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STATUS AND TRENDS REPORTING IN FISHERIES

A review of progress and approaches to reporting the state of world fisheries

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STATUS AND TRENDS REPORTING IN FISHERIES

A review of progress and approaches to reporting the state of world fisheries

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PREPARATION OF THIS DOCUMENT

The first session of the Advisory Committee on Fisheries Research (ACFR)[1] established a Working Party on Status and Trends of Fisheries (WP/STF). This Fisheries Circular comprises an edited compilation of papers prepared for the first session of the WP/STF[2], together with summaries of WP/STF intersessional activities in the preparation of a draft International Plan of Action for Status and Trends Reporting on Fisheries for consideration by the second session of the ACFR[3] and the recommendations of the third session of the ACFR[4].

Evans, D.W.

Status and trends reporting in fisheries: A review of progress and approaches to reporting the state of world fisheries

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ABSTRACT

This circular reviews recent progress and approaches made by FAO and other organizations to reporting on the status and trends of world fisheries. It includes a brief introduction on events that stimulated the creation of the ACFR Working Party on Status and Trends of Fisheries that resulted in this review, including the decision to prepare a draft International Plan of Action on the issue. Chapter 2 addresses the general issues that require attention as identified in the Code of Conduct for Responsible Fisheries, including the changing requirements resulting from international instruments and national laws, which are direct responses to changing perspectives on the information requirements to address sustainability, and the rising demand from all stakeholders for transparency and objectivity. The Circular then briefly reviews FAO's global perspective (Chapter 3) and approaches to reporting and research by a range of global, regional and national institutions (Chapter 4). It concludes with a general discussion of approaches to meeting information standards, quality and accessibility, including issues concerning frameworks, standards, quality assurance, the conduct of working groups, and suggestions for the development of a method for improving fishery information upon which status and trends reports might be based. In the latter area it provides a conceptual and generalized framework for a user-oriented method (as part of the FIGIS programme) for registering stock assessment and stock status information. Suggested templates for this are in Appendix 1. Appendix 2 offers brief case studies on the ways fishery status and trends are reported by three institutions: the International Council for the Exploration of the Sea (ICES), the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the United States National Marine Fisheries Service (NMFS).

[1] First Session of the Advisory Committee on Fisheries Research, FAO, Rome, Italy, 25-28 November 1997, FAO Fisheries Report No. 571, FIPL/R571(En).

[2] Working Party on Status and Trends of Fisheries, FAO, Rome, Italy, 30 November-3 December 1999

[3] Second Session of the Advisory Committee on Fisheries Research, FAO, Rome, Italy, 6-9 December 1999.

[4] Third Session of the Advisory Committee on Fisheries Research, FAO, Rome, Italy, December 2000.

FOREWORD

The basis of all actions in support of the management, conservation and development of fisheries is good information, analysed appropriately, and presented accurately and objectively. FAO recognises its global role in responding to the information needs of those charged with the management of fishery sectors, in particular to the FAO Committee on Fisheries (COFI). Better information – from a wider range of sources – is becoming increasingly important to the multifaceted analyses required for modern fishery management decision-making, and now includes economic, social and environmental dimensions in addition to the 'traditional' biological/stock perspectives. The State of World Fisheries and Aquaculture (SOFIA) is reported every 2 years and interim analyses of marine, inland and aquaculture resources are published separately. These publications increasingly reflect these wider dimensions of analysis and reporting.

Recent international instruments[5] lay great emphasis on the information required to fulfil their objectives. FAO has responded to these requirements in a number of ways, in particular in the ways in which information is disseminated, and in the research focuses that need to be adopted to generate it. As part of its regular programme, FAO is developing the *Fisheries Global Information System* (FIGIS) which aims to provide Internet access to the widest possible coverage of fishery information, from catches to markets, fishing vessels to human resources, species biology to large marine ecosystems, and to the references, bibliographies and other linkages that support these. A long-term project, *Support for International Fisheries Research* (SIFAR), aims to provide a global forum for the exchange of information, ideas, methods and results of researchers from all disciplines. The Director-General of FAO has re-established the *Advisory Committee on Fisheries Research* (ACFR) to advise him and the Fisheries Department on ways to improve fisheries research and reporting within FAO and globally.

The first meeting of the ACFR in 1997 called for FAO to address the issue of fishery status and trends reporting and established a *Working Party on Status and Trends of Fisheries* (WP/STF), which met in November 1999. The present Fisheries Circular summarizes the papers presented to the Working Party; the consideration of its report to the second session of the ACFR in December 1999; the intersessional work it carried out for submission to the third session of ACFR in December 2000 in the preparation of a draft International Plan of Action for Status and Trends Reporting on Fisheries for submission to COFI 2001.

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[5] Code of Conduct for Responsible Fisheries; UN Fish Stocks Agreement; FAO Compliance Agreement; International Plans of Action in fisheries.

CONTENTS

Chapter 1. Executive Summary 1

1.1 Recent events concerning Fishery Status and Trends Reporting 1

FAO Advisory Committee on Fisheries Research (ACFR) 1
UN Agencies 2

1.2 Information issues 2

Information quality 2
Information communication methods 3
Information activities 3

Chapter 2. General Issues in Status and Trends Reporting in Fisheries 4

2.1 Introduction 4

The scope of reporting 4
Data, information integration and technology 4
Quality policy 4

2.2 Analysis of the current situation in global fisheries reporting 5

National laws and information capacities 6
International law and requirements 6
Changing requirements through changing perspectives 6
Revised requirements of stakeholders 7
Public demand for information 7

2.3 Information approaches 8

Information systems 8
Transparency and confidentiality 9
Objectivity and opinion 9

Chapter 3. FAO's Global Perspective 10

3.1 Recent progress within FAO 10

Advisory Committee on Fisheries Research 10
Fisheries Department Information Strategy 10
FAO Corporate Communications Policy 11
International Plans of Action 11

3.2 Fisheries information in international agreements and initiatives 11

Code of Conduct for Responsible Fisheries 11
UN Fish Stocks Agreement and FAO Compliance Agreement 12

3.3 FAO approaches and initiatives 13

International standards, practices and guidelines 13
Information and database systems 14
FIGIS 14
Other FAO initiatives 14

3.4 FAO global analysis and reporting 15

Reporting the global fisheries trend since 1950 15
State of World Fisheries and Aquaculture 16
Reviews of World Fishery Resources 18
Reporting under resolutions, agreements and international plans of action 20

Chapter 4. National, Regional and International Organizations 24

4.1 Introduction 24

4.2 Institutional analysis 24

United Nations Environment Programme - UNEP 24
Commission for the Conservation of Antarctic Marine Living Resources - CCAMLR 25
International Commission for the Conservation of Atlantic Tunas - ICCAT 26
North Atlantic Salmon Conservation Organization - NASCO 26
International Council for the Exploration of the Sea - ICES 26
Secretariat of the Pacific Community - SPC 26
Northeast Atlantic Fishery Commission - NEAFC 27
Organisation for Economic Cooperation and Development - OECD 27
United States National Marine Fisheries Service - NMFS 28
Australian Fisheries Management Authority - AFMA 28

Namibia Ministry of Fisheries and Marine Resources - MFMR 29
New Zealand Ministry of Fisheries - MoF 29
4.3 Summary 30

Chapter 5. Approaches to Meeting Information Standards, Quality and Accessibility 31
5.1 Introduction 31
5.2 Status and trends reporting 31
Definition of status and trends 31
Precautionary approach 32
Fishery status and fishery performance indicators 33
Incorporating risk and ecosystem-based approaches in fishery analysis 33
5.3 Frameworks 34
Information framework 34
Sustainability frameworks 37
Process and communications framework 38
5.4 Standards 38
Incorporating uncertainty in information systems 38
Data quality reference system 39
Status definitions 39
Reference points and fishery control rules 40
5.5 Quality assurance 40
The basis of quality 40
Definitions of quality 41
Quality policy 42
Peer review mechanisms 43
5.6 Working groups: stock assessment in the institutional setting 46
Participation and framework 46
Performance and results 46
Working group stock assessment report profiles 48
5.7 Developments for improving fisheries information 49
A global database for working group results 49
FIGIS and templates for information submission 49
Information partnerships 51
Bibliography 53
Index 55
Appendix 1: Systems and templates for reporting 57
Appendix 2: Case studies of status and trends reporting by organizations 65
Appendix 2a: International Council for the Exploration of the Sea - ICES 65
Appendix 2b: International Commission for the Conservation of Atlantic Tunas - ICCAT 70
Appendix 2c: United States National Marine Fisheries Service - NMFS 73

List of Tables: **page**

Table 1. Information quality domains 5
Table 2. Summary of analyses, conclusions and diagnostics 17
Table 3. Fishery status definitions 18
Table 4. IPOA-Capacity - Section I: Assessment and monitoring of fishing capacity 21
Table 5. Types of Institution in this analysis 24
Table 6. Information requirements for fisheries management 35
Table 7. Examples of Pressure-State-Response indicators by fishery dimension 37
Table 8. Criteria, definitions and methods: a framework for fisheries science quality assurance 42
Table 9. Checklist for conducting or reviewing stock assessments 44
Table 10: General content of stock status and trends reports from working groups 48

Chapter 1. Executive Summary

1.1 Recent events concerning Fishery Status and Trends Reporting

- **FAO Advisory Committee on Fisheries Research (ACFR)**

The findings of the first meeting of the FAO Advisory Committee on Fisheries Research (ACFR) in 1997 on the issue of Fishery Status and Trends Reporting[6] were as follows:

- FAO plays a unique role in fisheries statistics and the preparation of information on the global status and trends of fisheries.
- Such reports play an important role by informing policy makers and the public.
- Current statistics collection system is limited to primarily landings and commodities statistics, whereas there is a critical need for data relevant to fleet capacity, participation in fisheries, economic performance and distribution.
- Data management is being modernized and there is a need to integrate the entire fisheries statistics system in light of modern information technology.
- Information quality criteria and quality assurance protocols are increasingly required.
- Regional bodies and experts should be involved in the assessment of status and trends.

As a result of these findings and other discussions it was agreed to establish an ACFR Working Party on Status and Trends of Fisheries (WP/STF) with the following terms of reference.

"The Working Party shall shall:

- Evaluate data needs for status and trends reporting on a global scale on marine fisheries, including fishery resources, fishing fleet capacity, participation in fisheries and economic performance, and propose a common template of essential information elements which could be used by the main providers of status and trends reports;
- Propose arrangements for the involvement of regional fishery bodies and non-FAO experts in a consensus-seeking process for assembling, reviewing and disseminating fishery status and trends information (including reporting to COFI);
- Advise on the relationship between FAO's data collection and status and trends reporting programme and the Living Marine Resources module of the Global Ocean Observing System (GOOS); and
- Report on these to ACFR."

The ACFR acknowledged that there is genuine global concern that fish stocks and fisheries are in crisis and that a wider research agenda is required. The committee agreed that a multifaceted approach to fisheries analysis and management should include consideration of all information concerning the utilisation of stocks, covering issues related to:

- fleet capacities and other capital employment;
- participation by communities, companies, nations; and
- economic performance and distribution.

In addition, the ACFR identified other research agenda that require attention, e.g. ecosystems, globalisation, research methods, aquaculture sustainability, and inland and small-scale fisheries. In this

[6] FAO Fisheries Report No.571. Report of the first session of the Advisory Committee on Fisheries Research, 25-28 November 1997, Rome, FAO. FIPL/R571.

Circular some of the information and reporting issues related to these agendas are also touched upon; all have aspects that will require information, analysis and reporting.

The 2nd Session of the ACFR received the findings of the WP/STF in December 1999[7] which called for the development of a proposal for an International Plan of Action for Status and Trends Reporting in Fisheries (IPOA-Status&Trends) The WP/STF continued intersessional preparation of this IPOA, which was then finalised at the 3rd Session of ACFR in December 2000. The approach of using an IPOA to improve information on status and trends of fisheries was considered by COFI[8] in 2001. COFI agreed on the need for improvement and recommended that a Technical Consultation be held to consider how such information should be improved, including the possible mechanism of an IPOA. and for submission to COFI in February 2001. The Technical Consultation will be held in 2002.

- **UN Agencies**

The issue of ecosystems and the environment is clearly one area that needs greater attention through research and communication at the global level. Indeed, part of the TOR of the WP/STF was to discuss how to include the work of FAO as a collaborating institution within the Living Marine Resources (LMR) module of the Global Ocean Observing System coordinated by UNESCO. The LMR module will need the information on fish stocks - their status and characteristics - to allow the sort of integrated analysis that it expects to be able to perform, in particular to describe the varying state of the ecosystems, and to predict future states of the ecosystems, including exploited species, on useful time scales.

These concerns have been mirrored in other global reports such as the UNEP's GEO2000[9], which called for "Filling the knowledge gaps" by improving environmental data and information, and evaluating policy performance. UNEP relies on FAO for much of its source data.

1.2 Information issues

- **Information coverage**

The nature and extent of fishery data need to be significantly increased to cover all information that might be used to estimate fishery performance and other sustainability indicators, including more information on the environment and ecosystems, on the conduct and economics of fisheries, on participation in fisheries, and on the methods used to manage fisheries.

- **Information quality**

Clear global understandings of the nature and requirements of fisheries sustainable development reference systems need to be established, i.e. the total quality of the information required for a preferred management and reference system for a fishery. The standardisation of nomenclature and definitions with regard to fishery status, reference points and the appropriate underlying stock assessments need to be addressed. A method for identifying basic data quality criteria and scores should be developed to enable databases to hold at least some uncertainty/certainty values associated with data. Uncertainty also needs to be further developed in relation to stock status and trends, and all stocks assessments should always include estimates of uncertainty in the results, whether mathematical or subjective. Information quality assurance needs to be established through a variety of methods; through the application of 'standard' methods (including appropriate check lists); through

[7] Report of the Working Party on Status and Trends of Fisheries, Rome, Italy, 30 November-3 December 1997. ACFR/99/2

[8] Committee on Fisheries, Twenty-fourth Session, Rome, Italy, 26 February - 2 March 2001, proposal for improved status and trends reporting on fisheries, COFI/2001/8

[9] UNEP GEO team, GEO 2000, 1999

transparent approaches (hence reproducibility); and with consistency in the presentation of results. Some further consideration is needed on how institutions - in particular regional fishery bodies - can develop, adopt and meet international service quality standards.

- **Information communication methods**

Rapid technical advances, coupled to increasing public demands for both transparency and appropriate confidentiality, are influencing the nature and scope of fishery information communication. Definitions and scaling of 'appropriate confidentiality', as required under the Code of Conduct for Responsible Fisheries (CCRF), need to be established. The processes and results of working groups need to be widely disseminated to provide for better performance of working groups, and to enable peer review to be conducted more often and more efficiently. Institution or fishery-specific standards for peer review should be developed and adopted, including those produced by FAO. Communication methods and channels need to be developed for access to fishery information, especially through capacity-building in countries and institutions where this is required.

- **Information activities**

Promoting the further development of fishery information systems should include support for and expansion of the Fisheries Global Information System; the development of partnerships and agreements to promote information exchange; and, in particular, an improved method for reporting on national/regional approaches to the implementation of the CCRF. Further elaboration (including the development of training materials and capacity-building) and wide dissemination of the Technical Guidelines for the Development and Use of Indicators for Sustainable Development of Marine Capture Fisheries should be a priority for FAO. This should be expanded to inland fisheries and aquaculture, in particular in data-poor situations and to include the development and use of fishery control rules. An appropriate and accessible information sharing and global research communication method should be developed through FIGIS through an open database for users, focussing on stock assessment and stock status and trends reporting.

Chapter 2. General Issues in Status and Trends Reporting in Fisheries

2.1 Introduction

- **The scope of reporting**

Fishery managers already take a wider range of issues into account when deciding the ways in which fisheries are to be exploited - when, to what extent, by what method and by whom fishing may be conducted - and hence the fishery-specific management framework that needs to be applied. Thus, knowledge of utilisation, environmental and socio-economic information already plays an enormous part in the multifaceted research required for modern fisheries management. There is also a growing awareness that fish stocks, as part of the ecosystem, need to be considered within the full scope of the environment; and that ecosystem-based fisheries management is likely to be an approach that will be increasingly adopted. For example, the relatively recent Sustainable Fisheries Act (USA, 1996) mandates that this approach be investigated as part of the process to ensure sustainable fisheries. A report to the United States Congress has been delivered on this issue.

- **Data, information integration and technology**

Data

FAO spends a considerable proportion of its resources on the establishment and maintenance of global fisheries data, and on an information system for its management. Hitherto, landings, fleets and commodities have received the greatest attention, producing the highly respected annual fisheries statistical yearbook series (now also available electronically as FISHSTAT and via the Internet). It is clear that a far wider range of information encompassing the fishery, biological, economic and socio-cultural domains are required.

Information integration

Other data sets and sources of information are also available to FAO, and should be communicated to the global community. Data integration and a widening of the scope of analyses is required, particularly in ways that meet growing requirements where the data held by FAO forms the basis for work undertaken elsewhere, in particular other UN agencies. The proposal and programme to establish the Fisheries Global Information Systems (FIGIS) is a first attempt to bring the power of modern technology to the issue of integration and accessibility.

Technology

The advent, development and accessibility of advanced computer communication technology is driving the long-recognised possibility that 'correct' data can actually be maintained in one place, while still offering global access. The Internet and the establishment of file transfer protocols that are available to all, given minimal hardware, mean that the quality of such 'reference' information must be beyond question. The accelerating development of web-based database software is an opportunity for maintenance of information at the same time as making it widely and simply available.

- **Quality policy**

General management methods incorporate many ways of looking at the quality of services. Like fisheries research, in relation to fisheries information quality, the issue is also multi-faceted, including the following questions:

- The scope, precision and accuracy of data: Is it sufficient, correctly scaled and reliable?
- The coverage and completeness of data (and the ways in which it is raised): Does it cover the sampling distribution necessary (and are the raising factors appropriate)?
- The acceptability of analytical and modelling methods: Is the method used to derive information appropriate to the task? Has it been accepted or validated?
- The statistical validity of analysis: What is the level of confidence in the information derived? What are the risks that 'reality' is outside the expectations arising from the analysis?
- The validation of the results of analysis: Has the whole process been independently peer-reviewed?
- Have alternative approaches been given sufficient recognition across the range of the above to ensure that the outcome (the meaning of the information) is accepted by stakeholders?

There is also the issue of presentation. Placing information within the context of decision-making in a way that ensures its value is taken into account, along with all other information, is vitally important. In some situations information may only be supportive of the issue in question; at other times the same information may be a critical input to the decision. Ignoring or concealing information, even if it has passed all the tests described above, can result in a decision that is contrary to the objective. For example, rises in catch rates are valid stock condition signals that fishers (and fishery managers) often cite when justifying their call for increased total allocations. Without also including the target reference point, such as MSY or Fpa, and the expected trend towards achieving these as a result of a stock re-building programme, managers might be tempted (or, at least, able to persuade decision-makers) to increase allocation. The result might be a reversal of progress towards sustainability, while satisfying a short-term gain.

Collaborative decision-making by all stakeholders who bring all their information to the process of management of fisheries - policy, biological, environmental, economic and societal - is not just desirable, but essential. Transparency improves confidence, confidence builds trust, and trust engenders objectivity. In establishing the framework for a quality policy[10] on the fisheries advice that the International Council for the Exploration of the Sea (ICES) provides, these sentiments as applied are better expressed as Relevant, Responsive, Right and Respected (see Table 1).

Table 1: Information quality domains

Information quality	*Information attributes*
Relevant	Information is appropriate in scope, precision, accuracy, coverage and completeness.
Responsive	Information analysis is appropriate to the task.
Right	Information results include estimates of confidence and risk.
Respected	Information is objective (satisfied by the above), transparent and communicated to and accepted by stakeholders.

2.2 Analysis of the current situation in global fisheries reporting

There is no doubt that progress is being made in global fisheries reporting. The problem is that it is patchy; often progressing at a much slower rate in less-developed countries. Nevertheless, all Governments are taking the issue seriously. Information requirements are being established through various mechanisms that express a commonality of purpose. This is clear at all levels, except perhaps

[10] ICES Quality Policy: a proposal. Internal document 1996.

at the fishery community level. With the movements towards community-based co-management in many areas, it is likely that the necessity of good information will be more widely recognised also at that level and moves will be made to obtain it.

- **National laws and information capacities**

Since the beginning of the 200-mile EEZ era, many – probably most – nations have undertaken at least some changes to their national fisheries laws. This has accelerated in recent years because of the need to enact domestic laws to cater for commitments under international agreements, including the licensing of regional or distant water fisheries.

In inland fisheries, particularly where rivers and lakes form boundaries with neighbouring countries, national laws on these water bodies are continuing to be implemented, reflecting the growing concern for and cooperation over watershed management.

In the European Economic Area (includes non-EU countries), individual countries are bound both by their national laws and by EU Council regulations. The Netherlands has no national legislation on fisheries reporting but simply follows the EU Council regulations. The EU Candidate countries (mainly eastern Europe and Cyprus) are all required to harmonise their legislation and systems as part of their candidacy; many of them have modernised their legislation through recent new or amended fisheries or statistics laws. In the South Pacific, member states of the Forum Fisheries Agency have for many years been harmonising their legislation to cater for UNCLOS and are, once more, upgrading their laws to meet new international agreements.

All too often, however, the implications for information management stemming from the law cannot be fulfilled for a number of reasons, only some of which are related to costs. Notwithstanding financial constraints, there may be many reasons why transparency is avoided. Primary among these is insufficient capacity. Training and management of fisheries information workers may be entirely absent, or the collection of fisheries information is bound up with objectives un-related to fishery management issues, such as the collection of municipal or state taxes. Nevertheless, information capacities are improving in most countries, prompted largely by international commitments but also from the recognition that it is essential for identifying the target of sustainable exploitation and the path towards it. A large regional project for sub-Saharan Africa to implement the CCRF, particularly at the poorest levels of fishers, is now under way. Regional and national development projects now largely eschew 'fisheries development' among their objectives; rather, fisheries management and its concomitant information requirements are the main focus for such assistance partnerships.

- **International law and requirements**

The UN Fish Stocks Agreement (UNFSA) and FAO Compliance Agreement (FAOCA) are formal instruments of two particular issues that stem from UNCLOS – transboundary stocks and the high seas. Although they have yet to come into force, these instruments will have long and extensive impact on the ways in which ocean fisheries are managed, in particular on the role of regional fisheries bodies with mandates and responsibilities for active fisheries management. Along with the CCRF, these instruments require a range of reporting and information management. These instruments are intended partly to satisfy management requirements over these stocks and on the high seas, and partly to effect standardisation. Importantly they encourage information sharing and communication between states. The precautionary approach in the CCRF (7.5.2 and 7.5.3) further encourages sharing information on the status and trends in fish stock attributes, "as well as environmental and socio-economic conditions", and in the "determination of reference points".

- **Changing requirements through changing perspectives**

It is the changing perspectives in fisheries management that are driving these changing requirements for information. It is becoming increasingly accepted that:

- the best approach to sustainability is through appropriate precaution;
- fishing influences the ecosystem, which is influenced by the environment;
- control of access and the appropriate application of fishing effort/fishing capacity is necessary component for ensuring fisheries management meets its objectives (sustainable fisheries); and
- an integrated approach considering information from and between all sectors is the only way to ensure transparency and the likelihood that compliance can be understood, accepted and implemented.

- **Revised requirements of stakeholders**

All fisheries stakeholders, from the industries and communities that depend on them, through government agencies and research institutions, to regional and international bodies and environmental NGOs, are becoming increasingly recognised as part of the overall fisheries management process. All are encouraged (by the CCRF) to participate in the development of 'best scientific evidence' and in some countries legislation is established to require the full involvement of participants in commercial or recreational fishing in the fisheries management process. In some countries, companies and NGOs may even participate in scientific stock assessment working groups; in others this approach has caused strains to scientific credibility and such participation has ended.

The continued movement towards rights-based fishing, from ITQs to the recognition of community traditional use rights, can be expected to increase the demand from rights-holders to be involved in the processes of fisheries management. These rights should always carry concomitant responsibilities towards the other participants in the process, the scientists and managers. Participation requires transparency; and transparency requires disclosure. Fishers must provide the data that they have so often in the past concealed. FAO is addressing this issue and an International Plan of Action International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated fishing was agreed in 2001 which has an information component.

- **Public demand for information**

There are three public issues that affect the matter of reporting, 1) the demand for more information, 2) requirements for transparency of process, and 3) specific requirements for knowledge about the environment and its use. This has led, among other things, to increased public support for advocacy groups, which, in turn, has forced some groups to adopt more professional approaches to their concerns and in themselves to become more accountable.

Many fishery and food companies have now accepted and recognised these public requirements. In the early 1990s, the issue of 'dolphin-friendly' in recognition of the US Marine Mammal Protection Act led to identification of this on tuna cans. Following the UN resolution on large-scale high seas drift net fishing (banning them), tuna cans also identify themselves as environmentally friendly, such as "caught by pole and line", etc.

In 1997, after several years of preliminary work the Wordwide Fund for Nature (WWF) and Unilever (an international food company) established the Marine Stewardship Council (MSC) to address this issue. This non-governmental organisation has now become an international accreditation organisation, with multiple sponsors independent from its founders. It seeks to persuade fishing and food companies to adopt terms of their businesses that reflect fishery sustainability. The MSC offers a means for authentication of their commitment and approach to sustainability through a certification scheme, which could then be used appropriately, most often at point of sale or on packaging. Response to this has been gradual and may accelerate. It may also be subject to formal international agreements some time in the future; and some issues in this area – e.g. the eco-labelling issue – have been discussed in international fora on fisheries trade in recent years.

The MSC has published its key 'Principles and Criteria' which are drawn directly from the CCRF, i.e. that a **sustainable fishery**:

- can be continued indefinitely at a level that does not deplete the target population, and allows it to recover to healthy levels from past depletion;
- maintains and seeks to maximise ecological health and abundance;
- maintains the diversity, structure and function of the ecosystem on which it depends as well as the quality of its habitat, minimising the adverse effects it causes;
- is managed and operated in a responsible manner, in conformity with local, national and international laws and regulations;
- maintains present and future economic and social options and benefits; and
- is conducted in a socially and economically fair and responsible manner."

Whatever process or organisation is involved in ensuring these outcomes, there will need to be some form of authentication process - such as the MSC Fish Custody Certification Process. The MSC gets some of its information from FAO, hence maintaining accurate and relevant information can assist fishery companies meet these standards if they wish to participate. It is likely that this form of advocacy in fisheries will continue for some time, perhaps transforming at a later date into something more formal. Nevertheless, public demand for such information is unarguable and needs to be satisfied in the best way possible.

2.3 Information approaches

- **Information systems**

Information technology and systems are developing rapidly. On the basis of what is possible now and the speed with which it has been achieved, it can be confidently expected that all states will soon be able to compile and share information relevant to fisheries; and not just the basic information, but with increased complexity (scope, detail, accuracy), and with improving timeliness and sophistication.

The main problem will always remain: How to collect the data in the first place? It is likely that many fisheries will be soon providing real-time, full-coverage data automatically, particularly through the introduction of vessel monitoring systems (VMS). Using VMS to transmit environmental information in addition to fishing data is likely to become a standard practice (as part of the responsibilities of rights-holders). If stakeholders accept environmental issues as important, then fishers must also accept the responsibility for collecting additional information. In small-scale fisheries, where information has traditionally been based on sampling, it may be possible to introduce simple and cheap VMS to generate effort information as a means to assessment.

The information age has also brought about rapid advances in the sharing of ideas - over the Internet, through easily portable electronic documents and wider access to training. Theoretical approaches, analytical methods, software applications are all now being made available to a wider audience. Unfortunately, this is not proceeding as rapidly in less-developed countries. However, there are programmes of assistance in this area under way, many based on established or emerging regional organisations, but also within the UN system (FAO, UNEP, UNESCO/IOC). These development programmes are based on a clear need but are also in response to the agreed special position of developing States, for example in the UNFSA the parties have agreed in the Preamble through the following:

"**Recognizing** the need for specific assistance, including financial, scientific and technological assistance, in order that developing States can participate effectively in the conservation, management and sustainable use of straddling fish stocks and highly migratory fish stocks."

A similar encouragement is also in the preamble to the FAOCA and explicitly in Article 5 of the CCRF and Article 25 of the UNFSA; and the Annexes to the UNFSA relate specifically to information and the precautionary approach.

- **Transparency and confidentiality**

The FAOCA also suggests that "the objective of this Agreement can be achieved through … increased transparency through the exchange of information on high seas fishing" and the UNFSA, in Article 6.13, encourages States to "ensure that decision making processes are transparent and achieve timely solutions to urgent matters".

These fisheries instruments and the CCRF are clear that confidentiality should be maintained 'where applicable', but it is only in the UNFSA that this is defined to mean non-aggregated data. Parties who share data are presumably required to agree on the level of aggregation that is appropriate for the task. In future it may be that the aggregated/non-aggregated issue will become less intense (although it will not disappear) as rights-based fishing replaces open access fishing in which fishing ground information is currently a competitive advantage.

Information confidentiality – often spurious or unjustified – has complicated and probably limited stock assessments, management advice, quota allocation and access negotiations. Nevertheless, it remains an issue that information systems are particularly capable of guaranteeing in a whole variety of ways. In a consultancy report on the development of tasks and partnerships for the project for FIGIS, it was recommended that some legal and technical interpretation of the notion of 'applicable confidentiality' be developed. This notion appears in several instruments, in particular the CCRF (Article 7.4.4), but needs proper consideration, including ways to assess and record information reliability.

- **Objectivity and opinion**

The issue of objectivity and opinion in relation to fisheries information and reporting - and the information systems that support them - is more complex. Part of the problem is to devise ways of attaching levels of confidence in the data/information maintained. Addressing this issue, the 1st Session of the ACFR agreed that "Another critical element of the research need concerning statistics and status and trends is for the design of quality criteria and quality assurance protocols." This is being addressed at a variety of levels, including at international organisations (See Appendix 2a. ICES and 2b. ICCAT).

Increasingly, the issue is raised in national and international contexts with the proliferation of electronic systems that can be subject to security attacks. Information systems are generally designed to provide some of the confidence in data quality by the application of security procedures, including audit trails. But this is not the key issue. Quality criteria (and scores) need to be established also for analysed data, for the information needed for fisheries management. Providing quality scores for information against a range of criteria (scientific, management) is going to be difficult for all information sources, particularly since there are no published quality standards for general fisheries information, but some approaches to this issue need to be made.

Chapter 3. FAO's Global Perspective

3.1 Recent progress within FAO

- **Advisory Committee on Fisheries Research**

It is clear that ACFR believed that the availability of data and information is generally inadequate to reveal properly the global and regional status and trends of fisheries. The Committee identified a number of areas that require research to answer the following general questions (in all disciplines and at all organisational levels) for any one fishery: What is the current position? What can we predict in the future? Or, put another way: What is the status? Where is the trend leading?

The traditional forms of reporting relate mainly to landings and commodities (the production dimension) both within FAO and at national, regional and international levels. Most regional organizations, through their participating members, report these together with varying extents of information on the status and trends of stocks (the biological dimension). But ACFR and others have identified a widening range of indicators in fisheries that require status and trends reporting, including:

- Fleets and participants – the socio-economic dimension.
- Economic performance and benefit distribution – the financial dimension.
- Policy, governance and institutional progress – the management dimension.
- Ecosystem, sustainability and aquatic enhancement – the environmental dimension.

There is considerable work under way at national, regional and international levels to seek ways of describing and monitoring these issues in ways that are useful to the international fisheries community.

- **Fisheries Department Information Strategy**

In FAO Fisheries Department Information Strategy[11], a range of issues are addressed, some of which are apparent and simply build on existing practices, others are novel. The main thrust of the document, however, is built around several suggested approaches:

A systematic assessment of data and information needs of the primary clients should be conducted, including regular -

- feedback and ongoing analysis of user access rates;
- improvements to functional integration, harmonisation of methodologies and nomenclature;
- simplification of data and information submission and methods through improved tools; and
- capacity-building at national and regional fishery body levels.

Many of the things it recommends have entered the FAO corporate programme. Many, of course, remain in progress and this report and other activities reported elsewhere are addressing these issues in a variety of ways.

[11] FAO Fisheries Department Information Strategy: Supporting Informed Decisions and Actions, 18 September 2000

- **FAO Corporate Communications Policy**

In the past the authority of some reports issuing from FAO has been called into question. In particular, the issue of verification and authentication of the information contained in them, and the quality of the analysis and opinion they provide, have received criticism.

In the foreword to the FAO's Corporate Communications Policy and Strategy, the Director-General reiterates FAO's mandate and places "communication … as a core strategy for achieving its goals" thereby fulfilling the often-quoted Articles 1 and 2 of the FAO Constitution.

This FAO corporate policy document provides a key reference for all forms of reporting within the organisation, including collective and individual responsibilities and procedures. For example, the policy indicates how "prior to final submission, papers should be circulated to appropriate individuals within the organization to ensure they meet high professional standards, particularly with regard to the accuracy and consistency of data".

It seems clear that not all FAO publications will need to receive the same level of attention, but the policy gives no specific guidance on this, leaving it up to the internal workings of the departments to establish the appropriate procedures. This is probably as it should be, but the Fisheries Department, if it has not begun the process already, should move towards a "structured peer-review" mechanism as envisaged by the policy. (See later section on the way the Forestry Department has tackled this.)

- **International Plans of Action**

Establishing the frameworks to address issues that stem from international concern on specific problems within fisheries has resulted in the preparation of voluntary instruments now known as International Plans of Action (IPOAs). These seek to identify the nature of the problems and provide general prescriptions that States and the international community should introduce in their alleviation. Four IPOAs have been adopted by COFI and endorsed by the FAO Council, and one is in draft for future consideration, as follows:

- International Plan of Action for the conservation and management of sharks, 1999.
- International Plan of Action for reducing incidental catch of seabirds in long-line fisheries, 1999.
- International Plan of Action for the management of fishing capacity, 1999.
- International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing
- International Plan of Action for Improving Information on Status and Trends of Fsheries (draft).

Each of these IPOAs contains large elements of monitoring and information management in achieving its objectives, the last (if adopted) providing a basis for some of the information upon which the implementation of other IPOAs and the CCRF itself can be assessed.

3.2 Fisheries information in international agreements and initiatives

- **Code of Conduct for Responsible Fisheries**

Given the recognition by all, that globalisation and international concerns in fisheries and aquaculture require appropriate responses, arrangements are gradually being made to address all dimensions of fisheries. In particular, the Code of Conduct for Responsible Fisheries sets out the framework for the practice of capture fisheries and aquaculture at all levels in the global economic and environmental setting.

Each article of the CCRF is set in the sense of a desirable outcome: "… should…" forms the operating tense of almost all the Code's sub-articles, and hence is either recognising a duty or obligation, or is expressing a purpose. Thus, when subscribing to this voluntary code, States (fisheries management organizations and others) have a duty to approach the desirable outcome. Where they are in relation to the outcome envisaged by each article, and under what circumstances the outcome will be reached, are understandings that come from knowledge of each issue's status and trend. For example, CCRF Article 12 – Fisheries Research fully describes in 20 sub-articles what "States should..." do to achieve the understandings (best scientific evidence) upon which informed decision-making can be made. Sub-article 12.1 is clear that fisheries research covers "all aspects of fisheries, including biology, ecology, technology, environmental science, economics, social science, aquaculture and nutritional science."

Monitoring and reporting on the implementation of the CCRF is part 6 of the Resolution that adopted it. Taking this requirement to its extreme, it is clear that virtually every CCRF sub-article might have an associated status and trend, and that States should report on all these, in addition to the traditional status of a fishery as measured by state of the stock parameters, or its landed mass, production, value, etc. For example, it is clear that the status and trend of fishing fleets needs to be determined if the serious problem of excess fishing capacity is to be prevented or eliminated by the means proposed in Article 7.1.8. States have been surveyed twice for this purpose and the FAO Secretariat reported twice on the Implementation of the Code of Conduct for Responsible Fisheries to COFI 1999 and 2001. The CCRF is a continuing and comprehensive set of fisheries desiderata and States (and others) should try their best to approach its outcomes. Demonstrating the processes of, and achievements towards, these outcomes through appropriate reporting will give national and international forums an indication of how far their pledge to collaborate in conducting fisheries responsibly is being achieved.[12]

The CCRF recognised that data gathering and exchange are specific issues that needed to be embedded in Article 7 - Fisheries Management with its own section, Article 7.4. Thus, the CCRF establishes principles with regard to information sharing; and there is now sufficient precedence and demonstration of intentions in the international adoption of the CCRF. What remains from these intentions is to put them into practice. There are three key issues raised by Article 7.4 of the CCRF.

- Applicable international standards and practices, and internationally agreed formats.
- Mechanisms for cooperation to compile and exchange such data in accordance with agreed procedures.
- Applicable confidentiality requirements.

These key issues are expanded and further addressed in Chapter 5.

- **UN Fish Stocks Agreement[13] and FAO Compliance Agreement[14]**

The intentions for the future conservation and management of fisheries, agreed under United Nations Convention on the Law of the Sea (UNCLOS) in 1982, have been revitalised during the mid to late 1990s. In particular, the notion that transboundary natural resource issues can only really be addressed properly through transboundary governance is now receiving increased attention. Also, in regions where States have a focus of common interest – shared stocks or common ecosystems – they can serve

[12] The development of a web-based CCRF reporting system might be actively pursued through a process of 1) developing a template consisting of linked pages that guide people through the evaluation 2) ensuring that questions and the range of answers are properly identified to meet the reporting required and 3) providing explanatory texts that assist information submission appropriately. Every attempt should be made to ensure that, if the response to a primary question is negative, then the user moves to the next question and is not asked 'What has been done on this issue?' Some questions require a compulsory answer, of course, but others might be discretionary, or not even relevant. Care in avoiding embarrassment that the question cannot be answered, or the information cannot be supplied, is essential to avoid the non-submission of any information, or fictitious information being delivered.

[13] 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. 4 December 1995. (not yet in force)

[14] FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas. 24 November 1993. (not yet in force)

their conservation and management purposes best through regional fisheries organisations (RFBs) or arrangements. Of these Regional Fishery Bodies; nine are convened under the FAO Convention, and many others are established by general international convention, some for many years.

The UN Fish Stocks Agreement (UNFSA) and FAO Compliance Agreement (FAOCA) are specifically designed to extend the scope of UNCLOS to specific areas of concern. Essentially they both address the question of how to manage fisheries on stocks that have their occurrence beyond zones of national jurisdiction (EEZs or EFJs), either because the range of the stocks occurs in both EEZs and the high seas (UNFSA) or on the high seas alone (FAOCA).

Both these instruments have specific information requirements that are well recognised but which need many processes to be put in place to achieve them. For example, FAO has established the High Seas Fishing Vessel Authorization Record in implementing the requirements of the FAOCA.

3.3 FAO approaches and initiatives

- **International standards, practices and guidelines**

As the global organization responsible for these things, it should be the task of FAO to formulate or coordinate the international standards, practices and formats for data compilation and exchange. Numerous efforts have been undertaken to do this through institutional relationships such as the Coordinating Working Party on Fishery Statistics, the publication of standards (species names and codes, fishing vessel and gear classifications and codes, etc.) and linkages to other standards prepared by other organisations, e.g. Inter-Governmental Oceanographic Commission/UNESCO standards for oceanographic data exchange (International Oceanographic Data Exchange - IODE).

The pressures are growing to standardise in ways that include more than just data. Recent efforts by FAO to address other standards and practices issues have been published by FAO; for example:

- *Guidelines for the Routine Collection of Capture Fishery Information*[15]

  This publication sets out the range of fishery performance indicator types, from Fishing and Operational indicators, through Biological indicators and Economic indicators, to Socio-cultural indicators. For each indicator the Guidelines elaborates on the data types and variables required for their estimation. It also recommends methods for the development of data collection strategies and methods, and data management and information system planning and implementation.

- *Indicators for Sustainable Development of Marine Capture Fisheries*[16]

  This publication describes the ways in which Sustainable Development Reference Systems (SDRS) and appropriate indicators can be defined. It also describes the development and use of frameworks that can determine the nature of an SDRS for particular fisheries. It refers specifically to marine fisheries; indicators of fresh water fisheries are likely to be different.

These two publications neatly complement one another and will probably lead to, at least, 'better' scientific evidence. They provide some of the key guidelines to enable the development and adoption of internationally agreed standards, and the proper focus on indicators, reference points and limits that are now being demanded. Internationally agreed formats are another matter, but this issue is also addressed in both of these documents, more in the former than the latter. It can be expected that a whole range of agreed data formats will become available in the near future; indeed, for the oceanographic sciences a lot of this has been agreed. In particular, standards for data geo-referencing and formatting should be adopted and published.

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[15] Guidelines for the routine collection of capture fishery data, FAO Fisheries Technical Paper, No. 382. FAO, Rome, 1999.

[16] FAO Fishery Resources Division. Indicators for sustainable development of marine capture fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 8. Rome, FAO. 1999. 68p.

The latter document also makes the case that "the whole process (*meaning SDRS, performance indicator, data variables, analysis and advice generation*) should be underpinned by an effective communication strategy." The paper goes on to state "Making the indicators system accessible through the Internet would be an effective way to communicate rapidly the results to a wider audience." The paper thus foresees taking increasing advantage of technology in reporting the status and trends of fisheries.

- **Information and database systems**

The long-running and respected statistical systems of ***FISHSTAT*** are the foundation upon which rests FAO's reputation as the foremost information source for global fisheries. With such a wide variety of data sources and qualities, it clearly establishes and maintains the system of global choice for much basic 'large map' fisheries statistics for the foreseeable future. FAO/FI is progressively taking advantage of technical advances in hardware, software and communications technology, and little more needs to be said about its applicability and use. However, part of the process being developed through the FIGIS project is to develop new ways of capturing data from States, and this is addressed below.

- **FIGIS**

The Fisheries Global Information System (FIGIS) project is intent on introducing a partial approach to the information deficit that contributes to inadequate conservation and management of both aquatic resources and the environment. It will not be the complete answer for the simple reason that the project cannot address all the problems associated with national incapacities to provide the required information. (Nor, of course, does good information magically turn into rational advice.). National fishery information systems need to be developed - they are not part of the FIGIS project - and are likely to be addressed by other agencies (national, regional or donors). Apart from leading by example, Regional Fishery Bodies are also likely to play an important role in improving national capacities for several reasons, including providing economies of scale, coordination of information requirements, standards and standardisation, and training and finance (through membership, participation and donors).

FIGIS will provide useful, compiled and analysed information at the global scale, available to all and subject to rigorous authentication. Effectively, the intention is that it becomes the internationally accepted standard (at specified, higher levels of detail) on all the world's fisheries. It seeks to provide information to both lateral (international agencies and institutions) and higher audiences, including the general public. But, in so doing it also provides national governments, in most cases the originators of the data, with access to information on their neighbours. Bilateral and regional issues and concerns will thus benefit from access to data of international origin. FIGIS, thus tasked, needs to investigate not just what information needs to be generated, analysed and shared, but how to do it in ways that meet the needs of all levels of clients.

- **Other FAO initiatives**

The reporting of fishery status and trends will be enhanced by further developments within FAO. The FAO World Fisheries and Aquaculture Atlas has been produced and the UN Atlas of the Oceans is in preparation. In addition, the SIFAR[17] project is developing a web-based system ("oneFish") to enable the establishment of an information network for fisheries research, which will form part of a panoply of services enabling fisheries research, in particular for those countries, institutions and individuals that do not have other forms of access to research networks.

[17] SIFAR - Support for International Fisheries and Aquatic Research.

3.4 FAO global analysis and reporting

FAO offers a wide range of fishery status and trends reporting through publications that offer both routine standard information and specific issues in anticipation of global needs for information (special topics). Thus, the following publications try to review the situation between intervening periods in a standard way and report on issues of current concern and, in so doing, can offer directions for further work, research and presentation.

- **Reporting the global fisheries trend since 1950**

In 1996, in support of the ongoing collection of landings information (FISHSTAT) and the need to set this against as long a time series as possible, FAO developed a single, one-off review document that extended the landings time series back to 1950[18]. From this the review concluded that the world's oceans might be fully fished at about 83 million tonnes by 1999 and that further increase would be unlikely. However, this apparent limit, when analysing the overall status and trends in different ways, was offered some evidence for potential increases in this total, if alternative aggregations of information are considered. When looking at individual oceans for example, an increase to 100 million tonnes was to be expected, mainly from potential yield available to development in the Indian and Pacific Oceans. If individual areas are considered, along with expected improvements to management in them (from successful returns to sustainable yields; by-catch and discard reduction; etc), then 125 million tonnes might be landed. That is, global yields higher by 20% and 50% respectively than the global aggregate analysis, for each scenario. This is encouraging, but is it really possible? Grainger and Garcia point out that uncertainty increases with the greater disaggregation, but that a composite global analysis does not take into account under-development or overfishing at the regional or stock level.

The basis for this analysis was the new availability of data from historically reconstructing the computerised time series of landings data from 1961 back to 1950, based on "reports from national authorities, supplemented with data from regional fisheries organisations and other sources. Where data were missing or considered unreliable, FAO included estimates based on the best available information from any source such as project documents, industry newspapers, or in the worst case, repeated figures from another year."

This pragmatic approach to historical data recovery resulted in a 44-year time series, and therefore might be trusted to reveal important patterns and trends that had occurred and from which some better understanding of the current and future status of fisheries can be derived. Whatever the reliability of the sources, it is apparent that this interpolated data has added some information to the overall (uniformly rising) global trends analysis. (What it doesn't reveal, of course, is the trends in the status of individual stocks.) The period from 1950 to 1960 now appears as a lag phase in fishery development with the bulk of increases appearing in the boom years of the 1960s and 1970s. Clearly, some of the analyses are troubling and it is from this document that the public received wisdom that "60% (of stocks) need urgent management" may have been derived.

Much of this information (including a variety of other analyses) is also presented in the context of a generalised fishery development model that adopts four phases: undeveloped, developing, mature and senescent. The report concludes with a summary of trend analyses, conclusions and diagnostics, including analyses for demersal fish, overexploited marine resources, highly migratory and straddling resources, distant water fishery resources, the 200 major fish resources, by ocean and compared to the 1992 assessed state of stocks (see table 2).

This technical report made no attempt to suggest how to address the overfishing, management, socio-economic and development issues it identifies. It was, as its title specified, a chronicle of events and a summary interpretation of the trends that the extended time-series now reveals. At the level of

[18] Grainger R. and S.M. Garcia. Chronicles of marine fishery landings (1950-1994): Trend analysis and fisheries potential, FAO Fish. Tech. Pap. 359. Rome, FAO. 1996. 51p.

aggregation and detail that it represented, it might have been expected to be controversial in its conclusions. Nevertheless, it forms a key analysis that has contributed to setting the tone of further research. The implicit finding is that fish stocks are, or may soon be, or could be, unsustainable, if the patterns of 'development' exhibited from the 1960s onwards are continued. Avoiding an inexorable decline to an 'all stock overfished' classification in a future 'chronicles' based on the same form of analysis is what should focus fisheries research and management.

- **State of World Fisheries and Aquaculture**

The biennial Committee on Fisheries (COFI) receives a comprehensive report on the Status of World Fisheries and Aquaculture (SOFIA), prepared by staff of the Fisheries Department. The first 1996 SOFIA adopted an approach (repeated in 1998 and 2000) in which it first summarises a world review and then addresses specific issues. In 1996, it focussed on the state of marine resources, regional overviews and fishery activity by country groupings. In the 1998 SOFIA the sections on regional reviews and state of marine resources were replaced by an expanded attention to selected issues; two special studies on inland fisheries and on fishers and fishing fleets, and a much more detailed outlook. This change was made probably because the supporting series of reviews of world fishery resources (marine fisheries, inland fisheries and aquaculture) are sufficient for the purpose of resource and regional reviews (see below).

It may be expected that further editions will also adopt a similar format, first conducting a world review and then focussing on current issues at the time and on trend prediction. SOFIA covers all the main issues and is presented in a comprehensive manner with interesting focus articles (boxes) and clear graphics. Choice of issues beyond the 'standard' world review section appears to rest with the project team, though it is evident that current fishery issues receive the attention they deserve at this level. Agreement on the 'issues section' of SOFIA with external inputs, in addition to any instructions from COFI, would probably be useful.

FAO's Forestry Department prepares a similar report (State of the World's Forests, SOFO) in collaboration with external experts from institutions and corporations. It contains a world review section, a general issues section, a special section on UNCED follow up, and ends with forestry activities by regional economic group (equivalent to country grouping in fisheries). SOFO also contains a bibliography/reference list and summary data tables (country data, forest cover, production and institutional analysis). SOFO 1999 was collectively produced by an Internal Advisory Committee, which manages the process of planning and reviewing the document with contributions from a wide range of department staff members. In addition, SOFO has an External Review Committee of named experts who provide guidance in its production. These experts are not identified by country or institution, but are selected for their expertise and independence from FAO. It seems this practice is perceived to add weight to the content and opinion expressed in SOFO.

SOFIA might consider introducing a similar External Review Committee, partly to ensure that the structure, scope and content are accurate and responsive to current issues, and partly to demonstrate transparency and confidence in the interpretation and outlook that it offers. The next SOFIA might also include summary data tables in appendix that support the analyses presented in all sections and a bibliography as a standard feature. It is clear that SOFIA will remain a key mechanism to "inform policy-makers, participants in fisheries and civil society in an accurate and objective manner".

Table 2. Summary of analyses, conclusions and diagnostics. (from Grainger and Garcia 1996)

Type of analysis	Conclusions	Diagnostics
Trends in demersal fish		
▪ Overall decrease ▪ Sum of peaks minus present landings	▪ Production stable since the 1970s ▪ In 31% of the FAO areas: increases ▪ In 67% of the FAO areas: decreases ▪ Minus 5 million tonnes	▪ Hiding overfishing ▪ Largely due to overfishing ▪ Possible increase unknown ▪ Obtainable through management
Trends in overexploited marine resources		
▪ Overall decrease ▪ Sum of peaks minus present landings	▪ Minus 6 million tonnes since 1985 ▪ Minus 9 million tonnes overall	▪ Overfishing ▪ Overfishing
Trends in highly migratory & straddling resources		
▪ Highly migratory ▪ Straddling	▪ Still increasing ▪ Minus 2 million tonnes since 1989	▪ Some overfished ▪ Mainly overfishing of Alaska Pollock
Trends in 200 major fish resources		
(accounting for 77% of world marine fish landings)	▪ 35% resources overfished ▪ 25% resources fully fished ▪ 40% still developing	▪ 60% need urgent management
Assessed state of stocks in 1992		
(Garcia and Newton)	▪ 31% stocks developing ▪ 22% stocks overfished ▪ 44% stocks fully fished ▪ 3% stocks slowly recovering	▪ 69% need urgent management
Trends by ocean Possible additional production		
▪ Atlantic	▪ Fully fished in 1983 (21.106 t.)	▪ No further increase
▪ Pacific	▪ Fully fished in 1999 (25.106 t.)	▪ Insignificant increase (+1.106 t.) through development
▪ Indian	▪ Developing (5.4% 1 year, 23.106 t.?)	▪ Substantial increase (+16.106 t.) through development to be verified
▪ Mediterranean & Black Seas	▪ Developing (2.6% 1 year) (2.106 t.)	▪ Increase through eutrophication (likelihood unknown?)
Three estimates of global marine potential		
▪ World Ocean	▪ Fully fished in 1999 (+82.106 t.)	▪ Further increase unlikely
▪ Sum of oceans	▪ Developing (125.106 t.)	▪ Substantial increase (+17.106t.) depends on reliability of Indian Ocean estimate
▪ Sum of Areas	▪ Developing (+125.106 t.)	▪ Very substantial increase (+42.106t.) mainly from management and development. ▪ Highly unreliable.

- **Reviews of World Fishery Resources**

Marine Resources Review

The Marine Resources review is one of a series of three published either as Technical Papers or revised Fisheries Circulars. In the Marine Resources volume[19], FAO defines six status levels (plus unknown or uncertain) as follows in Table 3.

Table 3: Fishery status definitions

Status Code	Definition
U	*Under-exploited, undeveloped or new fishery.* Believed to have significant potential for expansion in total production.
M	*Moderately exploited, exploited with a low level of fishing effort.* Believed to have some limited potential for expansion in total production
F	*Fully exploited.* The fishery is operating at or close to an optimal yield level, with no expected room for further expansion.
O	*Overexploited.* The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk or stock depletion/collapse.
D	*Depleted.* Catches are well below historic levels, irrespective of the amount of fishing effort exerted.
R	*Recovering.* Catches are again increasing after a collapse from a previous high.
?	*Not known or uncertain.* Not much information is available to make a judgement.

Tables I to XVI of the latest review provide a general overview for each major ocean statistical area by species group, giving:

- the main fishing countries in1994;
- decadal average annual catches since 1950;
- the annual average catches from 1988 to 1994; and
- an assessment of the state of exploitation against the above status categories.
- the last, 'states of exploitation', may be single evaluations or also describe their direction, e.g. F-O means fully fished but tending to overfished. Table XVII provides the same for tuna and tuna-like species by ocean region.
- a summary of the global status of exploitation is given by each fishing area, by ocean and for the world.

This latter summary provides, for each area:

- estimated potential and the year it reached (or is expected to reach) this level;
- a score for reliability of the assessment (** reasonably reliable regression, * less reliable regression, Unreliable regression);
- latest 5 year average landings and the difference between this and potential yield (i.e. surplus available); and

[19] FAO, Review of the State of World Fishery Resources: Marine Fisheries, FAO Fisheries Circular No. 920, FIRM/C920(En),1997.

- a status code (O = Overfished, I = Increasing, F = Fully fished)

The non-comparability of these three status indicators with the status definitions in the above table may be deliberate because each region has a mix of stocks with various exploitation states. Although this is not explained, the status by area (with three status codes) is a general overview of fishery development status, not of stock status.

This Marine Resources review is held by Alverson and Dunlop[20] to be "perhaps the most comprehensive ever published by FAO". They analysed the FAO fisheries information through a process of disaggregation and application of "stressed stock scenarios". For each fishery, they classified all stocks, by area, according to three scenarios (effectively different combinations of the status categories) for both numbers of stocks and catch. They also summarised the catch trend directions for major FAO species groups between 1994 and 1995 as UP (increasing), DOWN (decreasing) or NO TREND (stable). According to their analysis some of the information in the Marine Resources review could be viewed in quite a different manner. They point out that "conflicting classifications in the state of a stock may reflect definition differences". Their analysis of previous FAO state of stocks reports also reveals inconsistencies between classifications and uncertainties about their definition, from report to report.

Alverson and Dunlop suggest improvements to FAO status of stock reports are required, given their accessibility by and influence on professionals and politicians that "use FAO status reports as a barometer of the health of the world fishery resources". Key to this is "a more formal international peer process to assist FAO in the classification of the state of marine fishery resources". The process of such assistance is addressed in Chapter 5.

Inland Fisheries Review

The most recent report on inland fisheries[21] provides a brief description of the global, continental and regional trends in catch, using output from FISHSTAT to present and analyse the trends. It does not repeat the more detailed country information offered by the previous report in 1995. For each region (also summarised by continent) country catches are graphed for the 1984-1998 period, and a short narrative indicates the rising, stable or declining trend in the fisheries.

The report then identifies and reports on global and regional issues and directions, including the degradation of the environment, directions (conservation and restoration, enhancements, recreational use, management), species introductions and stocking. It offers no quantitative or other appropriate qualitative indicators for these issues. Although the report provides a generally comprehensive, if brief, overview of inland fisheries, it does not address stock or resource status or trend issues, except to say,

"Food fisheries on wild stocks depending on natural reproduction and fertility continue in most of the larger rivers and lakes of the world. Such fisheries are generally at or exceed the limits of sustainable yield and corresponding shifts in fish community structure are occurring with risks of diminished production and damaged stocks."

The references contain only one to a paper identifying an actual stock assessment, although some of the referenced regional/species review documents and reports of meetings probably contain further references to stock assessments.

Aquaculture Review

The latest biennial report on aquaculture[22] provides a highly comprehensive and well presented view of aquaculture, declaring at the outset that it is not a natural resource and should not be classified along with the marine and inland fisheries resources reviews.

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[20] Alverson, D.L. and K. Dunlop. Status of World Marine Fish Stocks. November 1998, University of Washington, FRI-UW-9814

[21] FAO. Review of the state of world fishery resources: inland fisheries. FAO Fish. Circ. No.943. Rome, FAO. 1999.

[22] FAO. Review of the state of world aquaculture. FAO Fish. Circ. No.886, Rev 1. Rome, FAO. 1997. 163p.

The report begins with a global overview of production and production trends by region (and, where important, by country, e.g. China) and the relative changes taking place in contributions to global aquaculture by species groups (e.g. salmonids, shrimps, tilapias). It then offers a range of articles for selected developments and trends that are prepared by the Fisheries Department and external experts. Finally, the review offers standard format articles describing regional assessments (with China separate, because of its importance). Each of the articles and regional reviews has a reference list.

With regard to the information upon which the report is based, no examination of the provision of information on aquaculture statistics is offered, other than to say that quality has improved from some countries, and that there are ongoing efforts to resolve the limitations in data submission identified in the previous version of the review. No general statistical tables of production are included, although the trends analyses offered in all sections are graphed clearly and appropriately. It is clear that this 'review' is precisely that, and does not attempt to catalogue all activities and issues in aquacultural production.

- **Reporting under resolutions, agreements and international plans of action**

General Assembly

FAO is required by the United Nations General Assembly (UNGA) resolution 52/28 (26 November 1997) to report on the implementation of 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.

This UN Fish Stocks Agreement (UNFSA) is likely to enter into force some time in the near future. In the meantime, the actions taken by FAO, regional fishery bodies or arrangements, and States, are reported by FAO biennially to UNGA. One of the most significant aspects of this process with regard to status and trends reporting in fisheries is the international agreement to promote the International Plan of Action for the management of fishing capacity, which receives particular attention in the UNGA report. That report goes further: When considering some of the issues raised in the UNFSA, it also addresses the same issue in the FAO Compliance Agreement and the Code of Conduct for Responsible Fisheries in which the problems of fishing capacity feature significantly.

All agreements and resolutions on fishing capacity recognise the need to address a range of issues. Indeed, information forms a key element of the Plan of Action for the Conservation and Management of Sharks and for Reducing Incidental Catch of Seabirds in Long-line Fisheries. Fishing capacity is addressed further below.

Fishing Capacity Status and Trends Reporting

Current global fishery status indicates clearly that, whatever the accepted limits are on global fish stock potential yields, many of them are subject to uneconomic and/or biologically unsustainable fishing effort.

Sustainability in fisheries is a general public objective; but sustainability, in itself, has different definitions depending on the fishery objectives. It may be that an objective for the fishery is maximisation of production from the ecosystem, and that this actually requires altering the structure and balance of the components, say by reducing predation mortality. To others, an objective might be to try to maintain the ecosystem in as near a pristine state as possible, maintaining biodiversity and the 'natural' relative composition and population dynamics of the biota. In practice, sustainability is a mixture of a several objectives. Since some of them are clearly conflicting it is necessary to seek compromises. The concept of maximum sustainable yield has been used as a primary basis for sustainability[23], but recognising that there are other objectives that affect fishery dynamics, as against just stock dynamics, alternative targets or limits are being developed. Indeed, in some regions and fisheries the failure to properly implement sustainable management by output controls through TACs

[23] It is the only explicit reference point in UNCLOS.

and quota management is prompting fishery managers to move towards input control through the management of fishing capacity.

Nevertheless, there will always be a need first to determine what stocks are available, what are their productive capacities and what their likely responses to fishing removals will be, i.e. stock assessment. The next task is to determine the ways in which removals are undertaken. Matching the appropriate machinery to the task that ensures sustainability is the key issue. Understanding the status and trends of fishing fleets at the stock, species, region and global levels is thus extremely important. The International Plan of Action on management of fishing capacity identifies three phases to the plan. In Part III - Urgent Actions, the IPOA calls on States (and implicitly their Regional Fishery Bodies) as follows in Table 4.

Table 4. IPOA-CAPACITY - Section I: Assessment and monitoring of fishing capacity

(*Note: bold emphasis added)*

Measurement of fishing capacity
11. States should support coordinated efforts and research at national, regional and global levels to better understand the fundamental aspects of issues related to the **measurement and monitoring of fishing capacity.**
12. States should support the organization by FAO of a technical consultation to be held as early as possible in 1999 on the **definition and measurement of fishing capacity and the subsequent preparation of technical guidelines for data collection and analysis,** noting that the result of this consultation should provide specific guidance for preliminary assessments of fishing capacity and excess fishing capacity at national, regional and global levels.
Diagnosis and identification of fisheries and fleets requiring urgent measures
13. States should proceed, by the end of 2000, with a preliminary **assessment of the fishing capacity** deployed at the national level in relation to all the fleets of principal fisheries and update this assessment periodically.
14. States should proceed, by the end of 2001, with the systematic identification of national fisheries and fleets requiring urgent measures and update this analysis periodically.
15. States should cooperate, within the same time frame, in the organization of similar preliminary assessments of fishing capacity at the regional level (within the relevant regional fisheries organizations or in collaboration with them, as appropriate) and at the global level (in collaboration with FAO) for transboundary, straddling, highly migratory and high seas fisheries, as well as in the identification of regional or global fisheries and fleets requiring urgent measures.
Establishment of records of fishing vessels
16. States should support FAO in the development of appropriate and compatible **standards for records of fishing vessels.**
17. States should develop and maintain appropriate and compatible **national records of fishing vessels, further specifying conditions for access to information.**
18. While awaiting the entry into force of the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (Compliance Agreement), States should support the establishment by FAO by the end of 2000 of an **international record of fishing vessels operating in the high seas**, following the model indicated in the Compliance Agreement.

The elements for the plan that address the information issue are as follows:

Monitoring and information sharing
27. Pursue regular assessment of fleets and fishing capacity very much in the same way as routine stock assessment is being conducted.
28. Develop and maintain appropriate and compatible national registers for fishing vessels, further specifying standard registration methods and access conditions to information, and to monitor fleet evolution on this basis.

29. Promote appropriate global monitoring and information systems, with emphasis being given to:
▪ developing an international register of larger fishing vessels;
▪ enhancing regional and international cooperation in the measurement and monitoring of fleets, especially for fleets which operate across national jurisdictions (directly or indirectly), in particular for high seas (tuna) vessels; and
▪ developing indicators and monitoring fishing capacity on this basis.
30. Address, with the assistance of FAO in particular, the need to:
▪ prioritize data need for the monitoring of fishing capacity;
▪ harmonize, at the international level, measures for the tonnage and horse-power of fishing vessels;
▪ improve statistical coverage at international level, in particular for fleets, catch, price, and trade, with due emphasis being given to timeliness; and
▪ develop some information sharing mechanisms to which countries could contribute on a voluntary basis, based on a common process to be adopted for reporting information.
31. Promote the creation of networking arrangements for further work and information sharing on fishing capacity issues.
32. Promote, with the assistance of FAO, the exchange of information on flag of convenience vessel activity.
33. Provide FAO with data on the catches of their flag vessels in high sea areas adjacent to the area under their national jurisdiction, so as to permit a truer estimate of high sea catches.
Training
34. Develop standard training tools, especially methods and computer software for measuring, monitoring, and regularly assessing fishing capacity.
35. Provide for training and implementation programmes in relation to regular assessment of fishing capacity.
36. Support human development and institutional strengthening in developing countries on all issues related to the management and effective control of fishing capacity.

The detail given above is provided in this Circular mainly because the scope of requirements is both large and new, and they need addressing quickly and appropriately. The above list of essential or desirable actions by the international community and FAO boils down to 4 key issues:

- DATA - increase the scope and coverage according to priorities, against accepted standards and through clear indicators.
- INFORMATION - improve the analysis and timely transmission of information based on a common standard.
- SYSTEM - create registers, arrangements for networking and communication.
- DEVELOPMENT - devise and introduce methods, standards and styles for communicating information, and undertake training in their use.

Almost every international fishery instrument – and the national laws that are being configured to meet their requirements – contains exhortations and mechanisms to improve the quality and quantity of information on fishing capacity. Activities are proceeding in this area, including the conduct of an FAO review on the management of fishing capacity in which calls were made, and some solutions given, for:

- better definition of what fishing capacity is and how it can be measured;
- how optimal capacity might be defined and measured;
- how to develop and monitor indicators of stock fishing capacity, target fishing capacity, limit fishing capacity;

- how to calculate fishing capacity indicators in relation to stock size, as an indicator of over-capacity and for multi-fishery fleets.

As with other areas of international effort at this time to investigate the best ways of approaching the CCRF, the work on fishing capacity remains problematic. In November 1999, FAO took the next steps in the above group of tasks by convening a further working group to address the key issue of how to measure it.

Chapter 4. National, Regional and International Organizations

4.1 Introduction

The review reported in this circular could not cover all institutions that report on fishery status and trends. However, it seeks to identify the common framework that institutions use for such reports, if possible. In the first instance, therefore, it is necessary to select institutions according to their level of responsibilities and reporting activities. By reviewing example institutions it may be possible to determine whether these classes have common approaches to reporting within their political setting. The following classification (Table 5) of fisheries institutions has been adopted.

Table 5: Types of institution in this analysis

Scope	Example	Fisheries reporting on -
Global	FAO, **UNEP**	Global issues to the United Nations
Ocean/ocean region	**CCAMLR**, GFCM, FAO regional organisations	Regional issues to member states
Species group	**ICCAT, NASCO**, IWC, IOTC	Species issues to member states
Regional research organisation	**ICES**, **SPC**, PICES	Scientific assessments to member states and clients
Regional management organisation	**NEAFC**, NAFO, FFA, IATTC	Scientific and management issues to member states
Economic group	**OECD**, CEC	Scientific and management issues to member states
National Agency	e.g. **NMFS** (United States), **AFMA** (Australia), **MFMR** (Namibia), **MoF** (NZ)	Scientific and management issues to national government
State Agency	e.g. (US Region) Fishery Management Council	Scientific and management issues to state government

4.2 Institutional analysis

The following institutional analysis provides a very general review of the example institutions highlighted in the table above. These reviews are generally brief and necessarily incomplete. FAO itself is reviewed in Chapter 3 above. They serve as a general guide only, focussing on their roles, required information and data sources, and the research and review procedures they adopt in meeting their objectives.

- **United Nations Environment Programme - UNEP**

UNEP produces the authoritative Global Environmental Outlook, the most recent of which was published in September 1999 as GEO2000. That document contains analysed fisheries data, mostly obtained through FAO. It integrates this information with what is held by other organisations and institutions to prepare an overview summary.

The GEO 2000 report states that “The global marine environment catch almost doubled between 1975 and 1995, and the state of the world’s fisheries has now reached crisis point. About 60% of the

world's fisheries are at or near the point at which yields decline." From this global doomsday vision, UNEP's report then moves to specific evidence (somehow given equal prominence with global issues) in a headline on the small, albeit troublesome issue of "The Patagonian toothfish, *Dissostichus eleginoides* (which) is being severely overfished."

The GEO report also makes the following general analyses:

- More than half the world's coral reefs are potentially threatened by human activities, with up to 80 per cent at risk in the most populated areas.
- Expansion of coastal settlements, industrial growth and increased fishing activities have placed enormous pressures on coastal ecosystems and have degraded marine and coastal resources.
- Most stocks of commercially exploited fish in the North Sea are in as serious condition - the North Sea fishing fleet needs to be reduced by 40% to match fish resources.
- A large decrease in marine fisheries catch is expected as a result of the 1997-98 El Nino.
- Fish stocks off the east coast (of North America) have nearly collapsed. The Atlantic finfish catch declined from 2.5 million tonnes in 1971 to less than 500 000 tonnes in 1994.
- Conservative estimates put the annual albatross mortality from fishing in the Southern Ocean at 44 000; similar problems exist in the Arctic.
- The reported legal catch of Patagonian toothfish in the Antarctic was 10 245 tonnes whereas the illegal catch was estimated at more than 100 000 tonnes in the Indian Ocean sector of the Southern Ocean alone.

It is inevitable, given the general state of the environment in all areas, that the report focuses on these problems and constraints and, in consequence, the position of fisheries is presented as difficult and getting worse. Nevertheless, information on fishery status and trends by FAO will remain a primary source of information for UNEP, and therefore it is necessary that FAO present information in a way that ensures UNEP can integrate this appropriately. The problem will always remain that aggregating both analysis and opinion will lead to short statements that cannot contain both the downside and the upside; that, in addition to fishery declines, there is a growing group of fisheries worldwide where rational management practices are having desirable impacts.

- **Commission for the Conservation of Antarctic Marine Living Resources - CCAMLR**

The Commission for the Conservation of Antarctic Marine Living Resources was one of the first organisations to be established "*under an international convention based on an ecosystem-wide approach to the conservation of marine living resources in the Southern Ocean, with conservation defined to include rational use. The conservation principles set down in the Convention require that exploited populations must not be allowed to fall below a level close to that which ensures their greatest net annual increase, depleted populations must be restored to such levels, and the risks of changes to the marine ecosystem that are not potentially reversible over two or three decades must be minimised. Importantly, ecological relationships between harvested, dependent and related species must be maintained..*"[24] It is widely held to be one of the most advanced organisations of its kind in the world. It provides a forum for agreement on the use of living marine resources within the scope of the Antarctic Treaty. Through its scientific committee it establishes the basis for scientific research and stock assessment which is then used by the Commission to set management rules for the conduct of fisheries.

[24] From: Coordinating Working Party on Fisheries Statistics: CCAMLR's statistics in support of the precautionary approach: CWP Eighteenth session 6-9 July 1999, Luxembourg.

CCAMLR has adopted a precautionary approach to the management of the Antarctic marine ecosystem. This includes monitoring and managing fisheries and the ecosystem of the Southern Ocean; monitoring marine debris and their impact on marine animals; and reducing the interaction between fisheries and non-target species including seabirds and fish by-catch.

CCAMLR's precautionary approach uses data sources, as follows:

- fishery catch and effort data provided by Member Countries conducting fishing in the Convention Area;
- biological information and information on by-catch of fish and incidental mortality of seabirds and marine mammals collected by scientific observers during fishing operations;
- fishery-independent information obtained from surveys; and,
- biological information on indicator species and environmental data collected under the CCAMLR Ecosystem Monitoring Program.

Reports of the status and trends of fisheries from the Scientific Committee are made widely available directly on the Internet as complete texts but would benefit from summarisation and improved presentation.

- **International Commission for the Conservation of Atlantic Tunas - ICCAT**

ICCAT covers all tuna and tuna-like species, i.e. highly migratory species as defined in the annex to UNCLOS, across the entire range of the Atlantic Ocean and adjoining seas. It conducts and coordinates tuna research on behalf of its members. It also develops management advice and provides a mechanism for contracting parties to agree on management measures, including TACs, size limits and other measures. (This review conducted a specific study of the work of ICCAT, the results of which are at Appendix 2b).

- **North Atlantic Salmon Conservation Organization - NASCO**

NASCO covers all salmonid species, i.e. anandromous species, across the entire range of the North Atlantic Ocean and adjoining seas. It is a management organisation with no direct research capacity. It contracts advice from ICES from whom it receives status and trends reports.

- **International Council for the Exploration of the Sea - ICES**

ICES is the oldest international fisheries research organisation, founded in 1901. Its mandate is to conduct scientific research on behalf of its members and clients, and to offer conservation and fishery advice. It advises NEAFC, IBSFC, NASCO and the EU (CEC). (This review conducted a specific study of the work of ICES, the results of which are at Appendix 2a.)

- **Secretariat of the Pacific Community - SPC**

This organisation (formerly the South Pacific Commission) maintains many programmes of interest to its members, principally in Oceania and Australasia, but also including some Pacific rim countries and some countries (France, UK, US) with dependent territories in the region. For many years SPC has maintained a highly respected tuna research organisation within an Oceanic Fisheries Programme covering the Western and Central Pacific Ocean. Over the years it has conducted specific research programmes (Skipjack Tagging Programme, Tuna and Billfish Programme) through which stocks

assessments are made public. It now publishes a key status and trends document[25], which provides a standard presentation for each fishery and each species.

The foundation of its authority in tuna research is the agreement by member States to provide SPC with logsheet data from all fleets operating in the region. The members States participate in a regular review of tuna stock status through a Standing Committee on Tuna and Billfish.

- **Northeast Atlantic Fishery Commission - NEAFC**

This organisation operates under the Convention on Future Multilateral Co-operation in North-East Atlantic Fisheries established in 1980. It functions to set management measures governing the conduct of fisheries by its members. In doing this it seeks "Such information and advice … including information and advice on the biology and population dynamics of the fish species concerned, the state of the fish stocks, the effect of fishing on those stocks, and measures for their conservation and management" from the International Council for the Exploration of the Sea.[26]

The Commission accordingly undertakes no research, nor does it publish status and trends of stocks. It limits its advice to recommendations to members on regulatory measures. In 1998, Recommendation 4 - Relating to Notification and Reporting Requirements, etc by Vessels Fishing in the Convention Area, became effective, which required appropriate reporting procedures (weekly reporting of operations and catches, and catch logbooks) from national authorities according to national regulations.

- **Organisation for Economic Cooperation and Development - OECD**

The OECD maintains a Committee for Fisheries, which prepares an annual Statistical Review. In 1998, the committee published guidelines for the statistical review that noted the need for:

- Links with FAO statistical requirements and the work it is doing on indicators.
- Maintenance of tables concerning fisheries policy and management, including on the identification and application of appropriate performance indicators.
- Inclusion of information on economic and ecological variables, including value of research, financial transfers, structural adjustment and status of fish stocks.
- Environmental outlook, in particular on by-catch reduction, and the identification of measures taken in response to conservation requirements of international agreements.

Accordingly the OECD recommended that its members should prepare the following list of reporting tables annually, and that this data would be used in the preparation of a biennial OECD Review of Fisheries.

- TACs and allocations
- Government Financial transfers
- National landings in domestic ports
- National landings in foreign ports
- Foreign landings in domestic ports
- Production from Aquaculture
- External trade (overview)

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[25] The Western and Central Pacific Tuna Fishery: Overview of the Fishery and Current Status of Tuna Stocks. Oceanic Fisheries Programme, Secretariat of the Pacific Community, August 1999.

[26] Article 14. Convention on Future Multilateral Co-operation in North-East Atlantic Fisheries, 1980.

- Imports by product (6-digit code)
- Exports by product (6-digit code)
- Imports by major product group and country
- Exports by major product group and country
- Fleet capacity and gear use
- Employment in harvesting and post-harvesting

- **United States National Marine Fisheries Service - NMFS**

The availability of information from NMFS is enormous. Significant efforts have been taken to establish the new directions in international fisheries management within the legal and administrative frameworks of the US. Many of the issues thus addressed have relevance to, and are being mirrored in, other organisations, in particular the issues of definitions of fishery performance indicators, including those relating to stocks status and trends. (This review conducted a specific study of the work of NMFS, the results of which are at Appendix 2c.)

- **Australian Fisheries Management Authority - AFMA**

Framework of reporting

The Australian Fisheries Management Authority (AFMA) is the Commonwealth statutory authority responsible for ensuring the sustainable use and efficient management of Commonwealth fishery resources on behalf of the Australian community and key stakeholders.

The AFMA Annual Report for 1997-98 contains short summary reports against the three key legislative objectives relating to "*ecologically sustainable development, maximising economic efficiency and ensuring accountability to the fishing industry and the Australian community",* for each fishery managed by AFMA. Where applicable, specific reports have also been made against the "*efficient and cost effective fisheries management objective"*.

The report contains a series of tables that provide an overview of each fishery managed by AFMA and includes a summary of the management methods used, the type of fishing concessions granted to eligible operators and the status of the stock in each fishery. The status of stocks section 1) identifies the management target or reference point used for that fishery or stock components of it (such as MSY, CPUE decline or other attribute); 2) identifies whether they have been exceeded; and 3) describes what measures have been taken and/or should be taken to meet the legislative objectives. In general, the status is explained in narrative terms without the use of formulae or illustration of control rules.

Stock assessment practices

These are undertaken by Fishery Assessment Groups (FAGs) with the following characteristics:

- They are independently chaired with invited scientists, management representatives (usually AFMA staff), industry and environmental institution representatives, government department and/or NGOs.
- They conduct their own internal peer review (they are often the core expertise in a fishery in Australia) unless there is wide uncertainty about an estimate, when an independent peer review is commissioned. Occasionally strong resistance to the results (in particular the management response to the scientific advice) from industry may result in appointment of an 'offshore' independent review. Choice of peer reviewer is the basis for confidence in the process.
- Results of the FAGs and reviews achieve transparency by very wide dissemination.

Research Project practices

All research is contracted out by AFMA, which maintains no scientific staff. Management of the process is through the Fisheries Research and Development Corporation. An External Review process evaluates proposals for research. Results of research are subject to scientific peer review, usually by one independent scientist; and/or review by the FAG that commissioned it; and/or by a management review by the fishery manager about quality, timeliness and usefulness. It is intended to commission periodic strategic reviews of research undertaken (by fishery) every 3-5 years to examine the package of research that has been undertaken or may be intended, and to identify the gaps that require filling.

- **Namibia Ministry of Fisheries and Marine Resources - MFMR**

The Ministry of Fisheries and Marine Resources conducts its fisheries management mandate within the scope of a new Sea Fisheries Act (Aquaculture and Inland fisheries are to receive separate attention). The National Marine Information and Research Centre within the Ministry's Directorate of Resource Management undertake scientific research. The directorate issues a quarterly report[27]. This report is designed for wide communication of fishery conditions and includes catch trends and biomass trends for each major TAC-controlled species, including hake, horse mackerel, orange roughy, monk, red crab, rock lobster, seals, tuna and others.

Detailed stock and trend assessments are presented, along with yield advice and other management measures, to the statutory Sea Fisheries Advisory Committee. This is a body appointed by the Minister under legal guidelines to include a wide range of interests, including from the industry, academia, and other government departments. This committee reviews all evidence and sends recommendations on TACs to the Minister for onward submission to and approval by Cabinet.

The Ministry is developing a wider approach to the development of its functions through the formulation of mechanisms for working group activities on stock assessments and management. The Deep Sea Fisheries Working Group (comprising all interested parties) was recently established at the onset of a new fishery for orange roughy and plans are to extend this activity to other fisheries. As part of the process of developing information for management the Ministry has completed the first phase of an integrated Fisheries Information Management System (FIMS). This covers the management of rights-holders, quotas, licences, landings returns and logsheet data. In addition, a confidential annual fishery statistical survey database on companies (income, expenditure, employment, shareholding) is in operation. Further additions to these core functions will add biological, oceanographic and compliance reporting functions to FIMS.

- **New Zealand Ministry of Fisheries - MoF**

All research activities required to support the Minister in his decisions about TACCs (Total Allowable Commercial Catch) and other regulatory measures are conducted through a process of competitive bidding. The bulk of the expertise resides within the former research branch, which is now part of NIWA (National Institute of Water and Aquatic Research). The key element of transparency and objectivity in stock status and trend research mirrors patterns developed elsewhere, i.e. through the conduct of working groups. The process follows:

Research and Stock Assessment Planning

A rolling strategic framework and directions for fisheries research document is developed and distributed to stakeholders for comment. This document sets the directions for fisheries research contracted by the Ministry of Fisheries for the next 5 - 10 years. In addition rolling 3 - 5 year medium term research plans are developed for the key orange roughy, hoki, rock lobster, and snapper fisheries.

[27] The State of the Marine Environment and the Commercially Utilised Living Marine \Resources, Directorate of Resource Management, Ministry of Fisheries and Marine Resources.

These form the basis for medium to long-term research planning by the Ministry. Proposals for research projects are developed after an extensive consultation and priority setting process with stakeholders at the regional and national levels. The end result of this process in 1997-98 was a total of 60 research projects that were input into the formal consultation on the Nature and Extent of Fisheries Services.[28]

Contracting and Review

The Ministry seeks bids and decides on contractors for the conduct of the research through a tender review process in which applicability of methods, etc, is reviewed (first level of review). Contractors such as NIWA conduct internal peer-review prior to submission to a Stock Assessment Working Group; their review follows guidelines similar to journal submission (second level of review).

Formerly, working groups consisted of scientists, managers, industry and advocacy groups, etc who conducted peer review of research; this is now limited to science providers (including some external to NIWA - sometimes competitors), plus industry consultants (third level of review).

Annually, all fish stock assessments are prepared into a single plenary report for publication which contains fishery status and trends. The Minister uses the information following extensive consultation with stakeholders (fourth level of review), via final advice papers on the review of sustainability, to adjust the Total Allowable Catch, catch limits and other management measures.

4.3 Summary

The reporting requirements and the research methods to obtain information established within fishery institutions vary considerably. For reasons that probably reflect the capacities, requirements and focus of the institutions, few of the institutions examined have similar content, style or framework for their reporting, and in some there is also no consistency between years for the same organisation. These issues are addressed in more detail in the Chapter 5, and it is apparent that some require further attention to:

- the precautionary approach;
- consideration of fisheries in the widest context, including, as appropriate, ecosystems and the environment, fishing operations and economics, management approaches; and
- the nature of the analyses that stem from research, including issues related to confidentiality and transparency, methodologies and peer review.

[28] Annual Report of the Ministry of Fisheries, New Zealand, 1998.

Chapter 5. Approaches to Meeting Information Standards, Quality and Accessibility

5.1 Introduction

The purpose of the discussions below is to draw attention to and provide background on key issues that affect status and trends reporting now and in the future, including,

- issues that need to be addressed by such reports, including reporting on precaution, indicators, risk and the place of fisheries within the ecosystem;
- frameworks for fishery information, sustainability analysis and communications;
- standards that should be applied, including uncertainty, data quality reference and definitions;
- quality assurance and how this might be addressed within institutions;
- working groups as a means to provide quality assurance; and
- practical approaches to improving fishery information and reporting.

5.2 Status and trends reporting

- **Definition of status and trends**

The dictionary definitions of status and trends are as follows:

> **status**, noun - a state of affairs; condition; position; importance; standing; rank;.
>
> **trend**, noun - a general tendency, a prevailing direction.

If these definitions of **status** are applied, fisheries are generally considered to be in a sorry *state of affairs* and their *conditions* are poor. Although their *position* and *importance* is high, since more people get their animal protein from fish than from any other form, in most economies the *standing* of fisheries is relatively low. In contrast the status of fisheries is generally *rank*ed high on the international oceans and global environmental agenda. Also applied to fisheries, the question related to the **trend** is: Is the *general tendency*, the *prevailing direction* getting worse?

The status of a fishery means different things depending on the issue under description. For a national statistics office, a fishery's current status may be estimated in relation to its contribution to GDP, or to export earnings, or to employment. For a fishery manager, a fishery's status might be the catch or landing in relation to long-term sustainable yield; or the situation against a national fisheries development target; or on the level of compliance with regulatory measures. Stock assessment scientists most often consider the status of the biological population in relation to some norm (target, limit, threshold) such as MSY, total mortality, minimum spawning stock biomass or yield per recruit. For politicians, fishery status might be described in relation to commitments made nationally or internationally regarding responsible stewardship, both in terms of fish stocks and their fisheries but – increasingly important today – also in terms of the environment and its ecosystems, including biodiversity. A fishing community or fishing industry would be more interested in the status of their fisheries as measured by profits, capital and human resources employment, or infrastructure development.

These are thus the views of the various participants in the fishery sector, from the resource users, through the technical and management personnel to the policy makers, but the wider general public is also increasingly aware of environmental and renewable resource concerns. They need to know what is the status overall, and they require answers to the following key questions. Are the custodians and stewards of fishery resources:

- honouring their commitments and plans?;
- preventing over-fishing while rebuilding stocks and ensuring sustainability?;
- rationally managing stocks and their utilisation?;
- controlling access in equitable and appropriate ways?; and
- getting better at predicting the effects that current actions today will have on these issues in the future?

One method that has potential for evaluating fisheries is the rapid appraisal framework, which should be further developed but is in its infancy (see Pitcher, 1999)[29] In all circumstances, however, it is now accepted that environmental exploitation critically needs to be approached with an appropriate degree of precaution.

- **Precautionary approach**

The precautionary approach stems from acceptance that environmental exploitation must recognise risk and that precautionary reference points need to be established[30]. It has been embodied in the Code of Conduct for Responsible Fisheries (Article 7.5), and forms a key part of the UN Fish Stocks Agreement (Annex II).

As an example of the efforts being made to address this issue, the Working Party on the Precautionary Approach at the 11th ICES Dialogue Meeting[31] concluded:

"The PA (precautionary approach) will be included in all advice in the future;

- Reference levels and risk levels have to be decided by the managers based on scientific evidence, and all stakeholders have to be involved in this process and in establishing harvest control rules (HCR);
- Annual TACs have to be set in the context of medium and long-term projections on different assumptions, given within confidence limits;
- Movement towards medium-term projections might alleviate the pressure on the scientists and shift focus away from the present annual TAC calculations;
- The present advice from ICES only gives information on a restricted part of the environment. In the future, the PA will make heavier demands on other parts of the ecosystem; and
- The Working Group raised the question of who should take care of bringing the fishers into the process, and also about ICES role in disseminating knowledge and information about stocks and fisheries and the advisory process to the general public."

In these short statements lie the range of decisions and actions that ICES and its partners and clients will undertake with regard to the precautionary approach. In summary ICES recognises; the involvement of stakeholders; establishing harvest control rules; diagnosis and prediction with risk; separating science from management; ecosystem approach; and the process of communication with the general public.

Many regional fishery bodies are addressing the precautionary approach similarly. For example, in 1998 the Council of NASCO adopted the Agreement on the Adoption of a Precautionary Approach, which lays out in some detail the practical measures the parties will take to satisfy this commitment.

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[29] Pitcher, T.J. (1999) Rapfish, a rapid appraisal technique for fisheries, and its application to the Code of Conduct for Responsible Fisheries. FAO Fisheries Circular No. 947: 47pp.

[30]United Nations Conference on Environment and Development UNCED Agenda 21, Chapter 40: Information for decision-making.

[31] Report of the 11th ICES Dialogue Meeting on the Relationship between Scientific Advice and Fisheries Management, ICES Coop. Res. Rep. No:228, January 1999.

- **Fishery status and fishery performance indicators**

Measuring status, and over time describing trends, requires the establishment of appropriate indicators. In 1998, FAO conducted an Expert Consultation on the development of FAO Technical Guidelines for the Routine Collection of Capture Fishery Data[32]. The Guidelines define fishery performance indicators within a framework as follows:

- Fishing and Operational Indicators
- Biological Indicators
- Economic Indicators
- Socio-cultural indicators

The document describes a very practical approach to the process;

- deciding what performance indicators should be estimated and the variables required to develop the indicators;
- assessing what data is needed to estimate the variables; and
- evaluating how to go about getting such data and storing it for analysis.

It provides no detail on the analyses required but concentrates appropriately on the fundamental issue of data collection itself.

In January 1999, Australia and the FAO conducted a Technical Consultation on Sustainability Indicators in Marine Capture Fisheries, which has resulted in the preparation of FAO Technical Guidelines for the Development and Use of Indicators for Sustainable Development of Marine Capture Fisheries[33]. The latter develops a Sustainable Development Reference System with indicators around 4 dimensions:

- Ecosystem (Environment and Resource)
- Social
- Economic
- Institutions/Governance

The preparation and reporting of indicators now forms part of the required participation of States in the work of the Commission for Sustainable Development (CSD). FAO also contributes to the CSD through the Inter-Agency Committee on Sustainable Development, and has so far provided full description of the key indicator, Maximum Sustainable Yield, now available on the CSD website. Work is in progress for the description of other fishery performance indicators.

- **Incorporating risk and ecosystem-based approaches in fishery analysis**

Risk

There is an increasing trend towards simple conceptual models of status, which include indicators of uncertainty in stock assessments. Fishery status and management criteria under the precautionary approach are being more precisely defined, leading to a clearer distinction between scientific advice and management decision-making. These trends need to be reflected in information management and modelling in all analytical areas, not just stock assessment.

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[32] Guidelines for the Routine Collection of Capture Fishery Data. FAO Fisheries Technical Paper No.382, Rome, FAO. 1999. 113p.

[33] Indicators for sustainable development of marine capture fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 8. Rome, FAO. 1999. 68p.

An important change in stock assessment methods is away from point estimates to estimates described by probability (or diffuse) variables, such as the *pdf* (probability density function) calculation. These are now being extensively used in the United States (see the example control rules in Appendix 2c, extracted from NMFS Report to Congress) and its use in risk assessment. Fisheries management is the management of risk, where uncertainties play a central role in making decisions (see further in section 5.4).

Ecosystem

The scientific domain of ecosystem assessment is still in its infancy, but is becoming recognised as a key approach, not the least in the conclusion of the Committee on Ecosystem Management for Sustainable Marine Fisheries of the US National Research Council which noted, however, "that a significant reduction in fishing mortality is the most comprehensive and immediate ecosystem-based approach to rebuilding and sustaining fisheries and marine ecosystems". That Committee also raised uncertainty throughout its deliberations, and reported:

"Fisheries are managed in an arena of uncertainty that includes an incomplete understanding of and ability to predict fish population dynamics, interactions among species, effects of environmental factors on fish populations, and effects of human actions. Therefore, successful fishery management must incorporate and deal with uncertainties and errors. Management incentives and institutional structures must counteract (short term benefit) responses to uncertainty that jeopardise sustainability"[34].

It is clear that there is a growing recognition and practice for reviews of fishery status and trends to incorporate environment information, including biodiversity and other ecosystem characteristics (stability, resilience, etc.), in their commentaries together with their uncertainties and risks, and where possible to take these into account in their assessment.

5.3 Frameworks

Consideration of the frameworks in which research and continuing assessment of fisheries should be conducted will inform and guide practical research programmes aimed at fishery assessment. There are a number of frameworks to bear in mind.

- **Information framework**

There are generally four groups of information required for the proper conduct of fishery management: 1) Resource, 2) Fishery, 3) Socio-economic and 4) Monitoring, Control and Surveillance. In addition, different information is required at three general but interacting levels in the fishery management process: *Level 1:* Policy-making, *Level 2:* Formulation of Management Plans and *Level 3:* Implementation of Management Plans.

Table 6 describes the fishery information requirements by information group and then by each of the above levels. These have been adapted and summarised from FAO Guidelines for Responsible Fisheries no. 4: Fisheries Management as in Table 6 below.[35]

[34]Sustaining Marine Fisheries. Committee on Ecosystem Management for Sustainable Marine Fisheries. National Research Council (US) Ocean Studies Board. National Academy Press, US. October 1999. ISBN 0-309-05526-1

[35] FAO Guidelines for Responsible Fisheries No. 4: Fisheries Management. Rome, FAO. 1997.

Table 6. Information requirements for fisheries management

(Note: In general, where an item is marked with * this means the information may be optional; otherwise the information is desirable or required.)

1. RESOURCE INFORMATION
Level 1: POLICY MAKING
• Summary of recent landings by fishery • Summary of potential yields by fishery, with options for possible alternative approaches • Probable inter-annual variability in yield and any likely long-term trends in productivity • Details of environmental constraints and sensitive habitats • Details on any international agreements which affect the fisheries
Level 2: FORMULATION OF MANAGEMENT PLANS
• Historical and current catch data (in weight or numbers), including directed and by-catch and discards, for fishery and fleets • Size and/or length composition of catch per fleet • Sex and maturity composition of catch per fleet * • Time, date and locality of all catches * • Fishery independent biomass estimates • Results of stock assessments indicating potential yields and resource status under different harvesting strategies • Annual estimates of number of recruits entering the fishery * • Stomach contents data for knowledge of trophic relations * • Data on mass of species consumed per predator and feeding preferences of predators) * • Time series of indices of environmental characteristics (e.g. sea surface temperature) *
Level 3: IMPLEMENTATION OF MANAGEMENT PLANS
• Most recent data on indices used in management procedure (e.g. catch, CPUE, biomass, etc) • Information on biological or environmental features which could affect interpretation of indices • Information on any unexpected event related to the stock (e.g. unusual recruitment, natural mortality, environmental condition) which could warrant departure from management procedures • Status of stock in relation ton trends anticipated in the management plan

2. FISHERY INFORMATION
Level 1: POLICY MAKING
• Summary of types of fishery and fleet and gear characteristics for each fleet • Number of fishing units for each fleet, at present • Extent and importance of recreational fisheries, where applicable • Key fishing grounds and their characteristics • Summary of number and distribution of landing sites • The impact of fishing gear and practices on the environment and on the ecosystem • Details of the costs of fishery management
Level 2: FORMULATION OF MANAGEMENT PLANS
• Gear used by different fleets and knowledge of its selectivity • Number of fishing units (e.g. vessels and fishers) in each fleet • Numbers and localities of landing sites and fishing units operating from or landing at each site • Total effort for each fleet • Relative fishing power for each unit • Area fished by each fishing fleet • Detailed characteristics on equipment per vessel which could influence efficiency (e.g. GPS, etc) * • Mass of catch by commercial size category * • Implications for each fleet for range of management approaches • Comprehensive data, per catch, on effort used, exact position, depth fished and other data relevant to characteristics of the catch for each fleet *

Table 6 Continued

Level 3: IMPLEMENTATION OF MANAGEMENT PLANS
• Total catch and effort data for the fishery or, if heterogenous, per fleet • Unusual features of fishery or fleet behaviour which could influence interpretation of stock indices used in the management procedure • Changes in fishery or fleet composition which could impact on management procedures

3. SOCIAL AND ECONOMIC INFORMATION
Level 1: POLICY MAKING
• Summary of existing user rights systems for each fishery and fleet • Major interest groups and their stakes, including gender and age sub-divisions within each interest group and likely policy implications • Any trends influencing or likely to influence fisheries, e.g. demographic changes, political changes, migrations, etc. • Employment characteristics by fishery and fleet and possible alternative sources of employment • Contributions to local or national economy by fishery and fleet • Existing or likely developmental activities and their implications for fisheries • Details of any subsidies being paid to fishers and estimated costs of reducing over-capacity • Characteristics of and trends in markets • Implications of state macroeconomic policies which could influence fisheries • Details of any existing international agreements on trade, cooperation, etc, which affect fisheries • Details on any existing or possible conflicts between fisheries or fleets, including the causes • Existing institutional structure related to the fishery, including traditional institutions
Level 2: FORMULATION OF MANAGEMENT PLANS
• Description of the types of production units in the fishery and the number of each type of production unit per fleet • Details of user or access right system related to the fishery • Total number of fishers employed in all fisheries-related activities, with details on gender and age-group characteristics • Existence of, and possible solutions to, any conflicts between fisheries and fleets • Total landed value of the catch for each fleet and any other benefits • Details on processing catch and on markets, as well as benefits derived from these activities • Existing or potential systems (institutions) and their potential roles in shared responsibility or co-management • Details on full costs of fishing by fleet and processing, marketing and distribution costs • Specific international trade or cooperation agreements relevant to fisheries • Details on socio-economic characteristics of national or local non-fishing activities which do or may impinge on fisheries • Procedures for consultation and joint decision-making
Level 3: IMPLEMENTATION OF MANAGEMENT PLANS
• Unexpected social changes which could require departure from management procedures, e.g. movements or changes in patterns of access • Unexpected economic changes, e.g. in markets, returns or costs which could seriously impact the management plan • Social and economic performance of fisheries and fleets in relation to objectives of management plan • Details on the nature and causes of any serious conflicts within the fishery

Table 6 continued

4. MONITORING, CONTROL AND SURVEILLANCE INFORMATION
Level 1: POLICY MAKING
• Summary of successes or problems in monitoring and control by fishery and fleet • Financial and institutional implications of different policy options for monitoring and control • Details of existing arrangements and potential for partnerships or co-management with user or interest groups
Level 2: FORMULATION OF MANAGEMENT PLANS
• Existing monitoring and control systems for the fishery and fleets within it • Known strengths and weaknesses of existing systems • Implications (personnel, costs, benefits, etc.) of range of approaches for monitoring and control • Potential for greater user participation
Level 3: IMPLEMENTATION OF MANAGEMENT PLANS
• Name of each fisher or licensed fishing unit (e.g. vessel) Address or port of registry of each vessel or fishing unit • Name and address of owner of each fishing vessel or unit • Information from each fishing unit necessary for enforcing management measures (e.g. catch, effort deployed, catch position, etc.) • In the case of vessels: 1) data and place built 2) type of vessel 3) length of vessel 4) vessel markings 5) type of gear 6) International radio call sign • Incidence and causes of any serious and ongoing violations of the management plan

- **Sustainability frameworks**

The Technical Guidelines for the Development and Use of Indicators for Sustainable Development of Marine Capture Fisheries contain several approaches to the issue, one of which is the Pressure-State-Response Framework (P-S-R) as in Table 7. Under this it is possible to generally characterise all dimensions in fisheries in a simple and effective way.

Table 7. Examples of Pressure-State-Response indicators by fishery dimension

(from Garcia and Staples, 1999)

Dimensions	Pressure	State	Response
ECOSYSTEM (Resource and Environment)	Total Catch Total Area fished Catch/Sustainable Yield % Resources > Target	B/Target B F/Target F E/Target E %TR > target % NTR > target Biodiversity index Community Structure Trophic structure Area of critical habitat	TAC/Sustainable Yield % Depleted stocks rebuilding Reduction of LBP Use rights established User fees established
SOCIAL	Fishing effort Number of vessels Number of fishers Immigration rate Social unrest	Number of fishers Demography Number Associations % below poverty line	Unemployment assistance Support to associations Resources allocation decision
ECONOMIC	Sector unemployment Subsidies	Profitability Sector employment	Incentives and disincentives Subsidies, Taxes
INSTITUTIONS/ GOVERNANCE	Employment policies *(International agreements, Public advocacy, etc*)	% resources assessed % with management plans % management cost recovery Rate of compliance % resources co-managed	% resources assessed Job conversion programme Retraining programmes Number of compliance operations

- **Process and communications framework**

Garcia and Staples also reported, "The purpose of indicators is to enhance communication, transparency, effectiveness and accountability in natural resource management. Indicators assist in the process of addressing the performance of fisheries policies and management at global, regional, national and sub-national levels. They provide a readily understood tool for describing the state of fisheries resources and fisheries activities and for assessing the state and trends of change in relation to sustainable development objectives." Communication through an open process is the route; and 'status and trends' is the message. A further process approach to an analysis framework was presented by Garcia. It relates the principles of the FAO definition of sustainability, the provisions of the Code of Conduct for Responsible Fisheries, and the criteria and indicators for sustainable fisheries. This is an interesting approach and deserves further attention and wider dissemination.

5.4 Standards

Several problems of standards exist within the field. As mentioned above one of the key considerations that need to be applied, as standard, to fishery information is uncertainty, including what to do when information quality is unquantifiable. Others, though not a complete list, are nomenclature, reference points and control rules, which are addressed further below.

- **Incorporating uncertainty in information systems**

The natural mathematical way to measure uncertainty is through probability. In this way, indices or parameters are represented as variables rather than fixed values. This forms the basis of Bayesian statistics, which aims to define explained variables and quantities of interest as probability density functions (pdfs), not point estimates. Fuzzy logic is a similar conceptual method, which spreads a variable between states (or sets) rather than assuming they can only occupy a single state. In these methods, points or states are represented as functions of the possible range of values rather than a value itself.

It is possible to represent pdfs in a table as objects. It would be possible to define a group of objects representing the different ways of recording uncertainty, from single point estimates, best estimates with confidence intervals, through to a full pdf. Even if there is no current plan to place pdfs on, for example, indicators and reference points, defining point estimates as objects will allow a seamless extension to more complex summaries and presentation of results in the future.[36]

The problem with trying to represent a pdf instead of a point estimate in a database is one of complexity, speed and size. A Bayesian pdf would be calculated using the original observations, which forms part of the function. This can be simplified using parametric distributions, but remains complex and gives no indication of how accurate the fitted pdf is to the empirical one. Other simplified methods for recording uncertainty are usually interpreted through a probability model. The standard error is often interpreted as the Normal pdf dispersion parameter. This is reasonable where the amount of data used for the estimate is large. The other (better) indicator of uncertainty is the confidence interval (although even these can have different meanings).

The common interpretation using probability may allow a quite terse summary of risk depending on the type of indicator. For example, the final quantity most of interest (and therefore an indicator itself) may be the estimated probability that the current indicator exceeds some threshold or limit reference point (e.g. what is the probability, Pr, $F_{CURRENT} > F_{MSY}$). One major advantage with probability, where it can be calculated, is that it presents a common dimensionless measure, that can also be interpreted both intuitively (with a little training) as well as formally.

So a precautionary approach could say,

[36] This option should be considered by information systems developers.

'Management action X will be implemented

IF $Pr(F_{CURRENT} > F_{MSY}) > 0.05$ OR $Pr(B_{CURRENT} > B_{MSY}) > 0.05$'.

This is valid even if the different estimates are not independent as long as the probability calculations are carried out correctly, a pure technical issue. (The US National Marine Fisheries Service has adopted definitions and appropriate use of pdfs in the development of formal fishery control rules)

As a minimum, it should always be possible to record a standard error with any estimate, if any measure of uncertainty is possible. (This requirement is included in the suggested templates in Appendix 1). Where a risk assessment is possible, it should be possible to summarise results by attaching a probability to defined fishery states, even if more complete information is not required.

- **Data quality reference system**

While in theory, probability could define all uncertainty; in practice more heuristic methods are required. This is because users find it difficult or impossible to record many sources of uncertainty in any but a categorical way. For instance, a user might define a data source as 'unreliable' and therefore a pdf defined on that data source also as 'unreliable', without putting that unreliability explicitly in the pdf as, say, an increased variance.

This source of uncertainty differs markedly from pdfs, as it propagates through analyses unchanged. Whereas data usually reduce uncertainty as they are added to an analysis, categories remain fixed, so that an analysis that contains any unreliable data remains unreliable. This often results in the exclusion of these data from the analysis because the information contained in the data cannot be properly defined. However, in the absence of any other information, it remains the best guess in defining the status of the fishery. (Best guess is also a recommended option in the stock status templates in Appendix 1.)

There is no standard for defining unquantifiable uncertainty. Categories could be developed for users to choose from in describing data sets. Broadly, such categories should allow users to place information in at least two broad groups: reliable and unreliable information. But there ought to be more.

Scoring methods could be used to help classify data quality, and to identify sources of quality problems. Scoring could be used to assess different aspects of data and methods, allowing the user (or working groups) to supply subjective scores on how well the data/method measures against different criteria. For example, the degree of bias in sampling of data, the degree of robustness of a model to possible assumption violations, and so on, could form additional template questions tailored to the data and methods used. A checklist method of basic data quality criteria and scores could be developed to enable databases to hold at least some uncertainty values associated with data.

- **Status definitions**

There is a small but significant problem in the fisheries assessment domain with definitions: for example, the indicators overfished, overexploited, overutilized; are these the same thing? On the definition of overfishing, Rosenberg[37] voiced the consensus of the participants to a workshop on this specific issue that "advice on management strategies (could be improved) by recommending more comprehensive overfishing definitions and rebuilding schemes, rather than employing the simple targets and thresholds in place in most areas".

The recent US National Research Council's Committee on Ecosystem Management for Sustainable Marine Fisheries defined overfishing thus:

[37] NMFS Defining Overfishing - Defining Stock Rebuilding. Report of the Second Annual Stock Assessment Workshop, La Jolla. A Rosenberg (Ed). Feb 1998.NOAA Tech.Memo.NMFS-F/SPO-8

> "By overfishing the committee means fishing at an intensity great enough to reduce fish populations below the size at which they could provide the maximum long-term potential (sustainable) yield, or at an intensity great enough to prevent their recovery to that size. Overfishing is a function of population size."[38]

The standardisation of definitions with regard to fishery status and the underlying stock assessments are thus being addressed, although new terms that describe the status of stocks and their exploitation rates ought to take both population size and the 'current' nature of the management strategy into account. Overfishing as a term may be applied during a fishing down strategy for a new stock, or a sustainable yield strategy on a fully exploited stock, or a recovery strategy for a depleted stock. They are different forms of overfishing with different implications both for analysis and advice on management.

- **Reference points and fishery control rules**

The issue of reference points is included here for completeness but is not discussed in detail. For an overview of the issue, see Caddy and Mahon, 1995[39]. It seems clear that the list of reference points will remain open and expand to cover a whole range of indicators, not just those associated with stock assessment. Some suggestions are made in section 5.7 on a means to establish a register of reference points under FIGIS to allow flexibility and further development.

Of particular important in many fisheries and countries is the need to devise and adopt reference points that reflect data poor situations. A recent FAO paper by Caddy[40] extends the earlier work on reference points to develop simpler ones, such as reference points that may be based on past fishery yields, survey data, and other empirical methods, e.g. Maximum Allowable Yield (MAY) and Current Annual Yield (CAY). It also describes the use of indicators to develop management control rules.

Similarly, the formulation of control rules that describe management decisions in terms of indicators cannot be addressed in this review. For example, the US NMFS, in its Congressional Report, sets its management advice according to a wide variety of indicators and the data used to derive them. The main point of note here is that the NMFS uses 6 tiers of control rules according to the availability of information; that is, at different levels of data availability different control rules are applied. The use of such tiers is both a reflection of reality and a systematic way of coping with uncertainty.

5.5 Quality assurance

- **The basis of quality**

There are numerous ways of analysing what information quality means. In the context of Status and Trends in Fisheries, effectively what recipients of information wish to know is:

STATUS: What is the current position of the fishery and its components in relation to agreed criteria?

TRENDS: How have these positions changed over time; is there no trend, indicating stability?; or is there an upward/downward trend, indicating change? Importantly in trend analysis, of course, is the severity of the trend against what might be expected, or has been recently experienced. The degree of change in a trend often highlights specific problems or successes.

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[38] National Research Council (US) Sustaining Marine Fisheries. Committee on Ecosystem Management for Sustainable Marine Fisheries, Ocean Studies Board. National Academy Press. October 1999. ISBN 0-309-05526-1

[39] FAO. Reference points for fisheries management. J.F.Caddy and R. Mahon. FAO Fisheries Technical Paper No. 347. Rome, FAO. 1995.

[40] FAO. A short review of precautionary reference points and some proposals for their use in data-poor situations. J.F.Caddy FAO Fisheries Technical Paper No. 382. Rome, FAO. 1998.

The quality of all fishery reporting can be addressed in a number of ways, but what is clearly essential is that it meets a number of criteria as follows:

- Appropriate analytical methods are used in a consistent manner and include indications or estimations of uncertainty;
- Reports are prepared that provide predictive power while also being practical and responsive to feedback;
- The preparation of reports is conducted free of influence and in a timely manner, bearing in mind the trade-off between speed and correctness;
- Reports should be presented in a way that is understandable and transparent to ensure that the results are respected and there is confidence in their use in decision-making.

Ultimately, fishery status and trends reporting is a basic service to people who need to inform their political, scientific or administrative decisions with the best available evidence and advice. Importantly, this reporting also provides feedback on the results of previous decisions and provides direction for further work. Such work might include the definition on new status definitions and criteria, or the revision of scientific approaches, or a change in the ways such reports are generated (including the collection of new information, or the administration of procedures for developing and delivering the advice).

- **Definitions of quality**

The following definitions on the character and quality of management advice, drawn from the proposal for an ICES Quality Policy - since this is also relevant to reporting - are applicable:

Making Management Advice Right:

Advice is right when it is based on relevant information and appropriate analytical methods that are used in a consistent manner, taking the uncertainties into account. It is independent and free from political influence. The advice expresses these uncertainties. Specific predictions do not always turn out to be true, but the advice must be based on projections that have a useful predictive power.

Making Management Advice Relevant:

Advice is relevant in a practical and political context, i.e., it must address management measures that can be implemented from a practical point of view and include practical considerations of the human activities affected (e.g., the fisheries and their constraints).

Making Management Advice Responsive:

Advice is responsive when the institutional arrangements allow rapid responses when required, clients are able to influence priorities for ongoing research and preparation of advice but unable to influence the scientific information and the formulation of the advice, and the advisory system has early recognition of changes in management needs and addresses the advice at the correct management level.

Making the management advice both right and responsive at the same time can be in conflict. Responsive advice may be based on limited or not (yet) fully validated information, while increased scientific scrutiny will make it more right at the cost of responsiveness. However, not all advice requires the same level of precision. Responsiveness means that both scientists as well as clients would accept scientific advice that is good enough, rather than always expecting it to be the best possible.

Making Management Advice Respected:

Even fisheries management advice that is right, relevant and responsive will not be useful unless it is respected (or credible) by those who make decisions and by those who are affected by these decisions. A precondition for having advice respected is full transparency of the advisory process leading to management advice.

- **Quality policy**

Both ICES and ICCAT offered detailed information for the conduct of this review since they, like many other regional fishery bodies and national institutions, are addressing the issue of quality assurance for their services. Indeed, demonstrating quality of advice may prove essential sooner rather than later if the pace of user-pays in fisheries and contracting-out in fisheries research quickens.[41] ICES, in developing its draft quality policy, now faces structural suggestions in order to meet and satisfy quality objectives. To achieve a transparency to such quality objectives it may be useful for institutions such as ICES to begin ISO certification, where this is feasible.

Taking all the processes and issues together, as a result of discussions with and information from institutions and individuals during the course of this review, it appears that there are 9 essential quality criteria that would underpin any advice required for status and trends reporting (and, of course, other research issues). Four criteria are associated with the scientific process itself, three apply to the results, and two apply to the administrative review mechanisms for the whole process (Table 8).

Table 8. Criteria, definitions and methods: a framework for fisheries science quality assurance

Criteria	*Definition*	*Methods to achieve quality*
The PROCESS should be:		
Transparent	The process, rules and procedures are well-defined and public knowledge.	▪ Tender rules publicly available ▪ Statutory arrangements clear ▪ Institutional publishing
Responsive	Timely and flexible to changing needs, while ensuring best practice.	▪ Tasks are well-defined and timely ▪ Requests for research/advice are appropriate, feasible and reasonable.
Independent	Scientifically objective and free from sectoral influence by government, industry, or advocacy groups.	▪ Open access to data, methods, raw results (including measures of uncertainty and risk). ▪ Clear method demonstrable in the integration and presentation of summary advice.
Consensual	Reports by consensus & include alternate views, incorporated as additional uncertainties to mathematical or conceptual uncertainties.	▪ Rules of procedure require no 'minority', externally published reports. ▪ Sufficient time is given to reach consensus.
The RESULTS should be:		
Integrated	All issues are considered in or enter into the scientific procedures, including environmental, ecosystem, economic and social issues, as appropriate.	▪ Research into and the application of holistic assessment methods. ▪ Time set aside for scientists to undertake theoretical research, in methods, in particular modelling and simulation.
Credible	Scientifically accurate within the limits of knowledge (methods and data) from respected scientists, and reflecting practical reality.	▪ Good data, appropriate to the task. ▪ Acceptance by scientists of the socio-economic dimensions of the fishery. ▪ Training and standards are recognised. ▪ Theoretical research supports methods.
Quality Controlled	Procedural error-detection at appropriate times or stages.	▪ Process for quality control established externally to the 'group'.

[41] In New Zealand, all research is contracted out, and while NIWA still gets the bulk of the work this depends on its ability to maintain its high level of excellence continuously if it is not to lose staff or succumb to competition. Internally then, NIWA already conduct stringent quality control on their output through several layers of review to ensure their excellence.

The PROCESS and the RESULTS should be subject to:

Internal peer review	Method for conducting procedural quality control and first review of results.	▪ Institutional mechanism established for formal/scheduled quality control activities by non-tasked expert and informed non-experts.
External peer review	Process and results conform to the highest international standards.	▪ Include scientists, and others, as appropriate, external to the institution, state or region.

- **Peer review mechanisms**

There are no clear international definitions of, or standard practices for, what peer review in stock assessment actually entails. Generally, there are three basic review mechanisms:

Working groups

Members interact to 1) discuss the nature of the data; 2) consider and decide on the appropriateness of the methods; 3) to 'peer' over the shoulder as the analyses are conducted; 4) to discuss results and conduct re-runs of analyses, where necessary. Thus, there is ongoing peer review during working groups.

Internal Peer Review

The results of Working groups or single scientists are given to scientists within the organisation who work in other areas but have stock assessment skills, plus non-experts who can look beyond the narrow confines of the science and perhaps advocate client responses.

External Peer Review

The results of Working groups or single scientists are given to a scientist or panel who work entirely external to the fishery/region but who have stock assessment and other expertise.

Many institutions have developed their own internal procedures, but these seem mainly for personnel and scheduling processes. How might a guide be offered for a new group starting out? This entirely depends on the circumstances, but there is one clear approach that can readily be used to ensure that stock assessments are on the right track - the checklist.

In 1996, the Ocean Studies Board of the US National Research Council commissioned the Committee on Fish Stock Assessment Methods to review current methods and "consider alternate approaches for the future". It produced a report called 'Improving Fish Stock Assessments' in 1998[42] in which number of key areas were raised and reviewed, including uncertainty and risk, assessment methods and harvest strategies, and simulations. That report included a generalised checklist for stock assessments. The steps required and important considerations were identified at a full range of levels. The table is reproduced below (Table 9) and would be useful to all forms of peer review process in the future.

What will also assist the peer review process is access to the methods, models, variants, tuning, fit, data sets, indicator choices, parameter estimates (and the time series of these) that the FIGIS Stocks Module could be designed to offer. It would certainly speed up the process, and in a sense would already provide some of the authentication required because much of the information has been registered prior to use.

[42] Improving Stock Assessments. Committee on Fish Stock Assessments, Ocean Studies Board, National Research Council, National Academy Press, USA. 1998

Table 9. Checklist for conducting or reviewing stock assessments

from: *Improving Fish Stock Assessments.* National Research Council, 1998. Appendix D.

STEP		Important Considerations
1.0	**STOCK**	
	Stock definition	What is the spatial definition of a "stock"?
		Should the assessment be spatially structure or assumed to be spatially homogeneous?
	Stock structure	Choose single-species or multi-species assessment
	Single or multispecies	Use tagging, micro-constituents, genetics, and/or morphometrics to define stock structure?
2.0	**DATA**	
2.1	***Removals***	Are removals included in the assessment?
	Catch	
	Discarding	
	Fishing-induced mortality	
2.2	***Indices of Abundance***	For all indices, consider whether an index is absolute or relative, sampling design, standardization, linearity between index and population abundance, what portion of stock is indexed (spawning stock, vulnerable biomass).
	Catch per unit effort (CPUE)	What portions of the fleet should be included and how should data be standardized?
		How are zero catches treated?
		What assumptions are made about abundance in areas not fished? Spatial mapping of CPUE is especially informative.
	Gear surveys (trawl, longline, pots)	Is gear saturation a problem? Does survey design cover the range of the stocks?
		How is gear selectivity assessed?
	Acoustic surveys	Validate species mix and target strength.
	Egg Surveys	Estimate egg mortality, towpath of nets, and fecundity of females.
	Line transect, strip counting	
2.3	***Age, size, and sex-structure information***	
	Catch at age	Consider sample design, sample size, high-grading selectivity, and ageing errors.
	Weight at age	
	Maturity at age	
	Size at age	
	Age-specific reproductive information	
2.4	***Tagging data***	Consider both tag loss and shedding and tag return rates. Was population uniformly tagged or were samples recovered?
2.5	***Environmental data***	How should such data be used in the assessment? What are the dangers of searching databases for correlates?
2.6	***Fishery information***	Are people familiar with the fishery, who have spent time on fishing boats, consulted and involved in discussions of the value of different data sources?

3.0	**ASSESSMENT MODEL**	
3.1	***Age-, size-, length-, or sex-structured model?***	Are alternative structures considered?
3.2	***Spatially explicit or not?***	
3.3	***Key model parameters***	Are these parameters assumed to be constant or are they estimated? If they are estimated, are prior distributions assumed? Are they assumed to be time invariant?
	Natural mortality	
	Vulnerability	
	Fishing mortality	
	Catchability	Is a relationship between spawning stock and recruitment assumed? If so, what variance is allowed?
	Recruitment	Is depensation considered as a possibility? Are environmentally driven reductions (or increases) in recruitment considered?
3.4	***Statistical Information***	
	What process errors?	If the model is in the form of a weighted sum of squares, how are terms weighted?
	What observation errors?	If the model is in the form of maximum likelihood, are variances estimated or assumed known?
	What likelihood distributions?	
3.5	***Evaluation of uncertainty***	
	Asymptotic estimates of variance	How is uncertainty in model parameters or between alternative models calculated?
	Likelihood profile	What is actually presented, a distribution or only confidence bounds?
	Bootstrapping	
	Bayes posteriors	
3.6	***Retrospective evaluation***	Are retrospective patterns evaluated and presented?

4.0	**POLICY EVALUATION**	
4.1	***Alternative hypotheses***	What alternatives are considered: parameters for a single model or different structural models? How are the alternative hypotheses weighted? What assumptions are used regarding future recruitment, environmental changes, stochasticity, and other factors? Is the relationship between spawners and recruits considered? If so, do future projections include autocorrelation ad depensation?
4.2	***Alternative actions***	What alternative harvest strategies are considered? What tactics are assumed to be used in implementation? How do future actions reflect potential changes in population size? Is implementation error considered? Are errors autocorrelated? How does implementation error relate to uncertainty in the assessment model?
4.3	***Performance indicators***	What is the real "objective" of the fishery? What are the best indicators of performance? What is the timeframe for biological, social and economic indicators? How is risk measured? Are standardised reference points appropriate? Has overfishing been defined formally?

5.0	**PRESENTATION OF RESULTS**	
		How are uncertainties in parameters and model structure presented? Can decision tables be used to summarize uncertainty and consequences? Is there explicit consideration of the trade off between different performance indicators? Do the decision-makers have a good understanding of the real uncertainty in the assessments and the trade-offs involved in making a policy choice?

5.6 Working groups: stock assessment in the institutional setting

Common practice in stock assessment, particularly in the final phase of determining stock status and appropriate control rules, is the establishment of working groups. This process in scientific work is not exclusive to fisheries; it is also common to many other domains of analysis. Data should be shared; no one group of scientists has all the information pertaining to a problem, and people need feedback on their ideas. They need both confirmation of their own views and the presentation of alternative views for a number of reasons. Partly, this is due to the fact that there is often no single right answer or point estimate that can be derived from a complex set of interacting variables (a model); it all depends on how you piece the model together. The use of models and methods is subject both to opinion and to recognised and accepted performance, in addition to novel and theoretical advances. As most stock assessment people know, scientists often prefer the use of models and methods with which they are familiar. However, there is no standard that is the most correct (or sacred!).

Once built, a model may be tuned according to a range of assumptions, model variations or data manipulation, etc. The structure and use of a model might depend on how much faith the modeller (= the working group) might have in each data source, and how various assumptions might be violated as well as many other factors. Consensus helps to smooth a variety of opinions into an acceptable answer. Working groups allow data to be shared between scientists, reducing uncertainty. The working group can plan simulations, which help address uncertainties and their complex relationship with the management outcomes more objectively. In working groups there is also safety in numbers; collective jeopardy is never as bad as personal jeopardy.

- **Participation and framework**

Working groups in fisheries stock assessment (and for other issues) have been established throughout all international and regional fisheries organisations, and in many countries. In the national setting they often bring together a range of specialist expertise; biologists, oceanographers/limnologists, modellers, computer programmers and analysts, plus managers, social specialists, economists and administrators. The latter groups of professions are becoming increasingly involved, together with commercial and community representation. At the regional (e.g. ICES, NAFO, SPC) or international (e.g. ICCAT, IWC, CCAMLR) levels, participants not only bring their expertise but also are there to ensure that the interests of their nations or institutions, including advocacy groups, are represented. In developing countries, working groups are sometimes used for additional training or capacity building in the techniques being used or in the participatory process that the working group method engenders.

Whatever is the case, working groups follow very similar patterns consistent with the seemingly universal ‘committee framework’ which has common characteristics. Working groups:

- meet to address a previously identified problem, often against highly specific terms of reference;
- establish a structure and hierarchy (convenor/chair, rapporteur/editor), and agree an agenda;
- they review previous work and methods, offer alternative views and methods and undertake or review analytical work; and
- agree and communicate a common or consensus statement of results that, hopefully, will fit the ‘best scientific evidence’ desideratum.

- **Performance and results**

Working group results

The results of stock assessment working group most often continue from the previous year (or last assessment), acknowledging and refining previous work, and presenting both status and trends for the issues under consideration. Many organisations now insist on a common framework for a report,

particularly in the 'executive summaries' that are often all that fishery managers need to see when considering such advice.

Sometimes working group reports also register dissenting or alternative positions. This is not necessarily a bad thing and is preferable to minority reports published externally, which undermine credibility in the overall process. What is clear is that alternate views and analyses should actually contribute to the results of a working group. Properly expressed, alternate views contribute to the uncertainty alongside the inevitable uncertainty (often expressed as pdfs, confidence intervals, etc.) that is, or ought to be, attached to the analytical results.

Some research organisations and their clients have expressed a demand that, if at all possible, consensus reports prevail. It seems that alternate reports - delivered independently - tend to throw doubt on the result of a working group in a way that exaggerates the weight of the alternate intervention. Clearly this cannot be 'dictated' against. "Consensus, if at all possible", however, ought to operate and, where this cannot be achieved, the alternate view should be clearly stated within the working group report.

Working group performance

It seems likely that working groups will continue as the basic institutional arrangement for most stock assessment decisions, either at the primary analytical level or as a part of a peer-review process of the results of other groups, including contractors. In some organisations these working group reports are part of the accepted procedural framework; in others they are ad-hoc. In either case, the results of the stock assessments (and perhaps the control rules that they imply) need to be communicated to managers at the earliest opportunity. Delaying delivery of the results always degrades the value of the work, given the retrospective nature of population analysis. We dealt with 1998 data (if we are lucky) during 1999 to predict 2000 stock status and the control rules that we need to apply; two years can be a long time in the variable aquatic environment. Longer delays introduce additional uncertainty.

In 1987, Brander[43] conducted an analysis of predicted catches by working groups against actual catches under 'current year' and 'year ahead' scenarios to develop estimates of 'prediction error' in a range of ICES stocks. He found that average prediction error fell from +21% for the year ahead to +14% for the current year and suggested that "since 'year ahead' forecasts are inherently error prone, the use of 'current year' forecasts to adjust TACs should be considered." Clearly, current year forecasts are also error prone but he questioned "whether such advance (year ahead) forecasts can ever be made acceptably precise and whether it would not be easier to alter the review and administration procedure for setting TACs so that 'current year' forecasts are used to fine tune TACs during the year." He argued that "it seems to be very difficult to change the institutional arrangements of ICES and the European Commission in order to allow up-to-date forecasts to be used." This issue remains, and reconsideration of the timings and conduct of working groups at ICES was still being considered at ICES in 1999.

It is clear that delivery of results is important, not just at the earliest time but at the most appropriate time. The most appropriate timing is entirely fishery and biology dependent. What timing is appropriate for salmon in the northeast Atlantic may not be the same for salmon in the northwest, let alone for cod in the Baltic, or tuna in the South Pacific. Prediction is also highly information dependent. In the above study, Brander also investigated the source of prediction error and found that at least three areas of uncertainty – recruitment, fishing mortality and catch composition – affected the year-ahead forecasts. In the absence of this information (or appropriate timings), he nevertheless concluded that "such 'year ahead' forecasts are no better than a 'precautionary' forecast which uses the average of a five-year period." Data and timing are therefore crucially important, in particular a better knowledge of expected fishing effort and the resulting estimate of expected fishing mortality.

A flexible approach needs to be adopted. Structuring working group meetings may be relatively simple for national organisations but in regional and international organisations this can prove complex and participation may be limited by external factors across all the members. This is

[43] Brander. K, 1987. "How well do working groups predict catches?". - J. Cons. int. Explor. Mer, 43: 245-252.

particularly the case, say, where a species expert needs to participate in working groups for several stocks on which fisheries operate at different times of the year (or for other reasons); or, where stock working groups require a different (overlapping) mix of participants because of a different mix of jurisdictions over the various stock's ranges.

- **Working group stock assessment report profiles**

Report Content

Although there are likely to be variations depending on the stock (or on the requirements of management authorities/clients, or on the history of assessments and assessment approaches), the stock status and trends reports from working groups generally have the characteristics identified in Table 10.

Report Management

It is difficult to assess within current institutional arrangements whether current status and trends reports from working groups actually meet content, scheduling and presentational requirements of stakeholders, although there are some reservations expressed in various documents.

Ideally, the reports should also be managed on the following basis. Stock assessment working group reports should:

- be made available at the earliest opportunity with caveats on their use within their political/procedural context;
- proceed as fast as possible through a process of becoming classified as public information;
- be presented in as transparent and understandable form as possible, for the following reasons:
    - to simplify any peer/committee review process, ensuring there is sufficient and accessible information for an independent conduct of the approach/ methods/ models and the generation of values and uncertainties;
    - to provide a sound basis for acceptance by a wide range of stakeholders, including commercial or community interests.

Examples of the general format and content of stock status reports prepared for ICES and ICCAT are described in Appendices 2a and 2b.

Table 10: General content of stock status and trends reports from working groups

Optional/Useful content
• narrative summary of the biology • general fishery description • management objectives • other information such as environmental conditions
Required/Essential content
• choice and technical basis of indicators and reference points • estimated of current values of required indicators (and other supporting indicators) • status of the stock and trend (including effects of previous management actions) • management advice or control rules (including options within/across years) • yield prediction or general outlook • sources of information.
Background Information
• catch/landings history • trends illustrations • indices • figures describing model outputs (with variants) and supporting data and statistics.

5.7 Developments for improving fisheries information

- **A global database for working group results**

Working groups in stock assessment occur worldwide in a range of contexts, but with generally similar mandates. The quality of their stock status and trends reports is highly variable from a number of perspectives, including the basis of the work, the approaches and methods taken, the presentation of results (including supporting evidence), the timeliness of the submission, confidence in their results, and other factors.

All fisheries research would benefit from knowledge of the ways in which the global fisheries research community, through their working groups, addresses the estimation of fishery performance indicators, in particular on the status and trends of stocks. Such global knowledge would assist in describing the status and trends in fisheries stock assessment research itself, and the ways and pace that nations and organisations are addressing the precautionary approach, thus perhaps responding to some of the desiderata of the CCRF.

A simple registry/database of basic information sets that come from individual stock assessments submitted by national liaison officials, or from working groups whether national, regional or international, would assist in this process. The database would offer the facility to register such basic information as data on sources; identification and rationale of indicator choices and reference points adopted; approach/method/models and variants used; assumptions required; estimation of indicator values (target, limit, threshold) and current reference point values (including their uncertainties, usually standard errors); and other, as yet unidentified, information.

The database could be held at the national, regional and international levels through the application of a common software package or through direct interface to an Internet-based entry system, perhaps maintained at FAO (under FIGIS). Among many other issues of security and verifiability, attention would need to be paid to the registration and authentication of persons updating the system.

Users in the global scientific community would be responsible for the data maintenance; it would be a user-orientated database. Working groups could choose to place it on-line, or at the very least to maintain it within their working environments thus assisting institutional memory. If made more widely available users would gain the benefit of best scientific evidence coupled with the knowledge of ways in which it was developed. FAO would gain the benefit of access to 'official', i.e. registered and authenticated, status and trends reporting that could be used - justifiably and without criticism - in the State of World Fisheries and Aquaculture series. Developing a discipline to keep this up-to-date at all levels would go some way to ensuring that the information used in any Fishery Status and Trends Reporting has a transparent and verifiable provenance.

- **FIGIS and templates for information submission**

The value of the Fisheries Global Information System will be extensive and varied and is discussed in Chapter 2 and elsewhere. It will offer a natural hierarchical and linked structure to enable access to information and to methods of information supply by countries in ways that suit them the best.

Part of the process to establish such an information supply method would investigate a nested hierarchy of templates, so that users (national statistical liaison officer, registered working group, etc) could enter as much as information, as is available or that they are capable of, without the embarrassment of submitting empty data sets (= mostly blank forms). The more detail you can provide the further down the hierarchy you progress. This requires a system of templates upon which the database and interface design would be implemented, and a partial investigation into this issue has been undertaken as part of this review. While the system described in Appendix 1 focuses mainly on the stock assessment aspects, it includes the following modules, most of which are in development under FIGIS:

- Stock assessment and status module templates

- Fishery module templates
- Fisheries management module templates
- Time series module templates
- External standard module templates

General approach to the stock assessment and status module

The templates aim to achieve a balance between standardisation and diversity for each stock assessment. If methods and results are standardised, they allow comparison between them, but more importantly are also easier to interpret by the people to whom the reports are addressed. However, if the standardisation is too strict, the results are easily distorted. Major and minor variations in method and results of assessments are sometimes necessary for a particular stock, and these need to be recorded for any respectable interpretation.

To allow this balance and deal with the complexity of the data, an object-orientated approach would be appropriate. Objects possess the key features of encapsulation and hierarchical structures (inheritance) and should be built into the templates and underlying data structures to the greatest extent possible. Encapsulation is useful wherever the form and structure of information is changing rapidly. Stock assessment methods are rapidly changing, but it is possible to impose some structure on the methods by encapsulating different parts and defining their attributes. For example, this can be seen in the Methods section (see Appendix 1), where models and fitting method are recorded separately. If the internal structure of any part is changed, it does not affect the other parts.

The most important consideration in encapsulating structures is their interface and the programming required. While changes can be made within single structures with no implications for other modules, changes to the interface may well require a more general overhaul and testing of the system. Records and tables in databases provide natural forms for objects, with their variable length and structure. However, the structure should be chosen to produce the greatest flexibility in recording information.

Hierarchies can make complex structures easier to grasp, both for the user and the software designer, and is a natural way to define relationships. Hierarchies might be used in the templates to allow users to justify their views/results on stock status with increasing detail. Failure to undertake the most sophisticated stock assessment should not prohibit registration of the results, even when these are only guesses supported by a narrative.

A second use of hierarchies is to provide inheritance, which allows users to concentrate on what makes an analysis different to some previous standard. Given someone is familiar with the standard, identifying the differences should allow a comprehensive shorthand for methods. This would be particularly useful for peer review. For example, assessments often consist of a sequence of trial assessments to see whether results are sensitive to some assumed model form. If a user recorded assessments with the same production model fitted with two different likelihoods, it should be possible to record the relationship (i.e. the difference) between the two. Differences in results could then be attributed to the difference in method. It would also avoid repeating the registration of all the information on the models and data used. A similar argument can be applied to registering models and methods. A new method that is different to those that have gone before is what makes it of interest to the scientist. For example, a Tuned VPA need only define the tuning if the user is already familiar with VPA. Tick boxes or drop-down lists could provide the appropriate mix of methods, models and fits from those previously registered within the system.

Advantages

Users would be able to upload changes in assessment methods and results without database structural changes. Improvements in stock assessment methods are inevitable, with more efforts to adapt models and data, and then simply record changes. Standardisation and record-keeping of this kind would allow users to avoid repetition, but also to build natural relationships between stock assessments, models and data sets. Most changes in the future would require little, if any, change to the templates,

since new models and data types should be able to be defined within the template structure. If it is decided to change how a method is recorded, only the method template structure needs be changed.

All possible information can be recorded. It is not claimed here that the templates are fully comprehensive; it is the approach that is suggested. The structure does not require just a single level of detail for and between different users, but allows any information on status, from full stock assessments to 'gut feeling' to be recorded.

The interface would guide the user through the complex procedure of providing information, minimising errors and workload. Much information, such as calculating fields, error checking and context sensitive data collection, can be automated. While the structure has been designed for templates, the underlying data structure may be able to mirror this. Oracle8i provides an object and extensibility option, which could be used to define complex components such as models, methods and data in an object orientated way. The interface between the database users and FIGIS, in particular the Stock Assessment and Status Module, which is key to a globally advancing accessibility to fisheries science, needs very careful consideration.

Disadvantages

To achieve encapsulation, access to data is often indirect, through a standard interface. This will mean slower access to data, as the number of lookups is increased, and probably higher start-up costs. With faster computers, these aspects are of lower importance compared to minimising system update and maintenance costs. In any case, such approaches are the methods for modern database management, with static reference tables/look ups, separately updateable (and less often) from the active data sets.

- **Information partnerships**

A recent FAO consultancy report[44] raised some of the issues that will inevitably arise concerning transparency and information sharing. These will need practical schemes to which parties need to agree to ensure they are continuous. The modern database capability of applying security access levels to any level of record makes this possible. What is more important is agreeing how access levels are defined between parties: What information is to be available to one party only, to both parties (or subsets of them), to other participants or to the general public? Applicable confidentiality, which describes this issue precisely, is raised as follows in the Code of Conduct for Responsible Fisheries:

> 7.4.4 States should ensure that timely, complete and reliable statistics on catch and fishing effort are collected and maintained in accordance with applicable international standards and practices and in sufficient detail to allow sound statistical analysis. Such data should be updated regularly and verified through an appropriate system. States should compile and disseminate such data in a manner consistent with any **applicable confidentiality** requirements.
>
> .....
>
> 7.4.7 Subregional or regional fisheries management organizations or arrangements should compile data and make them available, in a manner consistent with any **applicable confidentiality** requirements, in a timely manner and in an agreed format to all members of these organizations and other interested parties in accordance with agreed procedures.

[44] Evans, D. FIGIS: Report on the Assessment and Development of Tasks and the Establishment of Information Partnerships. FAO, FIGIS project internal consultancy report. March 1999.

As information architectures, transparency and data-sharing requirements become more open and shared, data should be categorised, or marked as to its level of use, and hence make 'applicable' the 'confidentiality' requirements appropriate to the information available to the partnerships. Some attention should be paid to establishing standard categories for typical information types, including to levels of aggregation.

Other issues in information sharing partnerships, particularly information supply by States to global information systems such as FIGIS, include:

- Make participation in data supply flexible and not based on the highest/lowest common denominator. (Thus, States with lower information capacities need not feel pressured by States with higher information capacities.)
- Mechanisms for establishment of partnerships (formal agreement, memorandum of understanding, exchange of letters of acceptance) should be developed for the future supply of data and the generation and dissemination of fishery status and trends and other information.

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Index

A

ACFM 54, 65, 66, 67, 69
ACFR ..... ii, iii, 1, 2, 9, 10, 57
AFMA 24, 28, 29
Applicable confidentiality 12, 51
Aquaculture ..... iii, 16, 19, 27, 29, 49, 53, 64
Australia 24, 28, 33

C

CCAMLR 24, 25, 26, 46, 53
CCRF 3, 6, 7, 8, 9, 12, 23, 49, 53
Checklist ..... vi, 44
COFI ..... iii, 1, 2, 11, 12, 16
Control rules 62, 73

E

Ecosystems 65
Environment 24, 29, 32, 33, 37, 54, 67, 68, 70, 71
EU 6, 26
External peer review 43

F

FAOCA 6, 8, 9, 13
FFA 24
FIGIS ..... iii, 4, 9, 14, 40, 43, 49, 51, 52, 53, 57
Fishing capacity 11, 20
FISHSTAT 4, 14, 15, 19
Fitting Method 58
Frameworks 34

G

GOOS 1, 54
Guidelines 3, 13, 33, 34, 37, 53, 54, 74

I

ICCAT 9, 24, 26, 42, 46, 48, 54, 70, 71, 72
ICES 5, 9, 24, 26, 32, 41, 42, 46, 47, 48, 54, 65, 66, 67, 68, 69, 74
Indicators 3, 13, 33, 37, 38, 53
Information Partnerships 51, 53
Information Requirements ..... vi, 35
Inland fisheries 29
Internal peer review 43
International Plan of Action 2, 11
IODE 13
IOTC 24

L

Link Model 57, 58

M

Marine Resources 1, 2, 18, 19, 29, 54, 73
Marine Stewardship Council 7, 8
MSC 7, 8

N

NAFO 24, 46

Namibia 24, 29, 54
NASCO 24, 26, 32, 67
National Research Council 34, 40, 43, 44, 54, 74
NEAFC 24, 26, 27, 54, 67
NIWA 29, 30, 42
NMFS 24, 28, 34, 39, 40, 54, 60, 73, 74

O

OECD 24, 27, 54, 67, 69

P

Peer review 43, 59
Population Model 57
Precautionary Approach 32, 53, 54, 60, 74

Q

Quality criteria 9
Quality Policy 5, 41, 42, 54, 68

R

Recommendation 27
Reference Point 58, 66
Reference Points 58, 66
Regional Fishery Bodies 13, 14, 21

S

SDRS 13, 14
SEAFO 70
SIFARNET 14
SOFIA ..... iii, 16
SOFO 16
SPC 24, 26, 27, 46, 54
Stock assessment 28, 31, 46, 48, 50, 59, 69, 72
Sustainability 20, 33, 37, 53
Sustainable Fisheries Act 4, 53, 73, 74

T

Transparency 5, 8

U

UNCED 16, 32, 54
Uncertainty 2
UNCLOS 6, 12, 13, 20, 26
UNEP 2, 8, 24, 25, 54
UNESCO 2, 8, 13, 54
UNFSA 6, 8, 9, 13, 20, 54
UNGA 20
Unilever 7
United Nations 12, 20, 24, 32, 53
United States 7, 24, 26, 28, 34, 39, 40, 43, 53, 54, 73, 74
US 7, 24, 26, 28, 34, 39, 40, 43, 53, 54, 73, 74

V

Vessel Monitoring Systems 8

W

Working Groups 67, 68, 70
WWF 7, 54

Appendix 1: Systems and templates for reporting

- **Background**

FAO's FIGIS project is required to establish a variety of modules within its framework to satisfy perceived user needs in a range of issues, including species, fisheries, stocks, resources, fleets, fishing gear and fisheries management. Once the approach, structure and implementation of FIGIS have been proven with these modules, it may be extended to cover other aspects, including ecosystem, environment, economics, trade, etc.

The ACFR has called for a review of fisheries status and trends in reporting, which also required the development of a proposal for a common template for status reporting by stock, fishery or species within FIGIS.

The following discussion offers a generalised approach, which includes:

- a preliminary suggestion of modules and templates, plus explanation of the approach taken with more detailed explanation of the intention of the Stock Assessment and Status Module (*note: the templates illustrated in the following pages do not represent database tables or imply a database structure*);
- a discussion of the benefits of the database of stock assessment and other modules;
- a suggested method for the submission of information by national liaison officials or working groups; and
- how, if the approach is accepted, the development of this proposal should be addressed further (user requirements study, functional design specification, systems analysis and implementation cycle).

- **Modules and templates**

This section is primarily concerned with the *Stock assessment and status module* and its templates. However, for the sake of completeness and to demonstrate the linkages with other modules, the proposed templates for the Fishery module, Fisheries management module, Time series module, and External standard module are also included in the tables, although these are fairly self-explanatory and self-evident, and are not discussed further.

The Stock assessment and status module is divided into two parts; Methods and Results.

a) Methods

Three templates in the form of registers are proposed; *Method Register*, *Reference Point Register* and *Model Register*. The registers define and hold the standard (registered) methods, reference points and models that are available in the system or which can be updated. When users submit information to the system they would select a defined stock assessment from the Method Register. If the stock assessment used is standard (e.g. was carried out using standard software, models, etc - see the Method Flag in Stock Assessment Methodology template) no method need be registered - one is simply selected (drop down list or other method). Otherwise the user will need to define what was done. Once the system becomes populated with methods, reference points and models, in rare cases the user may have to register a new one. Some thought will have to be given on how to avoid duplication and ensure quality for the registration process.

Method Register essentially has three parts, summarised as follows:

- The **Population Model**, which describes the population changes that the assessment addresses, and the process errors, if any. The population model includes recruitment, if used. Note that recruitment may be an estimated parameter, as in VPA; in others it forms part of the process, as in Beverton and Holt.
- A **Link Model**, that defines the link between the population variable and some observable variable (e.g. between population size and CPUE), including observation errors, if any.

- A **Fitting Method**, which defines the criteria under which estimates are defined, such as least-squares, weighted least-squares, maximum-likelihood, Bayesian. If maximum-likelihood or Bayesian, the population and link models together would have to define a likelihood model. A Bayesian assessment would also require a prior probability for parameters.

In most cases it is envisaged that some combination of registered standard methods can be chosen which may only require a few additional comments to describe some minor issues in relation to the standard. This will mean that experts who are familiar with standard methods, such as dynamic production models, XSA, etc can very rapidly assimilate the assessments. This information might be extremely important and useful for a peer-review process.

While in most cases methods can be broken down in structure, in some cases descriptions may be complicated and require more than one model, therefore requiring a Link Model. For example, size data may be converted to age, before carrying out a tuned VPA. This would require two link models describing how the cohorts link through to the measured variable.

In addition, the Method Register might have assumptions, descriptive narratives, software used and hyperlinks to bibliographic references.

Reference Points Register

Stock status is mostly defined through performance indicators and reference points, and therefore it would be important to register those chosen for the stock in the Reference Points Register. The general content proposed should cover most possible new assessment methods as long as new indicators and reference points can be defined. It should, therefore, be possible to record and maintain multiple indicators and reference points for a single stock.

Models Register

Registering models in the Models Register would probably be defined only as text, but should include a mathematical definition, if appropriate. It is also possible, and might be considered extremely useful, to consider offer a method to upload an object, method or function which defines the model in some executable form for inclusion, for example, to a spreadsheet, database or other software.

b) Results

The five *Results* templates define a particular assessment; the *Status of Stock*, the *Stock Assessment Methodology,* the *Data Used,* the *Assessment* undertaken, and *Working Group* (or individual) *Register*. These draw on the three Methods registers, but are strongly hierarchical in the sense only relevant templates are filled in. If no stock assessment has been done (Status of Stock '*unknown'*), no information relevant to stock assessment is asked for.

It is envisaged that, once complete, the Stock Assessment and Status Module would promote a discipline on individuals and working groups to add to the system what they have achieved, both at a theoretical level and for the results of individual stock assessments. In some senses it could be seen as a pro-forma summary for any stock assessment report. It would not force a structure on the input of the information because the information available to the user would be structured according to the general report structure from which it is drawn, not the standard interface required. More or less information can be entered as appropriate.

Importantly, however, it could be envisaged that a first action following a working group meeting might be the publication of the results information in this way (with appropriate level confidentiality, which is not discussed here and is a systems development issue). Working group (or individual) registration against a particular stock assessment is included as a separate template. Immediate or controlled access to the key information can therefore be achieved. FAO-convened working groups might be required to use this system. Such registers and results could even be maintained within institutions (or to individuals) until such time as they were comfortable with communicating them to others or uploading them to FIGIS.

In some senses this approach attempts to develop a taxonomy for the whole issue of stock assessment method. This is a first attempt and should be extensively investigated further. Again, the templates are not database tables or a data structure but simply an appropriate division of issues and their content (and may be incomplete); nor does their ordering suggest a hierarchy.

- **Benefits**

This approach would provide a wide range of benefits to the global research community and to the individual users and working groups. It would provide both a research resource and a training resource.

The template structure allows a user to enter data and information in an orderly manner providing details to the limit of their capability and results. (Of course, the user interface needs very careful implementation to achieve this.)

The templates enforce standardisation and inheritance, so relationships between different methods, and different data sets are made explicit. This also reduces the amount of data entry necessary. (The modern use of drop-down listings or look-up tables would assist in this.)

The templates encapsulate the different structures that make up a stock assessment. This not only makes it simpler to understand the data entry process, but also helps enforce standardisation and reduces maintenance. The entry procedure will allow timely and accurate dissemination of information from working group sessions.

All this information will make stock status and trends reporting more complete, verifiable, accurate and timely. It also provides the basis for a user reference data base for comparison of approaches used against a species; or for investigating which stocks use which reference points, models, or methods; or almost any other form of selected comparisons. Peer reviews could trace the history of particular stock assessments, for example; or for the analysis of the performance of control rules against results.

Also importantly for individuals and groups in less-developed countries that do not have access to libraries and experts, it would provide a significant resource that they can draw on, evaluate for their purposes and use to 'publish' their findings in ways that simplify the process. Over time it would provide the institutional memory on what was done in any one stock assessment where formal institutional publishing or results is either absent or delayed.

- **Method for use**

Entry to system

This requires some form of registration and authentication process at the global level. If the software is held at the national level prior to uploading it is less of a problem. Individuals might also maintain a system for themselves for testing methods prior to submission to their working groups, head of research or national institution. However, at the global level, for example, only primary authorised national/regional contact persons or current chairs of working groups would have write permission; everyone else would be read only.

Preliminary detail

The stock and status is defined; "was assessment done?" is flagged; if "not done", further information on methods, etc is not registered. If "done", then the stock assessment software used and methodology is selected; if "not standard" is flagged, the system defaults to the Methods Registers.

Methods Register

The registers offer all the currently available characteristics for methods, models and reference points. The user selects the combinations used and enters the non-standard variations; system would return "New Method Registered with <NAME>." or "This combination already registered as <NAME>".

Data Used

The user enters descriptions of the data, plus a pointer to the data sets.

Assessment

The results of the stock assessment are entered against the indicator types used along with standard errors and probability. Agreed control rules are also entered as the basis for management action.

- **System Development**

The above approach is inadequately defined; it goes beyond a concept note but does not approach a specific systems description. Therefore, considerably more 'project definition' would be required. In that process modules might change, templates might be added to and an overall objective, including uses, would be defined in greater detail.

However, this starting point is seen as essential if the reporting of fishery status and trends is to be effectively improved at the primary stock assessment level. All other fisheries tasks stem from or use this level as their starting point.

The system development cycle for this project would follow the normal route for such development, through a user requirements study, to a functional then technical design specification and, finally, a system implementation. Decisions on how this should proceed, and with which participants, might be undertaken in a full-scale project proposal.

A major exercise will be to review the taxonomy of reference points and establish the range of their characteristics and applicability. In addition, the range, characteristics and methods of the models that underlie these reference points need to be evaluated. Fortunately a large amount of this work has been undertaken[45]. As a starting point, a quotation from the footnoted paper is appropriate:

> "A **biological reference point** (BRP) in its most generic form is a metric of stock status from a biological perspective. The biological reference point often reflects the combination of several components of stock dynamics (growth, recruitment and mortality, usually including fishing mortality) into a single index. The index is usually expressed as an associated fishing mortality rate or a biomass level. The procedure for estimating the reference point and the underlying model is agreed within the scientific community."

This project seeks to establish a system for improving status and trends reporting by both registering best scientific evidence and meeting the information requirements to ensure that global approaches to the Precautionary Approach are, indeed, "agreed within the scientific community".

[45] Gabriel, W.L., and P.M. Mace. A Review of Reference points in the Context of the Precautionary Approach. In Proceedings of the Fifth National NMFS Stock Assessment Workshop: Providing Scientific Advice to Implement the Precautionary Approach under the Magnuson-Steven Fishery Conservation and Management Act, Feb 24-26, 1998. NOAA Technical Memorandum NMFS-F/SPO-40.

Appendix 1: Systems and templates for reporting

STOCK ASSESSMENT AND STATUS MODULE TEMPLATES

a) METHODS

Information Element	Comment or example or suggested further action
METHOD REGISTER	
Parent Method	key to closest relative already registered.
Method class	VPA, Biomass Dynamic, Recruitment Index, etc.
Population model	key to Model Register: Schaeffer, Fox, Beverton and Holt, exponential decay model etc.
Link model	key to Model Register: Linear relationship between CPUE and population size, log-linear relationship between index and population size etc., Battacharya's method for constructing discrete cohorts from continuous length frequency, etc.
Fitting method	VPA tuning method, least-squares, ADAPT, maximum likelihood, Bayesian, etc.
Fitting description	How the fitting works, what it produces, verification of results etc.
Assumptions	constant variance, total catch data complete, terminal F known, etc.
Software Used	Helps fill out structure and checks choices using registered software list: CEFAS VPA Excel Add-in, ELEFAN etc.
Bibliography	URL to text books, journal article, web-site, ASFA ref. no, etc.
REFERENCE POINTS REGISTER	
Name	
Recommended use	(target/limit/threshold)
Symbol	
Mathematical description	
Narrative description	
Methods used to estimate the reference point	(keys to methods table)
Bibliography	(URL to journal article, web-site, ASFA ref. no, etc)
MODEL REGISTER	
Parent Model	(key to closest relative already registered)
Model name	(exponential decay, logistic, delay difference, etc)
Model type	(Population, growth, linear etc.)
Function type	(Probability, likelihood, simple function, difference time series, differential time series, spatial etc.)
Description	(how it works)
Equation	(the equation of the model above e.g. $B_{t+1} = rB_t\left(1-\frac{B_t}{B_\infty}\right) - C_t$, etc)
Parameter number, type, measure, names and descriptions	(number of parameters vary from model to model, e.g. r, B∞, for logistic; L∞, T0, K for von Bertalanffy, etc. For linear models, for estimating fishing power for example, the numbers of parameters may be very large.)

B) RESULTS

STATUS OF STOCK	
Stock	key
Status of stock	under-utilized, fully-utilized, over-utilized and unknown?
Reason	how did you make that appraisal (guess or assessment)? If unknown, why has there been no assessment?
Date of assessment	when was the assessment done?
Applicable year	for which year does the assessment apply?

STOCK ASSESSMENT METHODOLOGY USED	
Analysis Software Used	FiSAT, CEFAS VPA package, ELEFAN etc. – helps identify the method.
Method used	key to method register.
Method flag	standard, or developed.
Comments	identify minor adjustments made to standard method used - avoids registering new method for every slight change.
Bibliography	URL to model description in journal article, web site, ASFA ref. no, etc.

DATA USED	
Data type	catch/effort, length/age frequency, sex, maturity, recruitment indices, abundance indices, etc.
Times series	start and end year
Census or sampling?	
Data source	logsheet, landing sheet, observer programme, trade data, etc
Quality	key to quality types table
URL to data source	URL

ASSESSMENT	
Indicator type	Biomass, F, mean size, CPUE, etc see/develop list
Current estimate for the indicator	
Standard error of current estimate	
Reference point type	key reference points register.
Limit or target or threshold?	definitions required.
Reference point value	
Standard error of reference point value	
Probability	probability that the current indicator exceeds a limit or threshold reference point, or other similar test.
Management action recommended	Control rules,etc.

WORKING GROUP REGISTRATION	
Working group Title	
Date established	
Meeting date	
Reporting Person	Name and URL
Participants	Names and URLs

FISHERY MODULE TEMPLATES

STOCK CHARACTERISTICS	
Species	(key)
Location	(key)
Age at first maturity	
Length at first maturity	
Spawning season	
Spawning location	
Description of stock	
Maximum observed size by sex	

FISHERY CHARACTERISTICS	
Stock	(key)
Fleet	(key)
Gear types	(key)
Fishing grounds	
Fishing season	(start/end dates)
Catchability	
Selectivity by sex, maturity, age, etc	(e.g. age and length at first capture) (key to a model?)

DATA COLLECTION PROGRAMME	
Fishery	(key)
Type of data	(data variables)
Measures	
Method of collection	(logsheets, observers, interviews, etc)
Data quality category	(score, rank, etc)
Use	(stock assessment, monitoring, reporting, etc)
Data Description	

FISHERIES MANAGEMENT MODULE TEMPLATES

MANAGEMENT SYSTEM	
Resource	(1 or more stocks)
Authority	(key)
Resource management goal	
Description	

MANAGEMENT CONTROLS	
Management system	(key)
Control name	
Objective of control	
Description	
Start date(s)	
End date(s)	

AUTHORITIES/STAKEHOLDERS
Institution/company type
Institution/company name
Contact information
Responsibilities
URL

TIME SERIES MODULE TEMPLATES

TIME SERIES UPDATE	
Fleets **Catch** **Landings** **Commodities** **Aquaculture** **etc**	A single update module returns a series of forms on the current time series requirements at FAO. The user perceives that he/she has a dedicated table at FAO related to the country for each of the time series that are then updated and submitted. Appropriate time series, which require updating are defined by the user, known through the login.
Function: Close time series	

CREATE/OPEN TIME SERIES	
Time series type	(fleet, catch, effort, etc)
Type category	(e.g. for fleet, vessel type, size category, etc; for catch/landings, species)
Start Date	
Values	(e.g. for fleet, numbers of boats, total tonnage, etc)
Function: Restart time series	(if, for any reason, a time series was closed temporarily)

EXTERNAL STANDARD MODULE TEMPLATES

These are standard reference databases and should not require user input to any fields, including:	
Species	
Legal instruments	
Bibliographies	(e.g. ASFA)
WAICENT	(e.g. country profiles, etc)
Fishing vessel types	
Fishing gear types	
Fish product types	
Measures	
Fishing areas	(Geo-references etc to statistical, national and regional areas)

Appendix 2: Case studies of status and trends reporting by organizations

(Note: These case studies are abbreviated versions of those that appeared in the working documents of ACFR Working Party on Status and Trends Reporting, December 1999)

- **Appendix 2a: International Council for the Exploration of the Sea - ICES**

Role of the organisation

ICES is an intergovernmental organisation that provides and organises the development of scientific advice to member governments and regional commissions. In its recent draft Strategic Plan, ICES seeks to clarify its role through definition and explanation of its scientific objectives which it sees as follows:

1. Understanding the physical, chemical and biological functioning of marine ecosystems;
2. Understanding and quantifying human impacts on the marine environment including living marine resources;
3. Advising on the sustainable use and protection of the marine environment, including living marine resources; and
4. Coordinating and supporting interdisciplinary and international marine science programmes.

For nearly 100 years ICES has offered an independent framework for scientific advice about the contiguous oceans of the North Atlantic. Its main purpose and its clients' requirements revolve largely around the nature and extent of advice under 3 above, i.e. "… advising on the sustainable use and protection …". It does this through a number of mechanisms, principally through the Advisory Committee on Fisheries Management (ACFM) and the Advisory Committee on Marine Ecosystems (ACME), which are advised by more than 100 Working groups. For the main advice objective, the draft Strategy also explains the priorities, which are:

- Provide sound, credible, timely, peer reviewed and integrated scientific advice on fishery management and the protection of the marine environment requested by client commissions, Member Countries, and Partner organisations;
- Be proactive by maintaining a dialogue with clients to improve ICES understanding of customer needs and to publicise new developments in science which will assist in the husbandry of resources and protection of the environment;
- To publicise the work of ICES and the contributions that ICES can make for its stakeholders, and for the wider public audience, regarding the understanding and protection of the environment.

Status and Trends Reporting in Fisheries (STRF)

The summary reports of the ACFM Annual Report focus entirely on the status of the stock in question. In most cases the primary statement indicates whether harvesting is within or outside safe biological limits as defined by the proposed reference points. Management objectives (if any) are then stated along with summary advice on management. This usually consists of the required reduction in fishing mortality to achieve the required precautionary F_{pa}. The landings equivalent to this fishing mortality for the year are then given. The report recommends that, where single year reductions to Fpa are not possible, the approach should be through multi-annual recovery plans, although these may not be defined in terms of number of years or inter-annual targets. Table 1 summarises the general framework and format currently used by ICES in the summary reports.

Table 1: ICES/ACFM Summary Reports

Species …….. in Division/Area/Sea ……
Summary Comment:
Status of Stock: Statement whether the current harvesting of the stock is **Above/Outside**, or **Below/Inside**, or **At** safe biological limits.
Management Objectives: Statement on management agreements, if any, (e.g. within EC, between Norway and EC, etc) in relation to limits (B_{lim}, F_{lim}, etc) or, where none are explicit, a statement on what F_{pa} and B_{pa} should be.
Advice on Management: Reduction in fishing mortality by X% (in one year or multi-annual) to F_{pa}, corresponding to landing of Y tonnes in (year).
Reference Points: 1. Calculation of B_{lim} and F_{lim} and proposal for precautionary targets, B_{pa} and F_{pa}. 2. Technical basis for reference point calculation/estimate, e.g. estimates for B_{lim} (lowest observed SSB) and F_{lim} , and equation to calculate F_{pa} and B_{pa} from them.
Relevant factors to be considered in management: A narrative that may contain numerous features including the stock relationship with stocks/sub-stocks in other areas, state of reporting, recruitment and current effort management action and needs.
Catch forecast of (year): Table of predictions one/two years ahead under different scenarios (usually F); calculation of corresponding landings and resulting SSB one and/or two years ahead, plus the effect of fishing at that level on the status of stock in relation to B_{pa}.
Elaboration and special comment: A narrative on stock condition (recruitment/year class strength), status of the fishery (markets/vessels), trends in fishing mortality, abundance indices, etc.
Source of Information: Usually the Report of the (Species) Assessment Working Group for the (Area), Date, (ICES CM (year)/ACFM: X)

Summary Tables and Figures:

Catch Data: 1987 to date - including the advice given, the predicted catch corresponding to the advice, the agreed TAC, the actual (official) landing, the estimated discards and the ACFM assessment of actual landings. (Note that the latter can be greatly different from the official landings for many reasons, including area mis-reporting)
Stock Recruitment Relationship: At F_{high}, F_{med} and $F_{low.}$ Run number is identified.
Trend illustration: 1950 to date - Bar charts (Landings, recruitment), Graphs (Fishing mortality, spawning stock biomass)
Yield and Spawning Stock Biomass: Short-term and long-term forecasts
Landings: By year by country, including unallocated and discards
Stock History: 1970 to date; recruitment, spawning stock biomass, landings and fishing mortality (by age group)
Spawning stock biomass/fishing mortality relationship: Including illustration of F_{pa}/B_{pa} parameter space and SSB/F trajectory by year

For each species stock/area, advice is generally divided into summary comment followed by summary tables and figures. Thus, they cover a large proportion of the information required for reporting on stock status and trends. The layout and style of these reports has improved considerably over the years but there is agreement to take these reports further in anticipation of various needs.

First, it has been recognised that a Census of Fishes is required and planning for that - to be supported by the Sloan Foundation - is well advanced. Second, it is also recognised that the issue of criteria for sustainable fisheries (certification/eco-labelling, etc) needs careful consideration. In support of the public pressures to address this latter issue, the Nordic Council of Ministers have proposed an "information programme with the aim to provide consumers, as well as the public in general, with reliable information on fisheries, to enhance knowledge and public awareness including a report by ICES on the north east Atlantic and fish stocks". Accordingly, the ICES Council agreed to establish a Steering Group on the Pilot Project on the Status of Fisheries and Related Environment of Northern Seas (SGFIRENS), the report of which will be considered at the ICES Annual Science Conference in October 1999. The primary requirement is "to provide the best available scientific information in an easily understandable format".

Several ICES Working Groups are involved in issues related to STRF. In particular, the ICES Resource Management Committee has a "scientific area of responsibility (which) should provide a bridge between fisheries and environmental issues, and between science and management. It should therefore be responsible for developing methods to:

- assess the status of exploited living resources;
- evaluate the effects of alternative exploitation and management strategies on the resources, and economic and social aspects of exploitation and management; and
- in consultation with the Marine Habitat and Oceanography Committees, take into account natural environmental effects and anthropogenic effects other than fishing, in resource management decisions."

Thus, ICES endeavours to look beyond the traditional area of stock status reporting towards a more integrated approach to fisheries. Indeed, ICES is also collaborating with the OECD Fisheries Committee for the establishment of a Fisheries Science Programme that will, among other things, develop models for the dynamics of a fishery in relation to its stock.

- **Memoranda of Understanding**

Recently all commission clients have negotiated and agreed the broad range of the advice they require through agreement via Memorandums of Understanding, all of which are slightly different according to client needs. These documents all contain the following key features:

- full recognition of both party's rights and responsibilities;
- the nature and conditions under which advice is sought and provided;
- the financial and general administrative arrangements for the relationship; and
- annexes describing the form and content of the advice required.

The annexes provide a list of the required advice relating to defined species, e.g. NASCO (Salmon), IBSFC (6 species), NEAFC (25 species). They also contain narratives about transparency, understandability, explanation of uncertainty and feedback (e.g. when further related advice is required). Of particular importance seems to be the continuing demand that advice is given which is independent, free from political influence, has been peer-reviewed and is, above all, timely. This form of relationship - based in essence on general contract law - is becoming required more often, partly to assure accountability and partly to establish the formal administrative and financial relationships, particularly now that ICES operates 100% cost recovery for its services.

In Table 2 the advice required by IBSFC is described. This is similar to the MoU for NEAFC but is completely different from that required by NASCO, for example. In the increasingly complex and information intensive world of fisheries science and management it is essential and inevitable that formal written descriptions of requirements are established, partly as reminders of work commitments but also, under the emerging strictures of 'user pays', as the basis for cost recovery.

Further explanation of the form of ICES advice is contained in section 1.1 of the 1998 ACFM report, which provides its current interpretations of the stock status parameters Blim, Flim, Bpa and Fpa.

Table 2: Standard advice from ICES

Annex 1: Layout of "Standard" (recurring) advice required from ICES by (this example based on IBSFC)

The standard layout contains an area overview for all stocks (Cod, Herring, Sprat, Flatfish, Salmon and Sea Trout by appropriate stock areas), by stock of:

- Development of Landings
- Fishing mortality
- Recruitment
- Spawning stock
- Historic development of the fisheries
- State of Stocks
- Short-term forecast table including for some stocks catches
- Medium-term consideration based on risk assessment
- Long-term consideration
- Management advice and recommendation
- Elaboration and Special comments
- Environment information of relevance to management
- Relevant technical and ecosystem interactions related to the point immediately above
- Data and assessment
- Source reference and tables and figures to support the text and conclusions

The content of the advice will reflect the request confined by the availability of data and knowledge about the biological, physical and technical processes. ICES should elaborate and make the advice as transparent and understandable as possible, including explicit explanation of uncertainties associated with the advice.

The Management advice and recommendations should also take into account the international obligations to gradually implement the precautionary approach and ICES undertake to establish a close co-operation of mutual benefit to develop this topic.

There are some stocks for which the standard advice form does not apply, notably the salmon stocks in the Baltic. These stocks would in principle be treated in a similar manner, but with reference points such as escapement or production targets. If a request is within the working format, it should not be regarded as an additional request.

IBSFC applies a number of management measures to secure sustainable fisheries such as closed areas and seasons, effort limitations, minimum mesh size in nets and minimum hook sizes. ICES routinely evaluates and reports, as part of the assessment of the status of the stocks, whether these measures are effective in achieving the targets defined under the precautionary approach. A request on evaluating a change of these measures should be regarded as part of a standard assessment.

Coordinating Group on ICES Advice (CGADV)

At the Annual Science Conference in 1998 the Council asked the CGADV to prepare a draft ICES Quality Policy, initiate the development of Quality Management Procedures (QMP) and prepare for their implementation. A first step in this direction has been the preparation of a proposal for an ICES Quality Policy. That document re-iterates the 4Rs - that ICES advice shall be Right, Relevant, Responsive and Respected.

The Quality Policy proposal is far-reaching and takes into account realistic assumptions about the way things work, current institutional arrangements and how improvements to the procedures might be reasonably achieved. In essence, the proposal suggests that Stock Assessment Working Groups do not conduct actual stock assessments but that these are prepared as a scientific report by “contracted laboratories” (most usually, and following some current practice, the national laboratories). The Working Group is responsible for:

- review of data (accessibility, scale, precision, accuracy, etc);

- methodology (established through review by a methodological science committee or publication in a peer-reviewed journal);
- verifying the subsequent conclusions of the scientific report; and
- formulation of the scientific conclusions in a format for direct use by the ACFM.

Other assessment and advice issues

Stock assessment and the consequences of stock removals clearly remain the key features of ICES advice. Increasingly, however, it is anticipated that future ICES reports of status and trends in fisheries will require socio-economic inputs, and this is evident in the cooperative work with OECD mentioned above.

In addition, there is rising acceptance of the need to address ecosystem management as an essential part of the overall assessment of living marine resources sustainable use. Again, part of the process will be to establish objectives, methods and standards in this emerging approach. Recent attention to this issue (Workshop on Ecological Quality Objectives, 1-3 September 1999, Scheveningen) made some progress towards a structured view by:

- defining what is meant by ecological quality (ECOQ), ecological quality objectives (ECOQO) and associated reference levels;
- setting the range of objectives within a structure of Lower (Species), Middle (Habitats and Communities) and Upper (Ecosystem) levels;
- reviewing some of the possible ECOQO at each level, from benthic indicator species through biodiversity indices to nutrient budgets and production at the lower, middle and upper levels.

- **Appendix 2b: International Commission for the Conservation of Atlantic Tunas - ICCAT**

Role of the organisation

ICCAT is established by international convention with a mandate to coordinate and present tuna fisheries research throughout their range in the Atlantic Ocean and adjacent seas. At the end of 1998 there were 26 contracting parties. It also establishes a forum through which management of tuna fishing can be conducted for all stocks across their migratory ranges. Through the convention it is established that it is the only fisheries institution in the Atlantic with competence for tuna. The forthcoming South East Atlantic Fisheries Organisation (SEAFO) has specifically excluded highly migratory species. The SEAFO convention will make it clear that its parties should cooperate with ICCAT on tuna issues.

ICCAT undertakes highly complex tasks, grown more complex by recent international agreements. What ICCAT lacks in species complexity compared to other fishery bodies, it makes up for in the number of contracting parties and geographic range.

Advisory structures

The Commission manages its affairs and conducts its scientific and management work through several bodies;

- **The Standing Committee on Research and Statistics (SCRS).**

The SCRS supervises and reports on all scientific investigations; it prepares and finalises the stock and yield assessments for 9 species or species groups. The Commission considers the scientific reports of species working groups and develops recommendations for approval or agreement by contracting parties. There are objection procedures.

Scientific reports are also prepared as Species Executive Summaries by the SCRS. These are published, along with the Report of the Commission meeting, as the main substance of the Report of the SCRS. In 1998, the coverage of the SCRS report (including its subsidiary bodies and national reports) required printing as a second volume. The Species Executive Summaries adopt a standard format (see section below).

The SCRS also maintains Sub-Committees on Environment, Statistics and By-catch; it supervises the conduct of permanent Species Working Groups and Ad-Hoc working groups.

- **The Compliance Committee**

The Compliance Committee reports to the Commission on the conduct of contracting and non-contracting parties to administrative and conservation measures. Continuing concern is expressed about the status of statistics although many issues in relation to historical time series are being gradually resolved. Other issues of current concern such as the Port Inspection Scheme, the application of and compliance with Conservation Measures, and matters that require direct contact with contracting parties are reported.

- **Permanent Working Group for the Improvement of ICCAT Statistics and Conservation Measures (PWG)**

The PWG considers Commission, Secretariat and national views on compliance with recommendations and decisions on statistical reporting, catches and activities by all parties in relation to conservation measures and other matters. The PWG also recommends matters and responses from the Commission that require direct contact by letter with any parties concerning collaboration and cooperation, statistical submissions and compliance with conservation measures.

Information and Stock Assessments

- **Sub-committee on Statistics**

This sub-committee reviews the coverage and complexity of the Statistical Bulletin46 and Data Records47, current and revised time-series submitted by parties, data management and other issues. In 1998, specific reference was made to:

- the publication of software packages (TUNASTAT and CATDIS) on the ICCAT web page;
- need to address the issue of historical data; and
- establish a Working Group on Data Management which would address an Information Quality and Distribution Policy (this is now under way).

- **Sub-committees on Environment and on By-catch**

The Environment sub-committee reviews the nature and condition of the environment, including analyses of the effect of variability on the catchability of the stocks. In 1998, attention was drawn to the need to integrate environmental information ("indicators") into the stock assessment process. In particular, it referred to the need to adapt time-area strata according to ecological aspects of the resource.

The By-catch sub-committee considers the problem of by-catch of fish and birds. In particular it addresses the issue of sharks and seabirds incidental catch and through it participates in the Plan of Action on this.

Executive Summary Reporting Format

Species working groups report to the SCRS through Executive Summaries for Yellowfin, Bigeye, Skipjack, Albacore, Bluefin, Blue marlin, White marlin, Sailfish, Swordfish, Southern bluefin and small tunas. These Executive Summaries provide all the key information, though not the full range of discussion or detail of analysis, on the biology, description of the fisheries, state of the stocks, medium-term outlook, effects of the current regulations and management recommendations. These narratives are then followed by a summary of key information; MSY, replacement yield, spawning stock biomass, relative biomass, fishing mortality and regulatory measures in effect.

In support of these descriptions, analyses and findings, the Executive Summaries contain tables of nominal landings, catch distribution maps, graphs of catch (often back to 1950), summary model graphs (with scenarios/tuning/runs), trends in SSB, F, Y/R, CPUE, etc.

No reference is made, at least in the 1998 report, to the origins of the analyses. Nor is there any record of whether the methods applied and the results obtained were independently reviewed as to their appropriateness or accuracy. See Table 1: ICCAT Summary Reports.

[46] ICCAT. Statistical Bulletin. Vol. 28 -1997

[47] ICCAT. Data Record. Vol. 39 - March 1998.

Table 1: ICCAT Summary Reports

Executive Summary Reporting Format

For each of the following species - Yellowfin, Bigeye, Skipjack, Albacore, Bluefin, Blue marlin, White marlin, Sailfish, Swordfish, Southern bluefin and small tunas - the Executive Summary includes narratives and key summary figures as follows:

Summary Narratives:

Biology:
stock(s) distribution, spawning distribution, schooling behaviour, size range, size by sex, size at maturity, natural mortality

Description of Fisheries:
Fishery types (longline, baitboats, purse seine), flag vessels operating, average size by fishery, development of catch history, trends in catch-at-age.

State of the stock:
Type of model used for assessment (if any), estimate of MSY and corresponding effort in standard days (by model), % of Bmsy, recruitment and spawning stock biomass and mortality (trends by different model with scenarios/tuning), minimum size/weight to increase yield per recruit

Outlook:
Predicted biomass/yield trajectory under current levels of fishing effort

Effect of current regulations:
Nature of the regulation (size at first capture, gear/season/area limits; ICCAT and voluntary), proportion of undersize fish, reduction/increase in effective fishing effort

Management Recommendations:
Effective fishing effort, recommended allowable catch (either as total or as some % of annual average)

Summary Figures:

Tables: Nominal landings (1975- present) by flag, fishing gear and ocean or region

Map: Geographical distribution of catch, Usually by graded pie symbols

Graphs: Accumulative catch 1950-present, catch-at-age

Stock assessment graphs for various stock attributes:	
Abundance indices Production curves Spawning stock biomass Fishing mortality rates	Yield per recruit curves SSB projections Stock size Yield projections

(SPECIES) TUNA SUMMARY

Maximum Sustainable Yield (likely range)	X00,000 - Y00,000 MT
Current (YYYY) Yield	X00,000 MT
Current (YYYY) Replacement Yield	X00,000 - Y00,000 MT
Relative Biomass (Byy/Bmsy)	0.X - 0.Y
Relative Fishing Mortality	Fyy/Fmsy (etc) 0.X - 0.Y
Relative Spawning Stock Biomass	SSByy/SSBref (etc) 0.X - 0.Y
Management Measures in effect: e.g. minimum size, X% of average catch from YYYY-YYYY, etc	

- **Appendix 2c: United States National Marine Fisheries Service - NMFS**

Report to Congress:

The key annual report made by the US National Marine Fisheries Service (NMFS) is its Report to Congress[48]. The status of each fish stock (total 544) is set against the 4 conditions; overfished, not overfished, approaching an overfished condition and unknown. The requirement for this report is set out in the Sustainable Fisheries Act[49], which also provides statutory definitions of overfished and overfishing. Apart from the previous year's information, no other trend analysis is provided in this report.

The report to Congress provides a stock-by-stock assessment of status and condition, including the basis of the overfishing definition, e.g. fishing mortality rate, stock level, or both. It then goes on to describe the definitions of overfishing for each fishery in a similar format, such as the following for the Bering Sea/Aleutian Islands Groundfish fishery.

> " (… Full list of all species ...)
>
> Overfishing is defined as any amount of fishing in excess of a prescribed maximum allowable rate. This maximum allowable rate is prescribed through a set of six tiers [which are listed in Appendix 4] in descending order of preference, corresponding to descending order of information availability. The SSC *(Scientific and Statistical Advisory Committee)* will have final authority for determining whether a given item of information is "reliable" for the purpose of this definition, and may use either objective or subjective criteria in making such determinations. For tier (1), a "pdf" refers to a probability density function. For tiers (1-3), the coefficient is set at a default value of 0.05, with the understanding that the SSC may establish a different value for a specific stock of stock complex as merited by the best available scientific information. For tiers (2-4), a designation of the form "$F_{X\%}$" refers to the F associated with an equilibrium level of spawning per recruit (SPR) equal to X% of the equilibrium level of spawning per recruit in the absence of any fishing. If reliable information sufficient to characterize the entire maturity schedule of a species is not available, the SSC may choose to view SPR calculations based on a knife-edge maturity assumption as reliable. For tier (3), the term $B_{40\%}$ refers to the long-term average biomass that would be expected under average recruitment and $F=F_{40\%}$."

The statement is similar in intent (if not scope) for all fisheries and includes three key issues;

- The definition of overfishing.
- The control rules prescribed which depend on a range of criteria in respect of information availability and reliability, for which both objective and subjective criteria may be applied.
- Definition of some of the terms within the Control rules.

The definition may be related to allowable biological catch, fishing mortality, biomass, MSY, OY, and various forms of spawning stock indices. The "Six Tiers" containing control rules referred to, and the acronyms used, are attached.

Our Living Oceans (OLO)

The mandatory Report to Congress provides the basics. However, NMFS, its associated centres and the regional Fishery Management Councils (FMC) also offer a very wide range of documents that report on fishery status and trends. In particular, the Our Living Oceans: the Status of U.S. Living Marine Resources (Vol.1) series comments on the state of fisheries in the widest sense, for the widest possible audience, the nation. The series has been extended, beginning in 1996 with Our Living Oceans: the Economic Status of U.S. Fisheries (Vol.2), and with expected completion of Our Living

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[48] NMFS. Report to Congress: Status of Fisheries of the United States. September 1998.

[49] Magnuson-Stevens Fishery Conservation and Management Act. 1996. (Public Law 104-297) Section that refers to``(e) Rebuilding Overfished Fisheries" is as follows: ``(1) Reports. The Secretary shall report annually to the Congress and the Councils on the status of fisheries within each Council's geographical area of authority and identify those fisheries that are overfished or are approaching a condition of being overfished. For those fisheries managed under a fishery management plan or international agreement, the status shall be determined using the criteria for overfishing specified in such plan or agreement. A fishery shall be classified as approaching a condition of being overfished if, based on trends in fishing effort, fishery resource size, and other appropriate factors, the Secretary estimates that the fishery will become overfished within two years."

Oceans: the Status of Habitat for US Living Marine Resources (Vol.3) in 2000. The FMCs contribute to the OLO series by reporting on the conduct of their Fishery Management Plans (FMPs) for their region.

Because these reports are for public consumption they offers slightly different measures of status to the mandatory requirements of Congress. In relation to stock status Vol.1 classifies stocks according to their abundance relative to the level that would produce the Long-term Potential Yield (LPTY, which is analogous to MSY) - the indicators being below, near, above and uknown. These are directly analogous to the categories submitted to Congress, overfished, not overfished, approaching an overfished condition, and unknown. In addition, it reports on the status of utilization of the stocks as being underutilized, fully utilized, and overutilized or unknown. These are determined by comparing the existing fishing effort with the appropriate levels necessary to achieve LPTY.

OLO (Vol.2) reports that "Detailed economic analysis … would probably reveal that … most US fisheries can probably be characterised as overcapitalised with too many vessels, too much gear and too much time spent at sea harvesting fish at a higher than optimal cost per unit of effort…". Demonstrating this is reported to be difficult not least for the reason that the information needs to undertake the economic analysis is incomplete. The report identifies data needs, analysis and economic information for the harvesting sector for an extensive range of economic data but routine availability of this information is poor, some is available by special study and some not available anywhere. Nevertheless, this report seeks to describe the status of fisheries through the gain or loss of net economic benefits.

The FMCs, from which the information in the OLO series is drawn, also prepare SAFE documents - Stock Assessment and Fishery Evaluation. These provide summaries of the most recent biological condition of species and the social and economic condition of the recreational and commercial fishing interests and the fish processing industries.

Advances in marine fisheries science, information and fishery management objectives

The driver for the major advances being made in the framework for assessing and managing US marine fisheries has been the Sustainable Fisheries Act. This establishes and requires the elaboration of ten National Standards, which NMFS has interpreted into National Standard Guidelines (NSGs). NSG 1 is for Conservation, avoiding overfishing and achieving optimum yield (OY). Technical guidance on implementing this has been prepared.[50] This provides the most comprehensive coverage of control rules and status determination criteria yet published, and includes methods for choosing and deriving them in different situations and under special considerations.

In support of these developments the National Research Council established a Committee on Fish Stock Assessment Methods (similar to the ICES Working Group on Methods of Fish Stock Assessment), which published its findings in 1998[51]. NMFS also conducts regular Stock Assessment Workshops, the most recent to address scientific advice in the precautionary approach[52]. The relevance of these issues to the present study is that greater effort is now being placed on formalising the key rules and processes that are required to understand and report on fish stock status and trends. The seemingly simple statement that precautionary approaches to fish harvesting is mandatory has obliged focused attention to what this means and how it can be determined quantitatively.

[50] Technical Guidance on the Use of Precautionary Approaches to Implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Tech. Memo. NMFS-F/SPO-## (draft, July 17, 1998)

[51] Improving Fish Stock Assessments. Committee on Fish Stock Assessment Methods, Ocean Studies Board. NA Press, 1998.

[52] Providing Scientific Advice to Implement the Precautionary Approach Under the Magnuson-Stevens Fishery Conservation and Management Act. Proceedings of the Fifth National NMFS Stock Assessment Workshop. February 1998, NOAA Tech. Memo. NMFS-F/SPO-40. July, 1999.