem] have been exceeded, changes can be irreversible".

When stocks have been accidentally driven to excessively low levels, they should be rebuilt. The concept of rebuilding is reflected in the 1982 Convention (Article 62.3) which requires restoring "populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors". This imperative is also reflected in the Australian ESD charter, which states that "for those stocks that are accidentally over-fished, the fishery must be conducted such that there is a high degree of probability that the stock(s) will recover". The CCAMLR Convention requires that, when stocks are accidentally overfished, "depleted populations must be restored to [former] levels". The related objective is to plan for, and implement within mandatory timeframes, a rebuilding strategy for exploited stock(s) that are below the agreed and preferably precautionary reference points.

Minimizing fisheries impact

Article 5f of the FSA requires that "fishing operations should be managed to minimize their impact on the structure, productivity, function and biological diversity of the ecosystem. Related objectives are to conduct fisheries in a manner that (i) does not threaten by-catch species; (ii) avoids mortality of, or injuries to, endangered, threatened or protected species; (iii) minimizes the impact of fishing operations on the ecosystem generally.

Considering species interactions

The 1982 Convention refers to the need to "take account of … the interdependence of stocks" (Article 62.3) and requires that "coastal states shall take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened" (Article 62.4). The requirement is also reflected in Article 5b of the FSA. The CCAMLR Convention requires that "ecological relationships between harvested, dependent and related species … be

maintained". This requirement often specifically refers to endangered, threatened or protected species. The related objective is to minimize by-catch and discards.

Ensuring compatibility

Boundaries of ecosystems and jurisdiction are unlikely to be fully compatible, and many ecosystems will straddle political boundaries, EEZs or extend into the high seas. However, management measures need to be coherent across the resource range. The FSA requires that "conservation and management measures [be] established for the high seas and those adopted for areas under national jurisdiction shall be compatible in order to ensure conservation and management of the straddling fish stocks and highly migratory fish stocks in their entirety" (Article 6.2). A related objective is to promote collaboration between sub-national or national authorities (as relevant) to ensure that measures taken under different jurisdictions converge towards agreed objectives.

Applying the precautionary approach

Aquatic ecosystems are complex and dynamic, and they change seasonally and in the longer-term. However, little is known about their complexity. Fisheries, aquaculture and other activities modify ecosystems. Their interconnections lead to potentially significant transboundary effects. Consequently, ecosystem resilience and human impact (including reversibility) are difficult to forecast and hard to distinguish from natural changes. In such circumstances, a precautionary approach is advisable. This approach is imbedded in the UNCED Declaration (Principle 15), which states that "the precautionary approach should be widely applied and that, where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation". The approach has been adopted for fisheries in the FSA and the FAO Code of Conduct, and guidelines are available for its practical implementation. Related objectives are to (i) improve research to better understand ecosystems, (ii) take measures that account for complexity and dynamics and uncertainty and (ii) give attention to transboundary impacts.

Improving human well-being and equity

The requirement to satisfy human well-being (compatible with ecosystem requirements) is central to the concept of sustainable development, and it recognizes that uses can be sustainable only if they are of value to human

beings and contribute to their well-being. The objective of EAF is the management and sustainable use of the aquatic resources in their marine environment for efficient and effective delivery of food, economic wealth and recreation.

With a view to improving human well-being, governance should endeavour to "establish and preserve inter-generational, intra-generational, cross-sectoral, cross-boundary and cross-cultural equity". Equity implies that similar options are available to all parties, a principle of stewardship by Governments and the community. There exist a number of sub-concepts, but as yet no consensus has been reached. "Inter-generational equity" is widely referred to, and requires that future generations be given the same opportunity as the present ones to decide on how to use resources. It requires avoiding actions that are not potentially reversible on some agreed time scale (e.g. a human generation), consideration of long-term consequences in decision-making, and rehabilitation of degraded physical and biological environments. Lack of "intra-generational equity" (i.e. equity among sections of the present generation) is recognized as a major source of both conflict and non-compliance. "Inter-sectoral equity" seems very hard to define and make operational, but implies, for instance, that the fishery sector be treated fairly when its interests conflict with those of other sectors. "Cross-boundary equity" may be a condition for successful shared-stocks agreements. "Inter-cultural equity" is relevant when allocating resources to different cultures or defining rights (e.g. between indigenous and other populations).

Allocating user rights

The need to explicitly allocate user rights in fisheries is now fairly widely accepted. The need to allocate them against payment (for example, to capture economic rent or pay for management costs) is a matter of ongoing debate. The "user-pays principle" aims at fuller internalization of production costs. It states that "all resource users should pay for the full long-term marginal social cost of the use of a resources and related services including any associated treatment cost". In other words, authorized users should pay for the exclusive privilege granted to them to use a public resource. The principle can be implemented through payments for licenses or quotas, or though taxes.

Promoting sectoral integration

The need for integrating the management of fisheries and other uses (e.g. in the coastal area) has been expressed in these terms: "States should ensure that an appropriate policy, legal and institutional framework is adopted to achieve the

sustainable and integrated use of the resources, taking into account the fragility of coastal ecosystems and the finite nature of their natural resources and the needs of coastal communities" (FAO Code of Conduct, Article 10.1). An expression of this need can also be found in the recent World Wildlife Foundation (WWF) guidelines, which state that "ecosystems are of value to society and can potentially be used in many ways, to satisfy various sectors' needs and strategic interests, now and in the future".[13] This requires functional connections between fisheries management institutions, other sectoral institutions, and other institutions in charge of the ecosystem maintenance.

Broadening stakeholders participation

Most recent international instruments require that stakeholders be more closely associated to the management process, in data collection, knowledge-building, option analysis, decision-making and implementation. The need to deal with fisheries in their ecosystem context implies an even broader participatory process. This requirement is often combined with that of decentralizing decision-making at lower levels of administration to better take account of all sectoral and community interests. The concept of subsidiarity proposes that decisions be taken at the lowest possible level. It is increasingly invoked together with the recommendation to decentralize decision-making and to increase direct participation of stakeholders. It implies the creation of institutions and the development of governance capacity at lower governance levels.

Maintaining ecosystem integrity

Integrity is often stated as one of the goals of ecosystem management. While there is no agreed definition, ecosystem integrity is usually taken as implying or requiring: (i) maintenance of biodiversity at biological community, habitat, species and genetic levels (as required in the CBD); and (ii) maintenance of the ecological processes that support both biodiversity and resource productivity.

[13] World Wildlife Foundation Australia, Policy proposals and operational guidance for ecosystem-based management of marine capture fisheries, 2002 (www.wwf.org.au).

Annex 3. Economic valuation[14]

Economic valuation provides a means for measuring and comparing the various benefits of fisheries resources and their ecosystems, and can be a powerful tool to aid and improve their wise use and management. It attempts to assign quantitative values to the goods and services provided by environmental resources, whether or not market prices are available. The economic value of any good or service is generally measured in terms of what resource users or society at large are willing to pay for the commodity, minus what it costs to supply it. Where an environmental resource simply exists, and products and services are supplied at no cost, then it is our willingness to pay alone which describes the value of the resource in providing such commodities, whether or not payments are actually made. Many environmental resources are complex and multifunctional, and it is not obvious how the myriad goods and services provided by these resources affect human welfare. Economic valuation provides a tool to assist with the difficult decisions involved.

Loss of environmental resources is an economic problem because important values disappear, some perhaps irreversibly, when these resources are degraded or lost. Each choice or option for the environmental resource – to leave it in its natural state, allow it to degrade or convert it to another use – has implications in terms of values gained and lost. The decision as to what use to pursue for a given environmental resource, and ultimately whether current rates of resource loss are 'excessive', can be made only if these gains and losses are properly analysed and evaluated. This requires carefully considering the values gained and lost under each resource use option.

Currently, most countries do not routinely carry out the valuation of fishery resources. While bio-economic analyses increasingly inform fisheries management decisions, especially with regard to determining optimal fleet sizes and fishing effort, they are not undertaken with the intent of estimating the *in situ* value of fishery resources, even though they could easily form the basis to do so. Mostly bio-economic analysis is based on single- or multispecies modelling

[14] Unless otherwise specified, the contents of this Annex have been adapted from: E. B. Barbier, M. Acreman and D. Knowler, *Economic valuation of wetlands: A guide for policy makers and planners*, Gland, Switzerland, Ramsar Convention Bureau, 1997.

that incorporates solely technological interactions (e.g. one type of fishing gear harvesting an assemblage of different fish species).[15] The construction of true multispecies models, i.e. incorporating biological interactions, has proven extremely complex and data intensive, but has shown to yield valuable insights, especially where a few dominant species interactions are critical for fisheries management decisions.[16] Area-based valuation approaches (as are commonly applied for estimating the value of, for example, mangroves) can be appropriately used for valuing other multiple-use resources such as coral reefs, which often supply a multitude of specific products and services including fish, medicinal products, diving sites (i.e. aesthetic values) for tourism, shoreline protection and biodiversity.

In most instances, for the purposes of resource valuation, EAF would have to resort to a combination of valuation methods including single and multispecies bio-economic analyses, area-based valuation and ecosystem-wide modelling.[17] However, these methods would typically relate to estimating only direct use, but not indirect and non-use values.

The greatest difficulties in resource/ecosystem valuation exercises are posed by the need to evaluate, on one hand, changes in the abundance, species and size composition of fishery resources along with alterations to their habitats and on the other hand to estimate non-use values as expressed in concepts of "option value" and "existence value". The concept of total economic value (TEV) provides a framework to comprehensively evaluate natural and environmental resources, and there is increasing consensus that it is the most appropriate one to use. To conduct a complete economic valuation exercise, it is necessary to distinguish between use values and non-use values. The latter refer to those current or future (potential) values associated with a resource that relies merely on its continued existence, unrelated to use. Typically, use values involve some human 'interaction' with the resource whereas non-use values do not. This distinction is sometimes difficult to detect. For example, when small-sized individuals of the

---

[15] Excellent reviews are provided by R. Hannesson, Bio-economic analysis of fisheries, published by arrangement with FAO by Fishing News Books, 1993; and by J.C. Seijo, O. Defeo and S. Salas, *Fisheries bioeconomics – Theory, modelling and management*, FAO Fish Tech. Paper, No. 368, FAO, Rome, 1998.

[16] See for example, O. Flaaten, The economics of multispecies harvesting: Theory and application to the Barents Sea fisheries, Berlin, Springer-Verlag, 1988.

[17] An example for an ecosystem-wide model is Ecopath with Ecosim (see: http://www.ecopath.org)

TABLE 1

Classification of total economic value for wetlands

Use values		**Non-use values**	
Direct use	**Indirect use**	**Option and quasi-option**	**Existence**
fish	nutrient retention	potential future (direct and indirect) uses	biodiversity
agriculture	flood control	future value of information	culture, heritage
fuel/wood	storm protection		
recreation	groundwater recharge		bequest values
transport	external ecosystem support		
wildlife	micro-climatic		
harvesting	stabilization		
peat/energy	shoreline stabilization, etc.		

Source: E.B. Barbier, M. Acreman and D. Knowler, *Economic valuation of wetlands: A guide for policy makers and planners*, Gland, Switzerland, Ramsar Convention Bureau, 1997.

target species are discarded because of high-grading, the discarded fish, while not used directly in increasing human welfare, nevertheless represent one use of a fishery resource. The use-value of the discarded fish is the opportunity cost of harvesting the fish before it has attained its reproductive age and its optimum marketable size (see Table 1).

Use values are grouped according to whether they are direct or indirect. The former refers to those uses most familiar to us: harvesting of fish or collection of fuel/wood in mangrove areas. Direct uses could involve both commercial and non-commercial activities, with some of the latter activities often being important for the subsistence needs of local populations in developing countries or for recreation in developed countries. Commercial uses may be important for both domestic and international markets. In general, the value of marketed products is easier to measure than the value of non-commercial and subsistence direct uses. Policy makers often fail to consider either the non-marketed subsistence uses or the informal uses of fishery resources and their habitats (such as mangroves) in many development decisions.

In contrast, various regulatory ecological functions of fish habitats such as coral reefs and mangroves may have important indirect use values. Their values

derive from supporting or protecting economic activities that have directly measurable values. The indirect use value of an environmental function is related to the change in the value of production or consumption of the activity or property that it is protecting or supporting. However, because this contribution is not marketed, it goes financially unrewarded and is only indirectly connected to economic activities. It is difficult to quantify these indirect use values, and they are often ignored in management decisions. They would also not usually be included in the kinds of bio-economic and economic-ecological models currently applied to fisheries and their ecosystems.

For example, the storm protection and shoreline stabilization functions of mangroves and other types of wetlands may possess indirect use value by reducing property, yet coastal or riverine wetland systems are often drained in order to build still more waterfront property. Mangrove systems are known to be breeding grounds and nurseries for shrimp and fish essential for coastal and marine fisheries, yet these important habitats are currently being converted for various other types of uses including residential and industrial development and coastal shrimp aquaculture. Natural floodplains may provide seasonally rich fish habitat, recharge groundwater used for dryland agriculture, grazing livestock and domestic or even industrial use, yet many of these floodplains are threatened by dams and other barrages diverting water for upstream irrigation and water supply.

A special category of value is option value, which arises because an individual or society may be uncertain about the future demand for a resource and/or its availability in the future. In most cases, the preferred approach for incorporating option values into the analysis is through determining the difference between ex ante and ex post valuation. If an individual is uncertain about the future value of an ecosystem, but believes it may be high or that current exploitation and conversion may be irreversible, then there may be quasi-option value derived from delaying the development activities. Quasi-option value is simply the expected value of the information derived from delaying exploitation and conversion of the ecosystem today. Many economists believe that quasi-option value is not a separate component of benefit, but involves the analyst in properly accounting for the implications of gaining additional information.

In contrast, there are individuals who do not currently make use of the goods and services of an ecosystem but wish to see them preserved ‘in their own right’. Such an ‘intrinsic’ value is often referred to as existence value. It is a form of non-use value that is extremely difficult to measure, as existence values involve

subjective valuations by individuals unrelated to either their own or others' use, whether current or future. An important subset of non-use or preservation values is bequest value, which results from individuals placing a high value on the conservation of ecosystems for future generations to use. Bequest values may be particularly high among the local populations currently using an ecosystem, in that they would like to see the ecosystem and its concomitant way of life passed on to their heirs and to future generations. While there are few studies of non-use values associated with particular ecosystems, campaigns by European and North American environmental groups to raise funds to support tropical wetlands conservation hint at the magnitudes involved.[18]

Valuation is only one element in the effort to improve management of ecosystems. At the same time, decision-makers must take account of many competing interests in deciding how best to use them. Economic valuation may help inform better management decisions, but only if those making the decisions are aware of the overall objectives and limitations of valuation.

The main objective of valuation is generally to indicate the overall economic efficiency of the various competing uses of natural resources and their ecosystems. The underlying assumption is that fishery resources and their ecosystems should be allocated to uses that yield an overall net gain to society, as measured through valuation in terms of the economic benefits of each use, minus the costs. Who actually gains and loses from a particular use is not part of the efficiency criterion per se. Thus, an ecosystem use showing a substantial net benefit would be deemed highly desirable in efficiency terms, although the principal beneficiaries may not necessarily be the ones who bear the burden of the costs arising from the use. If this is the case, then this particular use may be efficient, but it may also have significant negative distribution consequences. It is therefore often important that management policies be assessed in terms not only of their efficiency, but also of their distribution implications.

A major difficulty for evaluating a complex environmental system is insufficient information about important ecological processes underpinning the various values generated by the system. If this information is lacking – which is often the case for many non-market environmental values that may be deemed important – then it is incumbent upon the analysts to provide realistic

[18] For example, several years ago the United Kingdom's Royal Society for the Protection of Birds (RSPB) collected £500,000 (US$800,000) from a one-off membership mailing campaign to help save the Hadejia-Nguru wetlands of Northern Nigeria in West Africa.

assessments of their ability to value key environmental benefits. Equally, decision-makers must realize that under such circumstances valuation cannot be expected to provide realistic estimates of non-market environmental values – not, at least, without investment of time, resources and effort in further scientific and economic research.

Finally, economic valuation is concerned ultimately with the allocation of natural resources to improve human welfare. Consequently, the various environmental benefits of fishery resources and their ecosystems are measured in terms of their contribution to providing goods and services of value to humanity. However, some members of society may argue that certain ecosystems and living resources they contain may have an additional 'pre-eminent' value in themselves beyond what they can provide in terms of satisfying human preferences or needs. From this perspective, preserving certain marine resources could be a matter of moral values rather than efficient or even fair allocation.

Annex 4. Linkages between some basic data requirements, indicators (suggested examples) and operational objectives for a hypothetical fishery

Note: not all objectives will apply to all fisheries; many fisheries will be concerned by other issues, objectives and, hence, data requirements.

Objective	**Example indicator**	**Data requirements**
Fishery resources (target species)		
Reduce fishing effort	Fishing effort of different fleets	Vessels, time fished and gear type per fleet
Reduce fleet capacity	Fleet capacity	Vessels registered and gear type per fleet
Increase/maintain fish landings of commercially valuable species by area	Fish landings by major species by area	Total landings by major species per fleet per year
Increase/maintain spawning stock biomass of key retained species above a pre-defined limit	Spawning stock biomass of key retained species (or suitable proxy such as standardized cpue)	Length and/or age composition of major retained species
Decrease/maintain the level of fishing mortality for key retained species below a predefined limit	Level of fishing mortality for key retained species	Length and/or age of the discarded component of the target species catch
Other ecological concerns		
Reduce discards to the extent practical	Total amount of discards	Total catches of by-catch species (or species groups/indicator species), per fleet per year

Objective	Example indicator	Data requirements
Reduce discards of high-risk species (or species groups) to predefined level	Amount of discards of high-risk species (or species groups)	Length and/or age of high-risk by-catch species
Reduce number of deaths of vulnerable and/or protected species to predefined level	Number of deaths of vulnerable and/or protected species	Catch of vulnerable and/or protected species Catch of non-fishery material (critical habitat)
Decrease/maintain same area of the fishery impacted by gear	Area of the fishery impacted by gear	Area fished by each fleet
Increase amount of habitat protected by MPAs to predefined level	Amount of habitat protected by MPAs	Area under MPAs by habitats
Increase ratio of large fish in the community	Size spectrum of fish community	Length of fish in a representative sample of community
Minimize the impact of other activities on fish resources and habitats	Area of fish nursery habitat degraded	Area of habitat, e.g. seagrass beds, mangroves and coral reefs
Maintain ecological balance	Mean trophic level of catch	Species composition from sample catches
Economic		
Increase the contribution of fishing to the national economy	Net economic return for fishery	Revenue from fishing per fleet per year Costs per fishing unit per year
Increase/maintain profit of the harvesting sector to that of similar industries	Profit to harvesting sector	
Increase exports	Export value	Destination of landings from each fleet

Objective	**Example indicator**	**Data requirements**
Maintain or increase economic contribution to community	To be developed	
Social		
Health benefits/Increase fish consumption per capita	Fish consumption per capita	Fish consumption from representative sample
Ensure seafood quality meets food safety requirements	Number of food compliance reports	Food safety compliance reports
Increase/maintain employment in the harvesting and processing sector by fleet	Employment in the harvesting sector by fleet	Total number of fishers employed in each fleet Total number of people employed in fishery-associated activities (e.g. processing)
Maintain or improve lifestyle value	Life-style value	Social surveys
Maintain or improve cultural values	Cultural value	Cultural sites and values
Maintain/increase level of activity of indigenous community	Number of indigenous fishers	Dependence of local community on fishing as a source of income and/or food
Reduce the dependence of community on fishing	Dependence of community on fishing	Other income or livelihoods of the fisher
Management activity Have well-developed management plans, including indicators and reference points and evaluation procedure in place for all fisheries	Number of fisheries with well-developed management plans, including indicators and reference points	Number of fisheries with a well developed management plan, including operational objectives, indicators and reference points

Annex 5. Economic instruments for an ecosystem approach to fisheries[19]

There is growing interest in the use of economic instruments to achieve sustainable development objectives. This is due in part to the often disappointing performance of command and control measures (C&C). Such measures entail the setting of regulatory norms and standards that forbid or allow certain actions or outcomes. They generally focus on blocking the incentive created by various types of market failure for private operators to over-utilize natural resources (such as fisheries) and degrade ecosystem functions and services.

C&C standards are usually tailor-made to regulate how a specific activity, or class of activities, must be carried out. Compliance monitoring and eventual sanctioning of trespasses are usually indispensable features of effective C&C. The primary disadvantages of the C&C approach are: it is considered overly constraining, not adaptable on a case-by-case basis, leaves little room for flexibility and tends to retard technological change (probably for sound reasons in an already over-fished stock). While C&C is often criticized for these reasons, it is widely used by government agencies and even sometimes requested by the industry. Regulations are elaborated within public administrations, often with little concern about enforceability, but they have considerable political appeal because something is being done. The same norm or standard applies to everybody, and this provides a sense of fairness.

[19] This section is based on several sources including: *WHAT Commission Report*; D. Bailly and R. Willmann, *Promoting sustainable aquaculture through economic and other incentives*, in R.P. Subasinghe, U.C. Barg, P. Bueno, C. Hough and S.E. McGladdery (eds.), *Aquaculture in the third millennium*, Technical Proceedings of the Conference on Aquaculture in the Third Millennium (Bangkok, Thailand, 20–25 February 2000), 2001; and K. Cochrane and R. Willmann, Eco-labelling in fisheries management, in *Current Fisheries Issues and the Food and Agriculture Organization of the United Nations*, M.H. Nordquist and J.N. Moore (eds.), The Hague/Boston/London, Martinus Nijhoff Publishers, pp. 583–615, 2000.

Incentives represent an entirely different approach. The first step to provide incentives is to define and enforce user rights. These user rights should be secured in such a way that the benefits to the holders of the rights are linked to the productivity and value of the resource. With a right to a share in the fishery, the incentive is to maximize economic benefits by reducing the cost of using one's right and/or by increasing the value of the right: e.g. by restoring and maintaining critical ecosystem functions that impact on the productivity of the fishery resources. In theory, rights that are secure in the long term facilitate the acceptance of short-term sacrifices for long-term gains.

Governance systems that assign rights to shares of a fishery are specified by the nature of the fishery, the type of entities that hold rights and rules about transferability and enforceability of rights. Shares can be an amount of catch, units of fishing effort (such as days of fishing) or an exclusive geographical area and time period when fishing is allowed. In order to be effective, the sum of all of the shares must not result in overfishing or in the degradation of critical fish habitat. Shares that are specified as fishing effort units, or fishing areas and time permits may be more practical than shares specified as catch quantities, and more acceptable to fishers, easier to enforce, and not so dependent on scientific advice. There may be a need for additional rules, such as fish size limits, that apply to all holders of rights in the fishery.

The holder of rights can be a person, a corporation, a community, a collective or nominated representatives of a group. In many parts of the world, it will be appropriate to vest these rights in the local community where there are active fish harvesters and other fishery-related workers. This community then takes responsibility for further allocation and monitoring of the use of the resource. In such fisheries, peer monitoring may be important in control of the fishery. This is particularly true of many developing countries, where most of the people involved in fisheries in the world live and work (cf. Governance for a sustainable future, World Humanities Action Trust (WHAT) Commission Report, London, 2000[20]).

The assignment of specific use or access rights is, however, no panacea for removing all incentives (or market failures) to overuse or otherwise degrade and harm ecosystems. TACs and an individual transferable quota (ITQ), in particular, have been shown to create a quota-induced incentive for discarding fish in

[20] See http://www.earthsummit2002.org/es/issues/Governance/whatgov1.pdf

excess of what is socially optimal. This finding is corroborated by empirical evidence in several ITQ managed fisheries.[21]

Another type of incentive that is gaining considerable popularity is eco-labelling. The potential usefulness of eco-labelling schemes to create market-based incentives for environmentally friendly products and production processes was internationally recognized at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil. Here, governments agreed to "encourage expansion of environmental labelling and other environmentally related product information programmes designed to assist consumers to make informed choices". Consumers are provided with the opportunity to express their environmental-ecological concerns through their choice of products. The consumers' preferences are expected to result in price and/or market share differentials between eco-labelled products and those that either do not qualify to be eco-labelled or those whose producers do not seek to obtain such labelling. The label is obtained through a certification process based on a set of criteria (i.e. the desired standard). Potential price and/or market share differentials provide the economic incentive for firms to seek certification of their product(s).

[21] It has been argued that the assignment of value-based individual transferable quotas (VITQs) would remove the quota-induced incentive for high-grading and lower the costs of quota trading. Moreover, in the case of multi-species fisheries, VITQs may allow fishermen to respond with greater flexibility to changes in species abundance than under an ITQ system, and may confer greater economic stability. VITQs, however, would present the principal drawback of not fixing a specific target catch when observed fish prices diverge from those estimated at the time of setting the total allowable catch value. As a consequence, the total allowable catch value may have to be adjusted repeatedly within a one-year period, thereby creating insecure economic conditions under which the fishing industry is required to operate. These and other instruments to address the quota-induced incentive for high-grading and discarding are more fully discussed in S. Pascoe, *By-catch management and the economics of discarding*, FAO Fisheries Technical Paper, No. 370, Rome, 1997, 137 pp.

Glossary

The terms in this glossary are taken from a number of sources, but particularly from the FAO Technical Guidelines, No. 4, Fisheries Management and from the glossary on the home page of the FAO Fisheries Department (http://www.fao.org/fi/glossary/default.asp), which includes a large number of other fisheries terms.

Agenda 21
A comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations system, governments, and major groups in every area in which human impacts on the environment. Agenda 21, the Rio Declaration on Environment and Development, and the Statement of Principles for the Sustainable Management of Forests were adopted by more than 178 Governments at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil (3–14 June 1992).

biological diversity or biodiversity
The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Diversity indices are measures of richness (the number of species in a system); and to some extent, evenness (variances of species' local abundance). They are therefore indifferent to species substitutions, which, however, may reflect ecosystem stresses (such as those due to high fishing intensity).

broad fishery objective
Statement of what harvesting a particular resource attempts to achieve in terms of the fish resources and in terms of ecological, economic and social objectives.

by-catch
Species taken in a fishery targeting that is targeting on other species or on a different size range of the same species. That part of the by-catch no economic value is discarded and returned to the sea, usually dead or dying.

capacity
See fishing capacity

critical habitat
Fisheries habitat necessary for the production of a given fishery resource. May be critical nursery habitat (e.g. mangroves and seagrasses) or critical spawning habitat (e.g. particular geographic location in the ocean where fish aggregate to spawn).

discards
The components of a fish stock that are thrown back into the habitat after capture. Normally, most of the discards can be assumed not to survive.

ecosystem
An organizational unit consisting of an aggregation of plants, animals (including humans) and micro-organisms, along with the non-living components of the environment.

ecosystem health
A measure of ecosystem resilience (ability to maintain its structure and pattern of behaviour in the presence of stress), organization (number and diversity of interactions between ecosystem components) and vigour (a measure of activity, metabolism or primary productivity). A healthy ecosystem to maintain its structure (organization) and function (vigour) over time in face of external stress (resilience).

ecosystem integrity
The ability of an ecosystem to support and maintain a balanced, harmonious, adaptive biological community that demonstrates species composition, diversity and functional organization comparable to that of natural habitat in the region.

ecosystem productivity
The rate at which material is produced by an ecosystem over a specified period. In a strict sense, this term refers to the amount of energy fixed by plants in the system, but the term often refers to the ability of an ecosystem to produce goods and services to meet human needs.

effort
See fishing effort

exclusive economic zone (EEZ)
A zone under national jurisdiction (up to 200 nautical miles wide) declared in line with the provisions of 1982 United Nations Convention of the Law of the Sea, within which the coastal state has the right to explore and exploit, and responsibilities to conserve and manage, the living and non-living resources.

fish stock (also fish/fishery resource)
The living resources in the community or population from which catches are taken in a fishery. Use of the term "fish stock" usually implies that the particular population is more or less isolated reproductively from other stocks of the same species and is thus self-sustaining. In a particular fishery, the fish stock may be one or several species of fish, but the definition is also intended to include commercial invertebrates and plants.

fisheries management organizations or arrangements
The institutions responsible for fisheries management, including the formulation of the rules that govern fishing activities. The fishery management organization and its subsidiary bodies may also be responsible for all ancillary services, such as collecting information; assessing stocks; conducting monitoring, control and surveillance (MCS) and consultations with stockholders; applying and/or determining the rules access to the fishery, and for resource allocation.

fishery
The term "fishery" can refer to the sum of all fishing activities on a given resource, for example, a hake or shrimp fishery. It may also refer to the activities of a single type or style of fishing on a particular resource, for example a beach seine fishery or trawl fishery. The term is used in both senses in this document and, where necessary, the particular application is specified.

fishing capacity
The ability to take the maximum amount of fish over a period of time (year, season) by a fishing fleet that is fully utilized, given the biomass and age structure of the fish stock and the present state of the technology.

fishing effort
The total amount of fishing activity on the fishing grounds over a given period of time, often expressed for a specific gear type, e.g. number of hours trawled per day, number of hooks set per day or number of hauls of a beach seine per day.

Fishing effort would frequently be measured as the product of (i) the total time spent fishing and (ii) the amount of fishing gear of a specific type used on the fishing grounds over a given unit of time. When two or more kinds of gear are used, they must be adjusted to some standard type in order to derive and estimate of total fishing effort.

fishing mortality
A technical term which refers to the proportion of the fish available being removed by fishing in a small unit of time; e.g. a fishing mortality rate of 0.2 implies that approximately 20 percent of the average population will be removed in a year due to fishing. Fishing mortality can be translated into a yearly exploitation rate (see above) expressed as a percentage, using a mathematical formula.

fleet
The total number of units of any discrete type of fishing activity using a specific resource. Hence, for example, a fleet may be all the purse seine vessels in a specific sardine fishery, or all the fishers setting nets from the shore in a tropical multispecies fishery.

fully exploited/fished
Term used to qualify a stock that is probably being neither overexploited nor under-exploited and is producing, on average, close to its MSY.

genetic diversity
The sum of the actual or potential genetic information and variation contained in the genes of living individual organisms, populations or species.

genetically modified organism (GMO)
An organism that has been modified or altered by natural processes of mutation, selection and recombination; (now chiefly) artificially manipulated in order to produce a desired characteristic, which means the manipulation of the genome of an organism by laboratory techniques, esp. by the introduction of a new or altered gene using recombinant technology (Oxford English Dictionary).

harvesting strategy
Not to be confused with a management strategy. A harvesting strategy is a plan, under input or output control, for working out how the allowable catch from a

stock will be calculated each year, e.g. as a constant proportion of the estimated biomass.

high-grading
The practice of discarding of a portion of a vessel's legal catch that is considered inferior (and which could have been sold) to have a higher or larger grade of fish that brings higher prices. This practice may occur in both quota and non-quota fisheries.

indicator
A variable that can be monitored in a system, e.g. a fishery to give a measure of the state of the system at any given time. Each indicator should be linked to one or more reference points and used to track the state of the fishery in relation to those reference points.

interested party or interest group
See stakeholder

limited entry
A common management tool in which the government issues a limited number of licenses to fish, creating a use right (here, the right to participate in the fishery).

management measure
Specific controls applied in the fishery to contribute to achieving the objectives, including some or all of the technical measures (gear regulations, closed areas and time closures), input controls, output controls and user rights.

management procedure
The process of conducting fisheries management. Includes all aspects involved in fisheries management including planning, implementing, monitoring and assessment.

management strategy
The strategy adopted by the management authority to reach the operational objectives. It consists of the full set of management measures applied in that fishery.

marine protected area (MPA)
A protected marine intertidal or subtidal area, within territorial waters, EEZs or in the high seas, set aside by law or other effective means, together with the overlying water and associated flora, fauna, historical and cultural features. It provides degrees of preservation and protection for important marine biodiversity and resources; a particular habitat (e.g. a mangrove or a reef) or species, or sub-population (e.g. spawners or juveniles) depending on the degree of use permitted. The use of MPAs for scientific, educational, recreational, extractive and other purposes including fishing is strictly regulated and could be prohibited.

maximum sustainable yield (MSY)
The highest theoretical equilibrium yield that can be continuously taken (on average) from a stock under existing (average) environmental conditions without significantly affecting the reproduction process.

non-governmental organization (NGO)
Any organization that is not a part of federal, provincial, territorial or municipal government. Usually refers to non-profit organizations involved in development activities.

open access
A condition describing a fishery that is available to anyone who wants to fish.

operational objective
A specific purpose that can be achieved through the application of a management measure.

over-exploited/fished
Exploited beyond the limit believed to be sustainable in the long term and beyond which there is an undesirably high risk of stock depletion and collapse. The limit may be expressed, for example, in terms of a minimum biomass or a maximum fishing mortality, beyond which the resource would be considered to be over-exploited.

performance measure
A function that relates the value of an indicator to its reference point, and that guides the evaluation of fisheries management performance in relation to its stated operational objective.

policy goal
High-level policy objective relating to fish resources, ecosystems (e.g. biodiversity), economics and social benefits, usually at a specified at regional or national level.

principle
An overarching guiding concept for managing natural resources, usually developed in the context of global agreements and/or legislation. Examples: 'the precautionary approach", "maintaining ecosystem integrity".

property rights
A legal right or interest in respect to a specific property. A type of resource ownership by an individual (individual right) a group (communal right), or the state (state property).

quota
A share of the TAC allocated to an operating unit such as a country, a community, a vessel, a company or an individual fisherman (individual quota) depending on the system of allocation. Quotas may or may not be transferable, inheritable and tradable. While generally used to allocate total allowable catch, quotas could be used also to allocate fishing effort or biomass.

reference point
A benchmark against which to assess the performance of management in achieving an operational objective, corresponding to a state considered to be desirable (target reference point) or undesirable and requiring immediate action (limit reference point).

restocking
The release of cultured juveniles into the wild to restore the spawning biomass of severely overfished stocks to levels at which they can once again provide sustainable yields. Restocking requires managers to protect the released animals and their progeny until replenishment has occurred.

rights-based management
A fisheries management regime in which access to the fishery is controlled by use rights that may include not only the right to fish, but also specifications

about any or all of the following: how fishing may be conducted (e.g. the vessel and gear); where and when fishing may take place and how much fish may be caught.

species assemblage
The term used to describe the collection of species making up any co-occurring community of organisms in a given habitat or fishing ground.

stakeholder
Any person or group with a legitimate interest in the conservation and management of the resources being managed. Generally speaking, the categories of interested parties will often be the same for many fisheries, and should include contrasting interests: commercial/recreational, conservation/exploitation, artisanal/ industrial, fisher/buyer-processor-trader as well as governments (local/ state/national). The public and the consumers could also be considered as interested parties in some circumstances.

stock
A group of individuals in a species occupying a well-defined spatial range independent of other stocks of the same species. Random dispersal and directed migrations due to seasonal or reproductive activity can occur. Such a group can be regarded as an entity for management or assessment purposes. Some species form a single stock (e.g. southern bluefin tuna) while others are composed of several stocks (e.g. albacore tuna in the Pacific Ocean comprises separate northern and southern stocks). The impact of fishing on a species cannot be fully determined without knowledge of the stock structure.

stock enhancement
The release of cultured juveniles into the wild to yield desired levels of harvest by overcoming recruitment limitation. Stock enhancement is applied only to operational fisheries, and the additional value derived from the released animals at harvest should exceed the cost of producing the juveniles.

stock productivity
Relates to the birth, growth and death rates of a stock. A highly productive stock is characterized by high birth, growth and mortality rates, and as a consequence, a high turnover and production to biomass ratio. Such stocks can usually sustain

higher exploitation rates and, if depleted, could recover more rapidly than comparatively less-productive stocks.

strategic management
Management of the fishery's overall objectives and policy.

sustainable development
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

sustainable use
The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

target resource-orientated management (TROM)
A term constructed to refer to conventional fisheries management in which the stock of the target species is the main concern of management actions.

target species
Those species that are primarily sought by the fishermen in a particular fishery. The subject of directed fishing effort in a fishery. There may be primary as well as secondary target species.

territorial use rights in fishing (TURFs)
Fishery management methods that assign rights to individuals and/or groups to fish in certain locations, generally, although not necessarily, based on long-standing tradition ("customary usage").

total allowable catch (TAC)
Total amount of resource allowed to be taken in a specified period (usually a one-year period), as defined in the management plan. TAC may be allocated to the stakeholders in the form of quotas as specific quantities or proportions.

traditional ecological knowledge
The local knowledge held by a group of indigenous people and passed from generation to generation on the nature and functioning of the ecosystem.

user rights
The rights held by fishers, fishing communities or other users to use the fishery resources.

yield
The amount of biomass, or the number of units currently harvested.

These guidelines have been produced to supplement the FAO Code of Conduct for Responsible Fisheries. The Code and many international agreements and conferences highlight the many benefits that can be achieved by adopting an ecosystem approach to fisheries (EAF) and elaborate a number of agreed principles and concepts relating to EAF.

ISBN 92-5-104897-5 ISSN 1020-5292

9 789251 048979

TC/M/Y4470E/1/3.03/1300