PREPARATION OF THIS DOCUMENT

The 20th Session of the Coordinating Working Party on Fishery Statistics recommended that the Secretariat (FAO) should investigate the nature and extent of calls for improving the quality of fishery statistics, including a review of progress and further approaches to the issue of fisheries data quality indicators. (See terms of reference at Annex 1.)

Fisheries Data Quality Indicators: Review of progress and possible approaches to addressing data quality and cost-effectiveness. Rome, FAO. 2003.

ABSTRACT

This paper reviews the approaches being undertaken in national and international institutions on general statistical data quality issues, plus attention to the information focus required for the sustainable conduct of appropriate fisheries management for sustainable fish stock use.

It outlines an approach to initial implementation of some elements of the *Strategy for Improving Information on Status and Trends of Capture Fisheries* and the *Code of Conduct for Responsible Fisheries*. In particular, it addresses the Strategy's call for improved data quality, which has provisions concerning criteria and methods for ensuring information quality and security, including the issue of 'applicable confidentiality'.

It also outlines the basis for developing an understanding of the cost-effectiveness of improved statistical projects and programmes in supporting improved fisheries science and better management.

Contents

BOXES

LIST OF ACRONYMS

ACFR	Advisory Committee on Fisheries Research (FAO)
AIDCP	Agreement on the International Dolphin Conservation Program (IATTC)
APFIC	Asia-Pacific Fishery Commission
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCRF	Code of Conduct for Responsible Fisheries
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CECAF	Fishery Committee for the Eastern Central Atlantic
CWP	Coordinating Working Party on Fishery Statistics
CEC	Commission for the European Community
DQAF	Data Quality Assessment Framework
EOS	Earth Observation Summit
EU	European Union
Eurostat	Statistical Office of the European Communities
FAO	Food and Agriculture Organization of the United Nations
FFA	South Pacific Forum Fisheries Agency
FIDI	Fishery Information, Data and Statistics Unit (Fisheries Department, FAO)
FIGIS	Fisheries Global Information System (Fisheries Department, FAO)

FIRMS	Fishery Resources Monitoring System
GOOS	Global Ocean Observation System
IGOS	Global Observing Strategy Partnership
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
ISO	International Standards Organisation
IMF	International Monetary Fund
IOTC	Indian Ocean Tuna Commission
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
ISSCFV	International Standard Statistical Classification of Fishing Vessels
IUU	Illegal, Unreported and Unregulated Fishing
NAFO	Northwest Atlantic Fisheries Organization
NASCO	North Atlantic Salmon Conservation Organization
OECD	Organisation for Economic Cooperation and Development
PARIS21	Partnerships in Statistics for Development in the 21st Century (OECD)
RFB	Regional Fishery Body
SEAFDEC	South-East Asian Fisheries development Center
SPC	Secretariat of the Pacific Community
STATLANT	STATistical Programme for the ATLANTic Fisheries
TAC	Total Allowable Catch
UNCED	United Nations Commission on Environment and Development
USAID	United States Agency for International Development
VMS	Vessel Monitoring System
WCPO	Western and Central Pacific Ocean

Executive Summary

This executive summary outlines the issues and approaches to data quality that are currently in place and widely recognised by national and international policy, management and research agencies. It begins with a general introductory overview of data quality, followed by sections on the Institutional focus, a Fisheries focus and an Issues focus. The paper then ends with a suggestion for next steps in implementing the Strategy-STF on Status and Trends, and a conclusion on how to advance participation in this implementation. As the issue of data quality has received diverse and detailed attention, a selection of key activities, standards and developments are highlighted within the main body of the paper as text boxes and, where appropriate, in summary in eight Annexes.

Introduction:

The subject of data quality is consistently addressed in many international forums and arrangements, including many parts of the United Nations system and other institutions such as the Commission for the European Community (*CEC*) and the Organisation on Economic Cooperation and Development (*OECD*). For their own national purposes and to enable international participation, States have always addressed data quality from both practical and theoretical perspectives. New approaches stem from a growing consensus that governmental and intergovernmental policy and management decisions are increasingly reliant on better data if they are to be effective. Further, that such data must meet statistical rigor; must be appropriately transparent and available; and should be shared through the advent of new communications and data interaction technologies, in particular the Internet. The overall data quality concept and the international recognition of its importance are reviewed in the Introduction.

Institutional Focus:

Natural resources understanding, and general human activities in relation to the need to ensure natural resources sustainability, must respond to information requirements and circumstances that change over time, particularly as science improves. The global community has reached significant and substantial understandings about the criticality of data usage at the United Nations Commission on Environment and Development (*UNCED*) in 1992 and 2002. These acclaimed and rigorous forums effectively declared the recognition that all aspects of the environment need improved understanding. Furthermore, that economic use of the environment requires assessment of human impacts and the introduction and maintenance of environmental stability and productivity, to ensure sustainability now and for future generations. Information availability and data quality concerns are prime issues throughout many developments since RIO ’92, including the Code of Conduct for Responsible Fisheries, etc.

This review summarises approaches being taken at several international levels in the appropriate attention to fisheries data and statistical requirements, both at the specialist level and by the broader community of statistical users. The positive likelihood is that as nations are also doing this, they are probably intensifying their participation in and their demands on UN and other regional or sectoral approaches. The *OECD* has established a programme that recognises the policy-related data needs in developing countries and has lead to a new consortium called the Partnerships in Statistics for Development in the 21st Century (*PARIS21*). This is to initiate statistical capacity building programmes and the development of Strategic Statistical Master Plans in support of policy frameworks and country strategies. Partnership is also a fundamental requirement of the Code of Conduct for Responsible Fisheries (*CCRF*). Other institutions and information programmes are also briefly reviewed, including the Global Ocean Observation System (*GOOS*) and others.

Fisheries Focus:

Assessment of human impacts means the need to ensure the availability of useful information at all levels. First, there is the accepted modern vision that fisheries take place within ecosystems and that full ecosystem approaches to fisheries management will clearly contribute to sustainability. Second, many non fishing human activities will impact on fisheries’ environments now and in the future. These will include the activities directly related to natural physical, chemical and biodiversity domains, but also direct human influences, particularly in relation to coastal development and human effluent. Last, during the past 50 years fisheries and general

marine technology, and food needs, have taken fisheries to as wide a reach as possible across the globe. Where established for centuries, most often close to human populations, fisheries have often been subject to overexploitation and fish stock population crashes. The far and deep ocean fisheries have grown rapidly and discoveries of many further fish populations are now believed to be much less likely. Given our knowledge of these circumstances, our improved science and understanding, and our recognised goal of sustainability, it is believed that fisheries can be maintained at productive levels through appropriate precaution,. It is further understood that precaution can be achieved partly by better control of all fisheries to exploit aquatic populations within definable precautionary limits, often referred to as reference points. Beyond the theoretical basis, reference points require large amounts of data with known quality characteristics.

Of particular note, beyond the largely enclosed concerns of States on their agriculture, industry, health, etc, is that the oceans and shared freshwater systems are the complex concerns of international partnerships. These range from relatively simple bilateral arrangements, for example on rivers and lakes, to regional arrangements that may be limited to 200 mile zone jurisdictional relationships in defined areas of the ocean under United Nations Convention on the Law of the Sea (*UNCLOS*). What has always been recognized, and what is now moving towards global completion, is that the open commons of the high seas are also becoming subject to international partnerships (often simply called Regional Fishery Bodies - RFBs), on which there has been much progress in recent years. This review addresses the information aspects of international agreements, the *CCRF* and *IPOAs* which is then followed by a review of the institutional activities of *FAO* and its linkages.

Also of particular note and in relation to the origin of this review is the Coordinating Working Party on Fisheries Statistics (*CWP*). When the Atlantic Ocean predominated in global fisheries, the responsible RFBs established the CWP for the direct implementation of data standards throughout the Atlantic. Significantly, the CWP has expanded its interests and membership to all global oceans and waters, and recently has participated in the further development of data standards and the implementation of appropriate partnerships for these oceans and waters. The CWP has also supported other international initiatives such as the focus of the FAO Advisory Committee on Fisheries Research and the Strategy-STF for Improving Information on Status and Trends of Capture Fisheries (the *'Strategy-STF'*). Implementation of this Strategy-STF is now under way in the FAO Fisheries Department's FishCode Programme.

Issue Focus:

The institutional and programmatic reviews are followed by a general review of issues in fisheries data that are the main subject of this paper. These include the general acceptance of the ecosystem approach to fisheries management, the growing use of the precautionary approach, confidentiality and partnership, data use records and metadata, and the basis for methods to achieve data cost-effectiveness.

A key feature of these perceptions (discussed more in later sections) is related to society's need to provide relevant and useful data in a cost-effective manner. Collecting, managing and using data (and their statistical derivatives) always invoke significant costs in all sectors, whether the costs are related to planning, implementation and/or change, both for immediate purposes and to meet expected future requirements.

Next Steps and Conclusion:

In conclusion, the paper outlines the adoption of a phased work programme (Working Group, Expert Consultation and ACFR Review) process with the particular aim of establishing a framework to 1) address the guiding principles that were adopted under the Strategy-STF, and to 2) address information availability to all potential users from other scientific and management domains.

This suggested work programme will develop an acceptable international approach (including research and development) to develop standards and to seek ways and means to assist stakeholders (in particular in developing countries) in improving their capacities to collect, use and disseminate data according to their needs and recognised requirements.

Introduction

1. The Quality Concept of Data and Resultant Statistics

Quality assessment of data and statistical derivatives (both are 'the products' mentioned below) is often defined as a subjective opinion of whether the quality is good or bad. Quality assessment, however, does not depend solely on the product but, rather, on a combination of product and purpose. A single dataset or statistic (the products) may be good for one application and bad (or simply not useful) for another. Such information should possess attributes that meet theoretical decisions and a full understanding of their purpose, including decisions about bias, variance, combinatorial status with other datasets or statistical parameters, and practical issues such as coverage, cost, timeliness and many others.

Given that the users of a dataset or statistic are widely distributed and need it for different purposes, the notion of total quality has the following components[1]:

- *'A product's quality is determined by both the existing and potential opinion of users of the product and its **fitness** for their purposes in using it.*
- *The quality concept should reflect all aspects of a product that affect users' views on how well the product **meets their needs** and expectations.'*

2. Fisheries Data Quality

Recent and detailed attention to fisheries information on a global and research scale were undertaken by the Advisory Committee on Fisheries Research in 1999 at its Working Party on Status and Trends of Fisheries[2]. This is described further in later sections of this paper, but for the purposes of this introduction ACFR raised the following issues and came to agreement on further approaches. There are 9 essential quality criteria that would underpin any advice that might be required for fisheries status and trends reporting (and, of course, other research issues).

In summary the quality of fisheries science needs processes that are transparent, responsive, independent and consensual (including the acceptance of alternative views), The results of such process achievements should be integrated, credible and quality controlled. And, as part of the overall process and for acceptance and use of results, both process and results quality criteria should be subject to both internal and external peer review (see table 1 below).

Table 1. Criteria, Definitions and Methods: a framework for fisheries science quality assurance.

	Definition	*Methods*
The PROCESS should be:		
Transparent	The process, rules and procedures are well-defined and public knowledge.	▪ Tender rules ▪ Statutory arrangements ▪ Institutional publishing
Responsive:	Timely and flexible to changing needs, while ensuring best practice.	▪ Tasks should be well-defined and timely ▪ Request should be 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 on the process should include any alternate views, incorporated as additional uncertainties to the general mathematical or conceptual uncertainties.	▪ Rules of procedure require no 'minority', externally published reports. ▪ Sufficient time given to reach consensus.

[1] Encyclopedia of Statistical Sciences. Quality Concept for Official Statistics, Update Volume 3. John Wiley & Sons, Inc. pp 621-629.

[2] ACFR: Working Party on Status and Trends of Fisheries. Data and analysis issues: meeting standards, information quality and accessibility. ACFR:STF/99/INF.4

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. ▪ Theoretical research.
Quality Controlled	Procedural error-detection at appropriate times/stages.	▪ Process for quality control established externally to the 'group'.

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 the best scientists, and others, as appropriate, external to the institution, state or region.

The ACFR also noted other definitions of data quality, as follows:

Definitions of quality

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

3. Data Use

Each user may have a different view of a product's *fitness* and the degree to which it *meets their needs*; hence its quality assessment against theoretical and practical needs will be different for a user's purpose.

For example, total fish catch, say, by unique species is a dataset with different characteristics used for different purposes. Tasks of fisheries management, such as total allowable catch

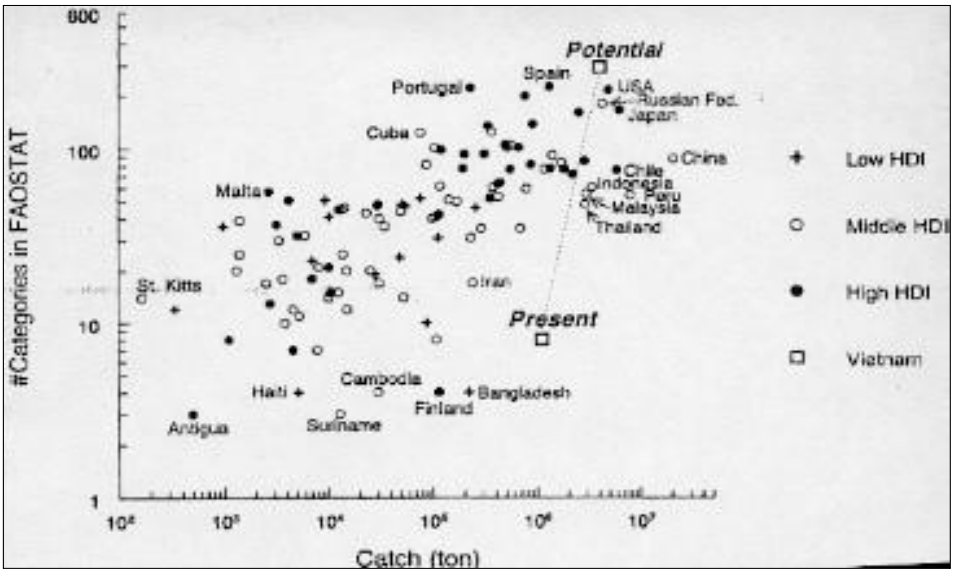
(TAC) or quota compliance control, require total enumeration of fish catch with coverage (including distribution), accuracy and timeliness requirements that are different from other study domains. Fisheries science for population dynamics may require different total fish catch product characteristics (coverage, etc) to contribute towards the timely completion of stock assessments.

Purpose may overlap to some degree. For example, quota control of total catch will contribute to both sustainability through exploitation control and to generating natural resource rent from legal and economic perspectives (compliance control and governance taxes, such as quota/licence payments). Also, for example, stock assessment, which may use total catch at different times during the species' assessment cycle, is a primary decision for fishing industry production certainties. In addition, stock assessment is also a contribution to understandings about an intensely utilized aquatic ecosystem. In the latter case, of course, there are many non-fishery sectors that use or impact the ecosystem, and which are responsible for using basic information, such as total catch, for their analytical purposes. The private sector (most often the primary data source) might benefit from nearly instantaneous catch and catch rate information, which it generates and uses for food production, business planning and market responses, including fish processing, fleet deployment and fishing distribution.

The widespread use of data sets for a review of fishery status position and future potential need not be purely analytical, perhaps presentational. An example of this requirement and presentational approach demonstrates that setting catch against another index can provide policy, development and management guidance (see Box 1.).

Box 1 - Presentation of Catches against the Human Development Index

In the journal paper[1], the total country marine catches in 1999 for 116 countries were extracted from FAOSTAT and set against the number of published species categories. All countries were categorized against the Human Development Index (HDI) published by the UNDP, noting that the HDI is an aggregate of indicators on Gross Domestic Product per capita, Adult Literacy Rate, Combined gross enrolment ratio and Life Expectancy.



The graphic presentation (see above) used a simple analysis for Vietnam based on the number of marine species categories currently reported (= PRESENT) and the new categories and the small total catch increase that were becoming available through a major improvement in the Catch and Effort Data Recording System (CEDRS) (= POTENTIAL). Thus, improved data quality through the new CEDRS (simply the number of categories of marine species) would contribute to the effort of fisheries policy and management to make a range of fisheries decisions.

Such a presentation assists policy makers and managers to make improved data decisions, including the scale and quality of data needs (in this case relatively small) and the costs and benefits within a global framework of comparison.

[1] P A M van Zweiten et al. Vietnam fisheries. Marine Policy 26, 2002, pp 13-34.

4. Data quality requirements and information partnerships

Each domain within fisheries and ecosystem utilisation may apply different quality declarations to the same product in ways that meet their requirements. Each may have a cost to pay for the data quality they have in mind or need. The application of real financial resources by users to data with a declared quality that meets their needs will, therefore, have different assessments of cost-effectiveness. In some circumstances, poor cost-effectiveness may generate further investigation of alternate theoretical and analytical approaches (models, equations, programming, etc), perhaps by obtaining the correct results from more limited information systems, or by other source and accessibility.

Some of the issues that will inevitably arise concern transparency and information sharing. There need practical schemes to which parties can agree to ensure this accessibility is 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.*

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.

5. Data collection and dissemination

Hitherto and significantly continuing, people do fisheries data collection and data supply, but the modern advent of data collection and communications technologies brings new and ultimately cheaper methods that enhance both data quality availability and cost-effectiveness. For example, while vessel monitoring systems (VMS) are being legitimated largely for compliance control of fishing operations, other VMS benefits will, in future, stem from higher spatial and temporal quality characteristics that benefit stock and ecosystem research.

It is expected that VMS will also eventually support the delivery of the electronic logbook; a primary source of fishing data with quality characteristics (including timing, transcription error control and source responsibility achievements – the metadata) that will reduce data costs and increase effectiveness. In the past, and in most fisheries at present, more and better data could not be achieved without significant cost increases. However, the VMS source direct from fishing vessels and the transparency of information dissemination will lead to more data of higher quality. Advances in these areas will become generally more acceptable at the resulting level of cost-effectiveness that stems from new data acquisition and dissemination methods.

6. Data quality progress and stakeholder accessibility

The issue of data quality has pervaded fisheries management since the 19th century. The data quality issue has continuously advanced, changed and become more achievable. It will always need to change as fisheries circumstances change further. The 20th century approached maximization of fisheries both in terms of production and through general improvements in three key areas: better biological population science; global environmental understanding and requirements; and global acceptance of proper responses and planning.

Lastly, of course, the Information Age is upon us, both in terms of computerized analytical ability and in communications. As part of these processes a big issue has become transparency in knowledge. In fisheries, probably as in other sectors such as banking, transparency and accuracy enable multifaceted data use for analysis, for whatever purposes and for different reasons by different stakeholders. Stakeholders will be in government, the private production sector and the general public, all with a wide range of information needs. Sustainability and ecosystem-based management require broad stakeholder involvement, particularly in relation to alternative use of aquatic environments and for attention to and the amelioration of general environmental impacts.

Different stakeholders have different roles to pursue. Some stakeholders are exclusive and uniquely information demanding, i.e. different data for fisheries management, the fishing industry and the environment analysts, to inform and protect their role. Other roles, as in the broadening commitment to ecosystem-based management of natural resources, brings mutual concern for, and the capacity to obtain and communicate, information that is commonly available to all stakeholders.

7. Data standards

In addition to the direct concern about data quality in relation to analytical purposes, many institutions respond to the growing adoption of ISO 9000 through which institutions tackle their purpose through internationally acceptable quality management principles. Institutions establish the eight ISO 9000 Principles to ensure that they have a basis for performance improvement and organizational excellence. With regard to the data quality issue, the following principle (ISO 9000 Principle No. 7 – see Box 2 below) forms an internationally acceptable approach to the global recognition that the International Standards Organisation (ISO) is designed to be adaptable to the circumstances of an organization, as follows:

'The ISO accepts that there are many different ways of applying quality management principles. The nature of the organization and the specific challenges it faces will determine how to implement them.'

Box 2. International Standards Organisation (ISO)

Principle 7 - Factual approach to decision-making

Effective decisions are based on the analysis of data and information

Key benefits:

- Informed decisions.
- An increased ability to demonstrate the effectiveness of past decisions through reference to factual records.
- Increased ability to view, challenge and change opinions and decisions.

Applying the principle of factual approach to decision making typically leads to:

- Ensuring that data and information are sufficiently accurate and reliable.
- Making data accessible to those who need it.
- Analysing data and information using valid methods.
- Making decisions and taking action based on factual analysis, balanced with experience and intuition.

8. Data quality and indicators

Most statistics producers currently discuss data quality in terms of a total quality concept in that the quality of statistics refers to all aspects of how well statistics meet users' needs and expectations of statistical information, once disseminated. Table 2 below outlines the quality concept components (contents of report, timeliness and accuracy) and sub-components that are generally accepted as necessary to meet all needs. This overall data quality framework that applies to the 1) contents of a statistical report, 2) timeliness and 3) accuracy is neither necessarily complete nor essential for fisheries data. Nevertheless, the development of an applicable fisheries data quality approach may need to address these and more data issues.

Table 2. Quality Concept for Statistics [3]

Contents of Report
Statistical target characteristics
Units and population
Variables
Statistical measures
Study domains
Reference time
Comprehensiveness
Timeliness
Frequency
Production time
Punctuality
Coherence, especially comparability
Comparability over time
Comparability over space
Coherence in general
Availability and clarity
Forms of dissemination
Presentation
Documentation
Access to micro data
Information services
Accuracy
Overall accuracy
Sources of inaccuracy
Sampling
Coverage
Measurement
Non-response data
Data processing
Model assumptions
Presentation of accuracy measures

[3] Encyclopedia of Statistical Sciences. Quality Concept for Official Statistics, Update Volume 3. John Wiley & Sons, Inc. pp 621-629.

9. Approaches to Data Quality

Different approaches to the issue of data quality have been undertaken for many years both at national and international levels. For example, at the International Monetary Fund (*IMF*) the whole issue of data quality has been addressed and made widely available through the generic Data Quality Assessment Framework (*DQAF*) (see Annex 3) and the IMF Approaches to Data Quality (see Annex 4). In brief, Box 3 below describes the basis of the DQAF[4].

Box 3. International Monetary Fund - 4th Review of the Fund's Data Standards Initiatives

The Data Quality Assessment Framework

The DQAF covers five dimensions of quality and a set of prerequisites for the assessment of data quality. The coverage of these dimensions recognizes that data quality encompasses characteristics related to the institution or system behind the production of the data as well as characteristics of the individual data product. Within this framework, each dimension comprises a number of elements, which are in turn associated with a set of desirable practices. The following are the statistical practices that are associated with each dimension:

- **Prerequisites of quality** - the environment is supportive of statistics; resources are commensurate with needs of statistical programs; and quality is a cornerstone of statistical work.
- **Integrity** - statistical policies and practices are guided by professional principles; statistical policies and practices are transparent; and policies and practices are guided by ethical standards.
- **Methodological soundness** - concepts and definitions used are in accord with internationally accepted statistical frameworks; the scope is in accord with internationally accepted standards, guidelines, or good practices; classification and sectorization systems are in accord with internationally accepted standards, guidelines, or good practices; and flows and stocks are valued and recorded according to internationally accepted standards, guidelines, or good practices.
- **Accuracy and reliability** - source data available provide an adequate basis to compile statistics; statistical techniques employed conform with sound statistical procedures; source data are regularly assessed and validated; intermediate results and statistical outputs are regularly assessed and validated; and revisions, as a gauge of reliability, are tracked and mined for the information they may provide.
- **Serviceability** - statistics cover relevant information on the subject field; timeliness and periodicity follow internationally accepted dissemination standards; statistics are consistent within the dataset, over time, and with other major data sets; and data revisions follow a regular and publicized procedure.
- **Accessibility** - statistics are presented in a clear and understandable manner, forms of dissemination are adequate, and statistics are made available on an impartial basis; up-to-date, and pertinent metadata are made available; and prompt and knowledgeable support service is available.

The views of the Canadian agency for statistics addresses data quality against 6 dimensions as described in Box 4 below, i.e. principles or dimensions of data quality that are different in outline from IMF but which may cover the same range of issues.

Box 4: Managing Data Quality in a Statistical Agency - Statistics Canada

The Six Dimensions of Data Quality

- ***Relevance***

The relevance of statistical information reflects the degree to which it meets the real needs of clients. It is concerned with whether the available information sheds light on the issues of most importance to users. Assessing relevance is a subjective matter dependent upon the varying needs of users, The NSO's challenge is to weigh and balance the conflicting needs of different users to produce a program that goes as far as possible in satisfying the most important needs and users within given resource constraints.

- ***Accuracy***

The accuracy of statistical information is the degree to which the information correctly describes the phenomena it was designed to measure. It is usually characterized in terms of error in statistical estimates and is traditionally decomposed into bias (systematic error) and variance (random error) components. It may also be described in terms of the major sources of error that potentially cause inaccuracy (e.g.

[4] 4th Review of the Fund's Data Standards Initiative. Supplement on Data Quality Assessment Framework. IMF Statistics Department. (It defines a methodology for assessing data quality.)

coverage, sampling, non-response, response).

- ***Timeliness***

The timeliness of statistical information refers to the delay between the reference point (or the end of the reference period) to which the information pertains, and the date on which the information becomes available. It is typically involved in a trade-off against accuracy. The timeliness of information will influence its relevance.

- ***Accessibility***

The accessibility of statistical information refers to the ease with which it can be obtained from the NSO. This includes the case with which the existence of information can be ascertained, as well as the suitability of the form or medium through which the information can be accessed. The cost of the information may also be an aspect of accessibility for some users.

- ***Interpretability***

The interpretability of statistical information reflects the availability of the supplementary information and metadata necessary to interpret and utilize it appropriately. This information normally covers the underlying concepts, variables and classifications used, the methodology of collection, and indications of the accuracy of the statistical information.

- ***Coherence***

The coherence of statistical information reflects the degree to which it can be successfully brought together with other statistical information within a broad analytic framework and over time. The use of standard concepts, classifications and target populations promotes coherence, as does the use of common methodology across surveys. Coherence does not necessarily imply full numerical consistency.

10. Data policies, guidelines and programmes

Many organisations are developing data policies and guidelines, and programmes for the improvement of all aspects of their information requirements. For the purposes of this brief review related issues are summarised for three institutions – IOC, ICES and IATTC (Box 5, 6 & 7 below), as follows:

Box 5. Data exchange policy and guidelines - IOC

IOC OCEANOGRAPHIC DATA EXCHANGE POLICY

During its twenty-second session (24 June - 4 July 2003) the Intergovernmental Oceanographic Commission (IOC) Assembly adopted Resolution IOC-XXII-6, as follows:

- **Preamble**

The timely, free and unrestricted international exchange of oceanographic data is essential for the efficient acquisition, integration and use of ocean observations gathered by the countries of the world for a wide variety of purposes including the prediction of weather and climate, the operational forecasting of the marine environment, the preservation of life, the mitigation of human-induced changes in the marine and coastal environment, as well as for the advancement of scientific understanding that makes this possible.

Recognising the vital importance of these purposes to all humankind and the role of IOC and its programmes in this regard, the Member States of the Intergovernmental Oceanographic Commission agree that the following clauses shall frame the IOC policy for the international exchange of oceanographic data and its associated metadata.

- **Clause 1**

Member States shall provide timely, free and unrestricted access to all data, associated metadata and products generated under the auspices of IOC programmes.

- **Clause 2**

Member States are encouraged to provide timely, free and unrestricted access to relevant data and associated metadata from non-IOC programmes that are essential for application to the preservation of life, beneficial public use and protection of the ocean environment, the forecasting of weather, the operational forecasting of the marine environment, the monitoring and modelling of climate and sustainable development in the marine environment.

- **Clause 3**

Member States are encouraged to provide timely, free and unrestricted access to oceanographic data and associated metadata, as referred to in Clauses 1 and 2 above, for non-commercial use by the research

and education communities, provided that any products or results of such use shall be published in the open literature without delay or restriction.

- **Clause 4**

With the objective of encouraging the participation of governmental and non-governmental marine data gathering bodies in international oceanographic data exchange and maximizing the contribution of oceanographic data from all sources, this Policy acknowledges the right of Member States and data originators to determine the terms of such exchange, in a manner consistent with international conventions, where applicable.

- **Clause 5**

Member States shall, to the best practicable degree, use data centres linked to IODE's NODC and WDC network as long-term repositories for oceanographic data and associated metadata. IOC programmes will co-operate with data contributors to ensure that data can be accepted into the appropriate systems and can meet quality requirements.

- **Clause 6**

Member States shall enhance the capacity in developing countries to obtain and manage oceanographic data and information and assist them to benefit fully from the exchange of oceanographic data, associated metadata and products. This shall be achieved through the non-discriminatory transfer of technology and knowledge using appropriate means, including IOC's Training Education and Mutual Assistance (TEMA) programme and through other relevant IOC programmes.

Box 6. Data Exchange Policy and Guidelines - ICES

ICES Data Type Guidelines - Data, Metadata and Quality Control

The International Council for Exploration of the Sea (*ICES*) established the Working Group on Marine Data Management (*WGMDM*) to take an active role in promoting proper data management practices for the marine community, including a set of guidelines:

- to describe the elements of data and metadata important to the ocean research community (physical-chemical-biological data types traditionally collected on oceanographic cruises).
- to address the data and metadata requirements of a specific data type. The proper documentation of data to include the processing applied to the dataset. Cruise collection information is also itemised, which can serve as a metadata checklist to ensure the collector acquires all required metadata at the source and time of initial sample collection.
- to describe quality control procedures applied to the dataset.
- to ensure that data centres also maintain procedure and problem histories to provide and make available value-added information to the dataset, to include information on the general service of data delivery provided by data centres, data descriptions and a full history of procedures and processing. Data quality flagging is described and any changes made to the dataset are noted.

ICES has applied metadata principles to a large range of information sources, including the use of environmental sensing equipment so that a standard metadata practice would include the following guidelines:

ICES Metadata

Sufficient self-explanatory information and documentation should accompany the data so that they are adequately qualified and can be used with confidence by scientists/engineers other than those responsible for its original collection, processing and quality control.

The data supplier should ensure that the following be provided with the (equipment/instruments) data submission. There should be metadata information:

- about the instruments.
- about the data precision and final accuracy.
- about the calibration and processing techniques used.

All data values should be expressed in oceanographic terms, in SI units, which should be clearly stated; time reported in UTC; units used for the measured parameters should be clearly described and consistent; and any ancillary meteorological information should be included.

ICES Data Quality Control

The ICES developed manuals and guides that include quality control issues, including specific details on quality flagging, quality control tests, duplicates management, implementation details. Quality control

findings for the original data set are shared with the data originator to maintain consistency and uniqueness of the mutual data set and improve its overall quality. A range of checks are carried out on the data to ensure that they have been imported into the data recipients format without any loss of information.

All quality control procedures applied to a dataset are fully documented by the Data Centre. As well, all quality control applied to a dataset should accompany that dataset. All problems and resulting resolutions will also be documented with the aim to help all parties involved; the Collectors, Data Centre, and Users. A history record will be produced detailing any data changes that the Data Centre may make.

Box 7. IATTC Resolutions and actions related to data issues

1999

- **IATTC Resolution on bigeye tuna** recognizes problems in identifying catches of bigeye tuna, calls for improved statistics, and establishes a working group to address statistical data improvement.

- **IATTC Resolution on bycatch** requires the Secretariat to develop statistics and methods to estimate the catch of miscellaneous species and the discards of any species from purse seine fisheries.

2000

- **IATTC Resolution on fleet capacity** calls for development and maintenance of a vessel register that will include the capacity of the fishing vessel in cubic meters well volume. The cubic meter capacity was decided following establishment of a working group on fleet capacity and many discussions about the fact that historical estimates of vessel capacity adequate for scientific purposes were not equitable for use in international agreements and fisheries management actions based on fleet and vessel capacity.

- **IATTC Resolution on bigeye tuna** recognizes the need to have statistics on captures of small bigeye, particularly by the unloadings of small purse seine vessels to obtain estimates of small bigeye. The benefit was in management: the fishery was managed on more accurate data, helping to prevent exceeding desired catch levels while at the same time not requiring the fishery to be closed too soon.

- **IATTC Resolution on bycatch** requires landing of all catch of tunas (prohibits discards) by purse seine vessels in order to encourage vessels to not catch fish which may not be sold and to develop the statistics required to estimate the total discards and impact on the fishery.

2001

- **IATTC Resolution on at-sea reporting** is a first step to requiring real-time at-sea reporting of catch and effort statistics to ensure adequate statistics for management of the EPO fisheries:

- **AIDCP** (Agreement on the International Dolphin Conservation Programme, 1998) Resolution adopting a Tuna Tracking System requires the development of statistical data systems to monitor and track the catch of dolphin-safe tuna from the point of capture to retail sale; a trade statistical system set up to ensure the marketability of catch.

2003

IATTC Resolution on data provision requires members of the Commission and others fishing in the Convention area to provide pertinent catch and fishing effort information to ensure that comprehensive information on fishing activities is available.

Institutional focus

11. Global views

The global community now recognises the advantages of identifying and developing highly appropriate and selective ways and means to promote natural resources sustainability. However, there are concerns that there is not yet a full understanding of all ways and means to minimize risks (biological, environmental and economic), although there is acceptance that risk assessments are always integral tasks that are necessary to meet the *precautionary principle*.

Three developing information capabilities are now recognised as key to achieving a sustainable future. There is:

- improved science, including analytical capacities;
- wider information participation by users, beneficiaries and governance, and remote sensing of key data requirements, from micro to macro scales;
- knowledge availability and accessibility through advancing communications.

As in so many land-based human environmental impacts, the water-based impacts of food production, alternate use and recycling capacity will require much improved and detailed analysis and understanding of the biological, chemical and physical attributes of oceans, lakes and rivers. Meteorology and oceanography now contribute in equal weight to the science of aquatic ecology in the search to ensure progress towards sustainability. Agriculture and other land use make significant uses of fresh waters, which, in turn, impacts productive aquatic ecosystems. Fish stock assessment science has grown rapidly, including the introduction of physical and chemical parameters (the non-living environment) as intrinsic elements to the models used to predict ecosystem use and external impacts. Fisheries management has matured with the political development of governing states and reflects the widely accepted need for impact management of production and alternative use.

The dynamic interaction of micro to macro scales of ecosystem information applies to both the science and management of fisheries. At the Earth Observation Summit (*EOS*, August 2003) the worldwide collaboration on gathering and disseminating important global observations (i.e. data) was welcomed and encouraged. The fisheries scientific and management communities are becoming increasingly interconnected through all environmental domains (meteorology and oceanography; environmental and biological heritage and use; agriculture and natural resources). These domains will benefit from EOS declarations and future planning by international, regional and national bodies. FAO was present at the EOS and was able to contribute to this holistic global view, because of its micro and macro observational involvement with regards to agriculture, forests and fisheries and its promotion of world food and environmental production economics. Given these recognitions, integrationist information capacities and understanding are proceeding rapidly, particularly with the growth of computing and communications.

FAO is also a member of the Integrated Global Observing Strategy Partnership (*IGOS*), which is also a strategic planning process (see Box 8 - Global Observation - EOS and IGOS).

Box 8. Global Observation – EOS and IGOS

EARTH OBSERVATION SUMMIT

The prospectus and results of the EOS noted the future need for an integrated international programme that would produce excellent results in a wide range of issues, including 'ecological management, … sustainable development, … and the needs of international environmental conventions'.

The summit called on countries to, inter alia;

- Exchange data with minimum time delays.
- Minimise data gaps.
- Improve the observation systems in developing countries and advance capacity building.

They reaffirmed 'the need for timely, quality, long term global information as a basis for sound decision making.'

The EOS noted some of the barriers to Establish an Integrated Earth Observation System (*IEOS*), as follows:

Insufficient data sharing; inadequate observations (spatial, temporal, and/or quality limitations); inconsistent data formats; costs; agreement on and development of mechanisms to maintain appropriate security, and in particular, to ensure that systems and/or data are used only for peaceful purposes; and complexity of global environmental problems.

INTEGRATED GLOBAL OBSERVING STRATEGY PARTNERSHIP (IGOS)

IGOS is a strategic planning process, uniting the major satellite and surface-based systems for global environmental observations of the atmosphere, oceans, and land in a framework for decisions and resource allocations by individual funding agencies. The purview of the IGOS Partnership includes the needs of multiple domains, the entirety of which no single Partner is able to address by itself.

The IGOS Partnership focuses specifically on the observing dimension in the process of providing environmental information for decision making. This includes all forms of data collection concerning the physical, chemical and biological environments of our planet, as well as data on the human environment, pressures on the natural environment, and environmental impacts on human well-being.

Data collection is not an end in itself, and the observing strategy must therefore fit into a broader global strategy to assess the environmental data and to deliver meaningful data products to users. Many of the various environmental initiatives, Treaties, and Conventions implemented over the last few decades require systematic observations of the Earth, and the IGOS Partnership is prepared to provide the necessary observational links in support of Conventions and other international initiatives. The Partnership has finalized its consensus view on the way forward with regard to ocean observations, which are in the implementation phase under the coordination of the Global Ocean Observing System. The IGOS Partnership is currently focusing on identifying and gaining commitments for essential requirements for observing global carbon, atmospheric chemistry, global water cycle, geohazards, and coral reefs. Other domains are under consideration. The IGOS Partners include the global observing systems (Climate - GCOS, Ocean - GOOS, Terrestrial - GTOS, etc) and sponsors, including WMO, UNESCO, UNEP, IOC, ICSU and FAO.

National institutional processes for sustainable natural resource management and use are under way in many countries with particular attention being paid to the policy level. The recently published Australia's Oceans Policy provides an important example of the integrationist approach now being advanced by national governments. It identifies, throughout the Oceans Policy, the information requirements and mechanisms that are essential to achieve its sustainability objectives. Annex 2 is a brief review of Australia's Oceans Policy through a *Summary of information principles in the policy*.

Many international institutional processes have been developed (e.g. see Boxes 4, 5 & 6) and are also under way to achieve both appropriate information sources for their focused tasks as well as for wide information dissemination for alternate data use by other domains. These processes highlight that the high quality of data (at whatever required scale) needs to be demonstrable for all purposes, particularly to non-source users, and that cost-effectiveness should also be demonstrable to ensure human endeavour to achieve it.

The United States Agency for International Development (USAID) has a Center for Development Information and Evaluation (CDIE) that produced a guideline for Indicator and Data Quality, in similar way to other institutions. It notes the key understanding that *'sound decisions require accurate and reliable information, and the benefits of this results-oriented approach depend substantially on the quality of the performance information required'* The guideline also includes their recognised issues: criteria, availability, objectives, practical aspects (including cost considerations), quality (validity, reliability, measurement error, assessment, representativeness, timeliness, etc).

The Secretariat of the Pacific Community (SPC), Statistics Section, has developed a Strategic Plan for 2003-2005, which addresses a regional mission, goals and three major objectives of 1) good quality socio-economic information, 2) better dissemination and 3) better statistical coordination. Meeting these goals requires reporting, monitoring and evaluation. As a large and diverse region that centres on one of the global tuna fisheries, this strategy is a good general approach to the information requirements of policy-makers and analysts. It is supported by development partners, conducted by the Statistics Section and designed to share information between all SPC programmes of mutual interest. The current approach notes a wide range of

performance indicators, largely to do with statistical capacity building and international standards but also concerning dissemination both regionally and globally. From both the ecosystem and economic perspectives this plan will also assist the fisheries sectors in a variety of ways and at all levels, from management and science to economics and business.

As a prelude to this brief review of data quality expectations against fisheries issues and to the specific proposal in this report, some of the institutions and processes are reviewed in terms of data achievement against the institutional requirements to obtain it and the protocols to share it.

12. United Nations:

- ### UNCED

Instruments agreed at the 1992 United Nations Conference on Environment and Development – Agenda 21 and the Convention on Biological Diversity (CBD) – refer more specifically to the ecosystem approach, and this was carried forward by the 1995 United Nations Fish Stocks Agreement[5] (*UNFSA*) and the 1995 Code of Conduct for Responsible Fisheries (*CCRF*). UNCED and the generated instruments focus intensely throughout on the needs for full information sources of the highest quality. The Global Environment Facility (*GEF*), an implementation and financing mechanism, has developed rapidly in almost all waters of the world. Freshwaters, oceans, international waters, coastal and biodiversity GEF programmes and projects will work extensively on improving knowledge and understanding of the aquatic environment and the impacts of human use. (See the information issues extracted from the Code of Conduct for Responsible Fisheries and the UN Fish Stocks Agreement - Annex 6.)

- ### FAO

The projection by the International Food Policy Research Institute (*IFPRI*)[6] is that 79% of projected food fish production in 2020 (130 million tonnes) will be from developing countries and that 41% of the total will come from aquaculture. The projection estimations included a wide range of economic data but largely used the primary fishery source data from FAOSTAT in the IMPACT model that IFPRI developed for the projection. As has been mentioned elsewhere, there are concerns about reliability of many fishery data sources that contribute their fisheries data submissions to FAO, and that such data uncertainty on fish production may mask fundamental and negative trends in world fisheries.

The issue of fisheries data quality at source is thus a key concern at FAO. This issue is a concern that is reflected both in global institutions and in the countries where data aught to be generated. It is recognised that there are many developing countries where statistical capacity is limited and should be built, but that it is needed in some developed countries too.

- ### Inter-agency Committee on Sustainable Development

The review and coordination of the ecosystems approach to the management of the oceans and their resources (as required under UNCED Agenda 21) has been undertaken by the Inter-agency Committee on Sustainable Development (*IACSD*) under the UN Administrative Committee on Coordination (*ACC*). Recent attention by the ACC Sub-Committee on Statistical Activities received a paper from FAO. (See Box 9 below)

[5] 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.

[6] IFPRI and World Fish Center. 2002. Fish as Food: Projections to 2020. Paper presented to the Biennial Meeting of the International Institute for Fisheries Economics and Trade (IIFET), 19-23 August 2002, Wellington. NZ.

Box 9. Summary of FAO paper submitted to the UN Administrative Committee on Coordination (ACC), Subcommittee on Statistical Activities (Washington D.C. September 2000)

Quality assurance, arrangements with common questionnaires and conflicting statistics

The FAO databases are being maintained to facilitate dissemination of global statistics pertaining to food and agriculture (including forestry and fishery) through yearbooks (and on the internet) and to enable the review and monitoring of the progress of nations in the State of Food and Agriculture (SOFA), the State of World Fisheries and Aquaculture (SOFIA), the State of World's Forest (SOFO), the State of Food Insecurity in the World (SOFI), etc. Primary data time series rely on a set of regular country questionnaires. Some country's official data are incomplete in terms of (a) the range of variables covered and (b) coverage of the nation. Some countries are characterised by poor resources and weak infrastructure, and lower priority to the importance of information for decision making. The data gaps are filled by FAO estimates. The issues relating to quality assurance are presented below.

(a) Quality assurance

The process of assurance of quality involve the following considerations:

Relevance of statistical concepts: Emphasis is being placed on harmonising these concepts with the concepts adopted (or recommended) by other international systems.

Comparability of statistics: Quality of data depends on the basic need to examine the comparability of the data over space and time, although there may be differences between the concepts or definitions used by a nation and those given by the FAO.

Accuracy: The degree of accuracy of the data is different in different countries. In the case of the FAO estimates, there is neither any statistical measure (like standard error) nor any reference population total to determine the accuracy of the data sets.

(b) Arrangements with common questionnaires and the policies for publishing the data collected in this way by the organisations involved

Other organizations are involved, e.g. OECD and Eurostat, which compile data for the developed or industrialized countries. A great deal of effort is required for harmonising the concepts and definitions used for collection of primary data before the issue of single common questionnaires can be considered. In the case of crops, livestock and fisheries at present, there are inter-agency forums where these issues are under active consideration; the Inter-secretariat Working Group on Agricultural Statistics (IWG.AGRI) and the Coordinating Working Party on Fishery Statistics (CWP).

(c) Conflicting data in organisations even when the same original national data is used as a starting point

Some of the common causes for this situation are: 1) Different practices relating to reference period, time the data supplied by the country, source (reporting office), 2) Specification provided (or required) by the organisation collecting the data, 3) Conceptual differences in the data collection procedure, 4) Method of estimation used by individual Organisations for completing missing observations.

(d) Conflicts between nationally supplied data and internationally comparable data prepared by some international organisations.

Conflicts between nationally supplied data and those published by international organisations are due to differences in concepts and classifications.

13. International directions:

Most, if not all, international institutions are involved in the issue of data and statistical quality (see Annex 4. for the current attention being applied to data quality). For the purpose of this review only a few are elaborated further. Nevertheless, it seems appropriate to recommend that further work be undertaken, against well-recognised sources, to assess the validity of data quality approaches across domains through which core fisheries data should be available at a variety of levels. Four of the key institutions and partnerships are addressed below.

- ### OECD

The OECD has a Directorate for Food, Agriculture and Fisheries, which manages a Fisheries Committee and produces *Draft Guidelines for the (*current year*) Statistical R*eview. The Review is required to prepare general fisheries production statistics, plus statistics on Government Financial Transfers, Imports/Exports by product, Imports/Exports by major products and by country, Employment and Fishing fleet. The guidelines also contain adopted reporting procedures and format**.**

- ### PARIS21

The OECD/PARIS21 Task Team on Statistical Capacity Building Indicators held a Seminar on the Framework for Statistical Capacity Building Indicators in 2002; Statistics Department, International Monetary Fund, Washington, D.C. April 29–30, 2002.

The PARIS21 Consortium is a partnership of national, regional, and international statisticians, policymakers, development professionals, and other users of statistics. Launched in November 1999, it is a global forum and network whose purpose is to promote, influence and facilitate statistical capacity-building activities, and the better use of statistics. Its founding organizers are the UN, OECD, World Bank, IMF, and EC. The IMF chairs the Task Team on Statistical Capacity Building Indicators. Its main purpose is to identify, validate and test indicators of statistical capacity building.

The seminar discussed extensively the use of the IMF Data Quality Assessment Framework (*DQAF*), in particular reviewing statistical operations according to the six-part DQAF Structure, including the following:

- Prerequisites
- Integrity
- Methodological soundness
- Accuracy and reliability
- Serviceability
- Accessibility

The seminar then discussed ways of Identifying Statistical Capacity Indicators that would assist the Task Team in meeting the goals of PARIS21.

- ### The Global Ocean Observation System (GOOS) Living Marine Resources Panel (LMR-GOOS Panel)

In 1998 it was decided that the intent of LMR-GOOS is to provide observational services and forecasts to those concerned with the harvest, conservation and scientific investigation of living marine resources of the deep ocean and shelf seas. The objectives are to obtain from various sources relevant oceanographic and climatic data, along with biological, fisheries and other information on the marine ecosystems, to compile and analyse these data, to describe the varying state of the ecosystems, and to predict future states of the ecosystems, including exploited species, on useful time scales. In meeting the LMR-GOOS goal there should be efforts in the identification and development of the more powerful and cost-effective means for monitoring marine ecosystems. For a general review of information issues see Box 11 below.

Box 11. LMR-GOOS

The LMR-GOOS monitoring programme should attempt to provide information that:

- describes changes in ecosystems over time, including fluctuations in abundance and spatial distribution of species;
- helps interpret the observed changes in relation to such factors as natural environmental variability, anthropogenic climate change (including increased ultraviolet radiation), predation/disease, and fishing activities; and
- contributes to forecasting of future states of marine ecosystems.

It reviewed the progress and direction of major international fora, including: International Council for the Exploration of the Sea (ICES), North Pacific Marine Science Organization (PICES), Food and Agriculture Organization (FAO), Intergovernmental Oceanographic Commission (IOC), Sir Alister Hardy Foundation for Ocean Science (SAHFOS), Census of Fishes, Global Ocean Ecosystem Dynamics (GLOBEC), Joint Global Ocean Flux Study (JGOFS), Large Marine Ecosystems (LME), Helsinki Commission (HELCOM), Oslo-Paris Monitoring Programme (OSPAR).

The panel made several requests to organisations - to FAO, in particular - noting that:

'A number of national and regional bodies collect and analyse fishery statistics and make fishery assessments. An aggregation of these analyses would be invaluable in assessing population changes in the upper trophic levels of marine ecosystems. The Panel therefore requests FAO, the global centre for fishery statistics, to identify on a global scale the existing fishery analyses that could contribute to the desired meta-assessment and to advise on how it could best be organized and carried out.'

With regard to assessment tasks the panel defined what is needed to be known, initially through the definition of monitoring products. At a minimum, an appropriate definition of monitoring products for a given region will require information on:

- the relevant ecological group, sub grouping, species or ecological condition to be monitored;
- the type of monitoring product required;
- its frequency of collection in time and space ;
- the accuracy (lack of bias) ;
- precision (Coefficient of Variation) ;
- whether it is already collected or not;
- whether its utility is conditional upon other data also being collected;
- the priority that should be assigned to its collection.

In addition to defining monitoring products this information framework clearly also revolves around the issue of data quality. Noting these decisions and appropriate frameworks the panel concluded that achieving goals is highly dependent on capacity building, and:

- For appropriate global or regional monitoring of living marine resources to occur it will be essential to build the adequate capacity to do the work in all regions.
- Some problems may concern infrastructure while others may require the development of skills.
- Appropriate expertise will need to be encouraged by peer contacts between scientists.
- Broad capacity building in systematics, in catch sampling, in at sea survey techniques and in model constructing are likely to prove beneficial.
- To describe better the need for capacity building, it will be helpful for panel members to co-operate regionally in identifying existing capacity and to identify clear current gaps in capacity.
- A subset of the LMR-GOOS panel will be requested to develop a standard proforma intersessionally for collecting information on the various types of capacity required.

The three global observing systems (the Global Climate Observing System GCOS; the Global Oceanographic Observing System, GOOS; and the Global Terrestrial Observing System, GTOS) are designed to detect and assess global change. A land-based coastal observing system initiative under GTOS is at the beginnings and will lead toward the integration of terrestrial and freshwater observations with marine observations under the auspices of coastal GOOS.

The GTOS infrastructure already builds on national, regional and global programs for terrestrial observations, but more emphasis is needed on the unique circumstances of coastal ecosystems. Coastal GTOS will use the observing system philosophy and infrastructure to:

- Identify and improve access to data and information about coastal change;
- Assist users to make that access systematically;

- Ensure that appropriate measures are being or can be made; and
- Integrate terrestrial observations with marine observations.

Key variables have been defined for GTOS. But major challenges include evaluating these and others for coastal ecosystems and identifying the indicators of coastal condition that operate at appropriate scales. The observations proposed for this initiative are of terrestrial and fresh water variables and complement those described for the coastal oceans by CGOOS, LMR and HOTO and for other GTOS programs. For example, many of the observation variables and the protocols for their sampling (including sites, frequencies and methods) have already been designated under the Global Hierarchical Observing Strategy (GHOST), the GTOS sampling strategy. GHOST spans a large range of sampling intensities and sophistication from elaborate, intensive and large-scale experimental studies to simple periodic sampling on the ground to satellite-based measures.

These have been systematically organized within the Terrestrial Ecosystem Monitoring Sites (TEMS), the GTOS metadatabase of terrestrial observing sites and networks. It allows querying by country, site, and eco-region. Sites can be identified by their distance from the coast. TEMS also lists over 115 variables that have been identified by GTOS. Descriptions of each variable include definition, rationale, potential users, measurement method, units of measurement, frequency of measurement, spatial resolution, accuracy/precision required, associated measurements, present status, research and development needs, global/regional data holders, and data policy.

As of now, Coastal GTOS has not advanced to the point that a list of specific variables, models or indicators has been identified. Some variables have been suggested for Coastal GTOS by COOP, including surface and groundwater transports of water, nutrients, sediments and contaminants.

- ## The Inter-Secretariat Working Group on Agricultural Statistics (IWG.AGRI)

The IWG.AGRI was created in 1991 by the Organisation for Economic Co-operation and Development (*OECD*), the European Union (*EU-EUROSTAT*), the United Nations Economic Commission for Europe (*UN-ECE*) and the Food and Agriculture Organisation of the United Nations (*FAO*).

It also took the initiative of creating an organizing committee for the 2nd World Conference - Conference on Agricultural and Environmental Statistical Application in Rome (*CAESAR),* which was hosted by ISTAT (Italian statistical organisation) in 2001.

Key fisheries and related statistical papers were presented (see bibliography) under a Fishery Statistics: Current And Future Challenges forum, including:

- Norms and standards for co-ordinated fishery statistics gathering
- Sustaining fishery statistics programmes in developing countries
- Sustainable statistical development for fisheries: role of the international institutions
- Information management and dissemination – Offering access to a comprehensive cross-section of statistical data and meta-data in support of multidisciplinary projects
- Electronic mapping utility – A solution to geographic process
- Lower census costs through the use of administrative sources
- Cost-effectiveness of remote sensing in agricultural and environmental statistics
- Graphical methods in editing

Thus, many theoretical and practical solutions to the enhancement of fisheries information (sources, standards and analytical practices) have been addressed and institutional processes are under way, including the international co-ordination of agricultural statistics.

- ## Eurostat

A recent report prepared by Eurostat (the organisation that supports statistics for the European Community) reviews the nature and extent of *Quality Work and Quality Assurance with Statistics*. It notes:

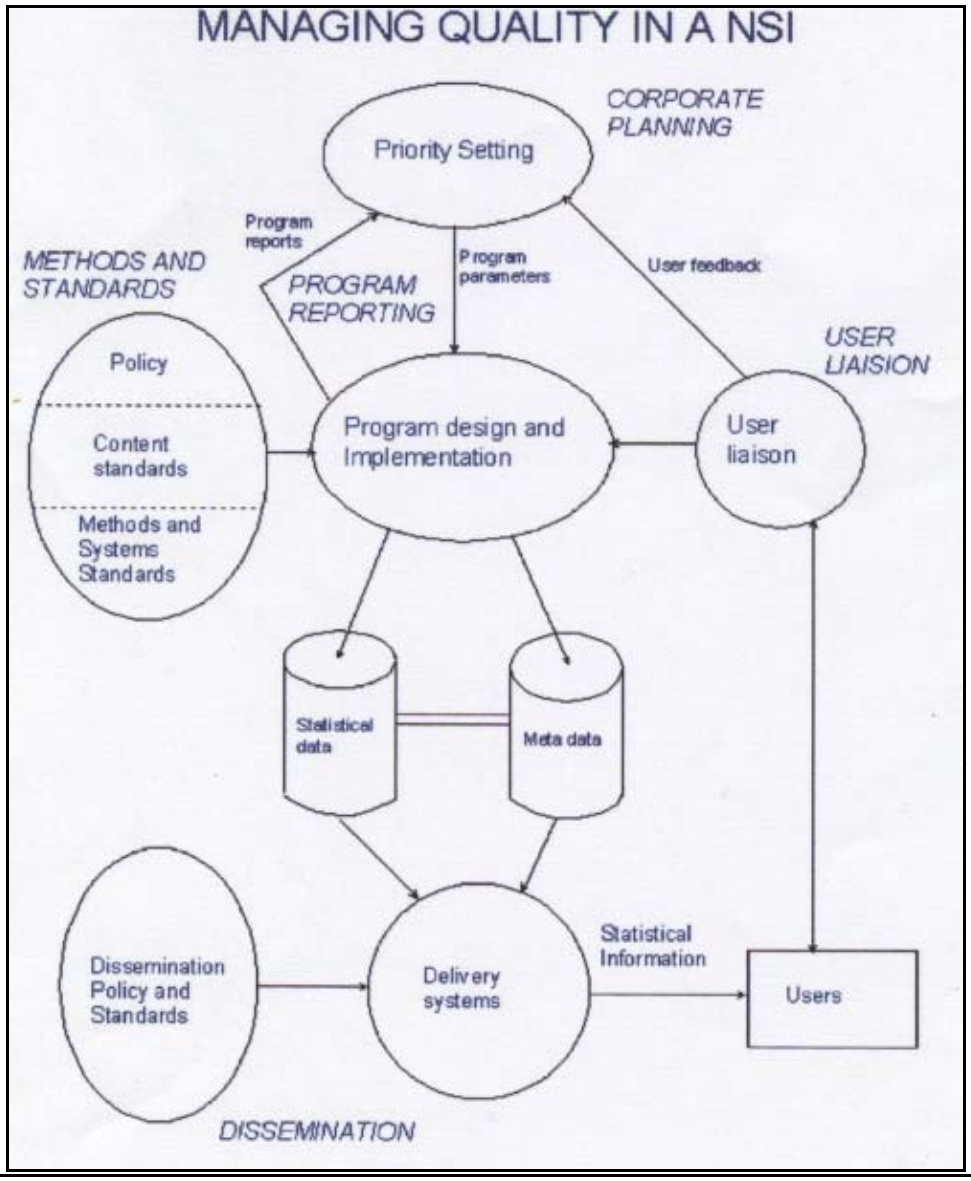
- *Quality has always been the obvious requirements of statistics, although the notion of 'quality' has changed over the years.*

- *A statistical product must exhibit reliability, relevance of concept, promptness, ease of access, clarity, comparability, consistency and exhaustiveness (= criteria).*
- *Users will attach more or less importance to each of these criteria.*
- *Quality work and conflicting quality objectives result from the lack of a 'quality' defined concept. It is multi-faceted and statistics are regarded as having high quality for one purpose and may be less adequate for another.*
- *Quality improvement can come as the result of large or small initiatives and are all important.*

In defining a quality concept the report asked the principles question: ***Quality: What is it?*** First, it is multifaceted, and second, it depends ultimately on what users consider to be important.

The operational control by a national statistics institute is highly complex and an example of programmatic components of managing statistics by an NSI (National Statistical Institute) is given in the box 12 below, originating from Canada Statistics. Such a corporate data quality framework might be applicable to any institution (national, regional or international).

Box 12. Managing Quality in an NSI – Canada Statistics



Fisheries Focus

14. Agreements:

• UNCLOS, UNFSA, FAOCA and CCRF

The United Nations Convention on the Law of the Sea (*UNCLOS*) and subsidiary implementation instruments focus intensely on the use of best scientific evidence. In addition to that simple requirement (largely undefined), the subsidiary UN Fish Stocks Agreement (*UNFSA*) and the FAO Compliance Agreement (*FAOCA*) focus on the issue of information exchange for the defined purposes of the agreements, noting that **applicable confidentiality** (to be agreed between use partners) shall be implemented for good reasons. Similarly, the Code of Conduct for Responsible Fisheries (*CCRF*), which is a globally accepted but voluntary instrument, also makes direct reference to best scientific evidence and information exchange, and notes the as yet undefined quality criterion reflected in the applicable confidentiality principle.

• IPOAs

In addition to formal and general voluntary agreements FAO has coordinated concern, attention and solutions to significant difficulties with regard to fisheries. Four International Plans of Action (*IPOAs*) on Seabirds, Sharks, Fishing Capacity and Illegal, Unreported and Unregulated Fisheries are now accepted and in operation. Much of the approach of these IPOAs will include information issues, many of which need significant attention. This applies in particular to IUU fishing, much of which has origins in the lack of information from vessels operating outside the law; vessels not reporting properly what they catch; and vessels operating within a management environment that is not regulated in a manner that reflects modern understanding.

In relation to IUU fishing it has been noted[7]:

> *Incomplete knowledge in managed fisheries compromises fisheries management approaches. The absence of information in unmanaged fisheries limits the ability to establish management at some future date. The complex problem of the lack of fishery information results from IUU fishing, including its setting and scale. Issues that relate to information* ***coverage, precision and accuracy*** *are relevant, together with measures that can be adopted to improve these. Improving fishery information through system developments will include improvements to Observer Programmes, Monitoring Control and Surveillance and the new methods of Vessel Monitoring Systems. Alternative methods to assess fishery information are available. Human and financial resource problems limit more effective collection of fishery information, particularly those that face developing countries. The paper concludes that there are few technical impediments to obtaining the necessary data, but that policy, legal and institutional arrangements, particular at the international level, need to be more firmly established and actively implemented, in particular Flag State duties and responsibilities.*

15. Institutional:

• FAO

In SOFIA 2002[8], it was reported that the inland fishery resources have long been under-valued and under threat from habitat alteration and degradation, and from unsustainable fishing activities. Accurate information is crucial to understanding the importance of inland fishery resources and to manage these resources for the benefit of rural populations, in particular where water use is multi-faceted. Incomplete or incorrect information is a liability in efforts to provide food security to developing regions.

Recent field studies in Asia[9] have revealed that there are significant problems concerning the

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[7] *text extracted from the abstract of* Fisheries information and illegal, unreported and unregulated fishing. Expert Consultation on Illegal, Unreported and Unregulated Fishing organized by the Government of Australia in cooperation with FAO, Sydney, Australia, 15-19 MAY 2000. Document AUS:IUU/2000/12 –

[8] FAO. 2002. The State of World Fisheries and Aquaculture, 2002. FAO Fisheries Department. Rome. ISBN92-5-104842-8. 2002

[9] Coates, D. 2002. Inland capture fishery statistics of Southeast Asia: Current status and information needs. FAO Regional Office for Asia and the Pacific, Bangkok. RAP Publication 2002/11. 121 pp.

accuracy of inland fishery statistics in the region. These problems stem from inadequate resources to collect fishery statistics, the difficulty in accessing information from the sector, mis-reporting, and lack of capacity to use information to improve management of inland fishery resources. As with many other developing countries and regions, in both freshwater and marine fisheries and through higher scale programmatic and partner agency support, there has been a general recognition (discussion, contribution and action) of the need to improve fishery statistics. For example, the UN Asia Pacific office has conducted many approaches and SEAFDEC is now closely considering the *Partnership* for the development of the Fisheries Resources Monitoring System (FIRMS). In the Asia-Pacific region there has been a long term recognition that better fishery statistics are needed from both capture and aquaculture fisheries for a long time. Box 13 below is extracted from a compilation prepared by Shunji Sugiyama at the FAO Regional office for Asia and the Pacific, and it identifies the regional, national, sectoral and specialist interests in fisheries information conducted, attended or contributed to since 1997. Similarly, in the Southern Africa Development Community (SADC) there is a progressing Regional Fisheries Information System (RFIS) programme.

Many other countries (e.g. USA)[10] and regions also have statistical understandings that are under way or needed renewed attention. Clearly, many countries and regions recognise the need and capacity to share high quality data in order to properly contribute to global productivity and environmental management. There is a standards element to quality, which has been tackled for a long time, e.g. CWP (see later section). There are now many different standards that should be developed, mostly with regard to purpose, availability, confidentiality, use and use-history. The issue of such metadata, with appropriate quality, has now become well recognised as a direct benefit of computing and the Internet. The Strategy-STF (detail on its development below) focuses on capacity building and partnership. SOFIA 2002 also focused on three key selected issues relating to information in fisheries:

- Implementing the ecosystem approach to capture fisheries management;
- Reliable statistics as an essential basis for effective fisheries management; and
- Catch certification and catch documentation.

Box 13. Chronology of important events on fishery statistics in Asia and the Pacific Region (1997-2002) - *Shunji Sugiyama, FAO Regional office for Asia and the Pacific*

1997

- Reformulation and Strengthening of Fisheries Statistics System in Myanmar
- FAO/SEAFDEC Regional workshop on Fishery Statistics
- APFIC Joint Working Party on Fishery Statistics and Economics
- ACFR meeting
- WP/STF Meeting
- Guidelines on the Collection of Structural Aquaculture Statistics
- Status of Fishery Statistics in Asia
- Status of Fishery Statistics in the South Pacific

1998

- APCAS meeting (17th session)

1999

- CWP meeting (18th session)
- APFIC Ad Hoc Working Group of Experts in capture fishery data collection
- ACFR meeting (2nd session)
- Guidelines for the Routine Collection of Capture Fishery Data
- Report of the Working Party on Status and Trends of Fisheries

2000

- Workshop on Census of Agriculture 2000: Structural Aquaculture Statistics
- APCAS meeting (18th session)
- ACFR meeting (3rd session)
- 2001
- COFI meeting (24th session)
- CWP meeting (19th session)
- Regional workshop Pacific countries - Support for Improvement of Statistics on Coastal and Subsistence Fisheries and Aquaculture
- Workshop on Improvement of Fishery Statistics in Asia and Pacific Countries
- ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in the New Millennium
- Status and Trends reporting in Fisheries (Fish. Circ. No. 967)

2002

- Technical Consultation on Improving Information on Status and Trends of Capture Fisheries. (FAO Fisheries Report No. 680.)
- FAO/SEAFDEC Workshops on the Use of Statistics and Other Information for Stock Assessment
- Sample-based Fishery Surveys (Fish Tech Pap 425)
- Inland Capture Fishery Statistics of Southeast Asia: Current status and information needs

[10] NRC. Improving the Collection, Management and Use of Marine Fisheries Data. National Academy of Sciences, Washington, D.C. 2000. p160.

• Advisory Committee on Fisheries Research (ACFR)

In 1998 the Advisory Committee on Fisheries Research was re-established to re-apply global attention to fisheries research and advice to the FAO Director General. The ACFR has met 4 times since its re-establishment in 1997. At its most recent meeting it considered its achievements[11] in relation to 8 key research issues, each of which has information implications, as follows:

- Economic aspects of trade in fish and fish products
- Aquaculture Sustainability
- Inland and Small-Scale Coastal Fisheries
- Status and Trends of Fisheries
- Globalization - implications for fisheries
- Research Methods
- Marine Fisheries Management
- Ecosystem Effects of Fishing

One of the highest priorities for attention to research needs was on Status Reporting Methodology and Data Needs. It established the Working Party on Status and Trends of Fisheries (*WP/STF*). Following conduct of the WP/STF, the working papers and information documents were published at a later date as a single report[12].

The ACFR has concluded that:

- the objectivity and transparency demands were being increasingly placed on status and trends reports at all levels, and concluded that appropriate quality assurance procedures should always be applied, where practicable, including processes of peer review, certification and authentication of data, analytical methods and results.
- the development of improved systems for fishery reporting should be through the Fisheries Global Information System (*FIGIS*);

and recommended that:

- attention should be paid to those areas that were under-represented, such as in inland fisheries and the social and economic dimension of fisheries, and to include areas other than resources; and
- an International Plan of Action on Status and Trends Reporting which would include 1) continuation of the development of a status and trends information database, including capacity-building in its use; 2) development and expansion of the scope of reporting, including for small-scale and multi-species fisheries (including inland fisheries); and 3) the development of partnerships, practical guidelines for quality assurance and the role of working parties at all levels.

The following recommendations were noted by the ACFR and WP/STF (as noted in detail in Annex 5 of this report), as follows:

- Recommendation: some measure of uncertainty should be included in all stock assessments in future and provision should be made to allow and encourage this through records of analysis.
- Recommendation: a checklist method of basic data quality criteria and scores should be developed to enable databases to hold at least some uncertainty values associated with data.
- Recommendation: Some attention to standardisation of nomenclature with regard to fishery status and the underlying stock assessments need to be addressed, including estimates of reliability/uncertainty.
- Recommendation: training materials in the nature and scope of reference points, and management control rules, in particular in data-poor situations, should be prepared.

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[11] ACFR (2002) Achievements of the Advisory Committee on Fisheries Research, 1997-2002. Rome, FAO, 9-12 December 2000. *ACFR/IV/2002/X*.

[12] FAO (2001) Status and Trends Reporting in Fisheries: A review of progress and approaches to reporting the state of world fisheries. *FAO Fisheries Circular No 967*. Rome, FAO. 2001. 74 p.

In 2000 the ACFR completed a draft proposal for improving global reporting on status and trends reporting of fisheries for submission to the Twenty-fourth Session of the FAO Committee on Fisheries (*COFI)* (Rome, February 2001). It also recognized that there was also a need for improved status and trends reporting for aquaculture, as a separate initiative such as an equivalent IPOA for aquaculture. The draft IPOA (similar to others) addressed, inter alia, the following issues:

- The guiding principles should include considerations of timeliness, flexibility, expanding scope (e.g. social and economic aspects, all fisheries segments to be adequately addressed) and feedback of data and research findings to stakeholders, fishers and fisherfolk in particular;
- recognition of the role of traditional knowledge in ensuring sustainability and involvement of stakeholders; and
- the special needs of small-scale fisheries and multispecies fisheries, emphasizing the need for human capacity-building to ensure priority attention of donors to these special needs in resource-lacking developing countries.

An International Plan of Action (*IPOA*) on Status and Trends Reporting was prepared and submitted to COFI in 2001. COFI instructed that this important issue required the attention of a general *Technical Consultation on Improving Information on the Status and Trends of Capture Fisheries*, which was conducted in 2002[13] to undertake the following:

- consider how fisheries status and trends reporting could be improved effectively;
- consider the possible development of an international plan of action;
- consider data and information collection and analysis at the national, regional and global levels;
- give particular attention to the needs of developing countries for capacity-building; and
- elaborate proposals on these issues for presentation to the Twenty-fifth Session of COFI to be held in February 2003

The *Technical Consultation* revised the approach, considering that the contents of the IPOA would be better described as a Strategy, and referred it to COFI 2003 for consideration. The Strategy-STF for Improving Information on Marine Capture Fisheries was adopted by COFI in March 2003.

• Strategy for Improving Information on Status and Trends of Capture Fisheries

The Strategy agreed by COFI contains the following Guiding Principles (Part 4) for implementation.

- Sustainability
- Best scientific evidence
- Participation and cooperation
- Objectivity and transparency
- Timeliness

Part 5, Required Actions, of the Strategy are summarised as follows:

- Need for capacity-building in developing countries
- Data collection systems in small-scale fisheries and multispecies fisheries
- Expanding the scope of information on status and trends of fisheries, including consideration of the needs for ecosystem based fisheries management.
- Global inventory of fish stocks and fisheries
- FIGIS participation, structuring and capacity-building
- Development of criteria and methods for ensuring information quality and security
- Development of partnership arrangements
- The role of working parties to assess the status and trends of fisheries
- Sustaining data collection, information on the status and trend of fisheries

[13] FAO. (2002) Report of the Technical Consultation on Improving Information on the Status and Trends of Capture Fisheries. Rome, 25-28 March 2002.*FAO Fisheries Report* No. 680. Rome, FAO. 2002. 75p

- ## Code of Conduct for Responsible Fisheries (CCRF)

In relation to fisheries information, the CCRF notes the requirement to consider and develop, *inter alia*:

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

The Strategy-STF has been incorporated within the *FishCode* Programme of the FAO Fisheries Department, an institutional process to address FAO's responsibilities and requirements for implementation of the Strategy. That programme will address many of the Strategy's requirements, including capacity building as required.

- ## FIGIS and SIFAR

The Fisheries Global Information System (FIGIS) is rapidly under development and implementation. As a central information communication facility it is developing rapidly including many developments that approach the data quality issue. Many other institutional programmes worldwide are also addressing the data quality issue, e.g. Marine XML (see Box 14 below), and are being adopted where appropriate for the FIGIS developments.

The Strategy-STF for Fisheries and Aquaculture Research (SIFAR) has recently conducted a Workshop on a Draft Integrated Information Strategy with the following objective. It developed a Strategic Action Plan for closer information system integration and proposed the primary objectives of that strategy and the tasks involved in achieving information system integration.

Box 14. Benefits of a MarineXML (Summary)

The development of a marine XML will support the tracking of data from collection through to the generation of integrated global and regional datasets. XML can support the metadata describing the data collection, quality control and subsequent processing. The generation of data tagged with XML at the instrument level would provide the ability to automate such processes as generation of metadata descriptions. There are a number of reasons for using a marine XML:

Exchange of data. A major strength and source of potential of XML is that it facilitates the exchange of data between different applications and operating systems. Because different organisations (or even different parts of the same organisation) rarely standardise on a single set of tools, it takes a significant amount of work for two groups to communicate. XML makes it easy to send structured data across the web so that nothing gets lost in translation. XML is potentially the answer for oceanographic data exchange, as long as all sides agree on the markup to use.

Extensibility. Extensible means that it is not a fixed format like HTML. While HTML tags must follow pre-set standards, new XML tags can be created by anyone at any time. XML will allow groups of people or organisations to create their own customized markup languages for exchanging information in their domain. Examples of existing industry-specific XML include music, chemistry, electronics, linguistics, engineering and mathematics.

Plain Text. Since XML is not a binary format, files can be created and edited with a standard text making it useful for storing small amounts of data. At the other end of the spectrum, an XML front end to a database makes it possible to efficiently store large amounts of XML data. XML provides scalability for anything from small configuration files to an industry-wide data repository.

Data Identification. The XML standard specifies how to identify data, not how to display it. HTML, on the other hand, describes how things should be displayed without identifying the content. Because the different parts of the information have been identified, they can be used in different ways by different applications.

Stylability. When display is important, the style sheet standard, XSL, can dictate how to portray the data. Since XML is inherently style-free, different style sheets can be used to produce output in postscript, PDF, or any other format.

Hierarchical. XML documents are hierarchical in structure. Hierarchical document structures are, in general, faster to access because you can drill down to the part you need, like stepping through a table of contents.

• Coordinating Working Party of Fisheries Statistics (CWP)

At an intersessional meeting of the CWP it was agreed to conduct work that would result in detailed descriptions of national statistical methodologies. The meeting stressed that national methodological reports are an important tool in the assessment of data quality and that this topic should be addressed in more detail at CWP-20; and consideration should be given by CWP to developing a template for the format and content of these reports so as to avoid national authorities being faced with differing requests from CWP agencies.

CWP has also noted that it might be considered a general rule that the closer the fishery can be managed to approach the 'real' sustainable yield, the higher the data requirements to estimate necessary precaution will be, and hence the higher the costs. The inverse is probably also true; the lower the data quality (hence costs), then the higher the likelihood that over-exploitation will result, causing lost benefits, both present and future. In addition, as mentioned above, in future attention to the precautionary approach the lack of data will result in lost opportunity for harvest and perhaps under-utilization of the available resource.

A review of the requirements for Progress in Fisheries Statistics, and other matters[14] was undertaken for CWP in 2002 for submission to the Inter-Sessional Meeting of the Coordinating Working Party on Fishery Statistics, 21-22 March 2002 (FAO, Italy). A revision was then prepared for submission to the 20th Session of the Coordinating Working Party on Fishery Statistics, Seychelles, 21-24 January 2003. In the review the following key issues were elaborated.

1. Analysis of requirements for improved fishery statistics; including:

- Analysis of sources, including the EU system for fisheries data collection
- Changes in statistical requirements
- Development of the Strategy for Improving Information on Status and Trends of Capture Fisheries

2. Summary of key quality issues, including

- Timeliness of data submission, Dataset documentation, data formats and comparability, and Standardisation of data types
- Cost-effectiveness of data collection, including;
- Measures of effectiveness
- Measures of costs and their comparability
- Data quality and indicators
- Methods to address cost-effectiveness
- Cost-effectiveness of sampling
- Management method simulation of cost-effectiveness
- Retrospective analysis of cost-effectiveness

3. Approaches to statistical development and a global advocacy role for the CWP, including options and two proposals;

- *Proposal 1.* On the relationship between information inadequacies, fishery science, fishery management advice and fish stock failure: theoretical approaches and case studies into the risks and costs of poor data.
- *Proposal 2.* Technical standards and solutions for statistical transactions.

Some key issues were elaborated in the CWP 20 final report[15], as follows:

- The FAO Agricultural Bulletin Board on Data Collection, Dissemination and Quality of Statistics (ABCDQ) project is presently under development by the FAO Statistical

[14] Review of the Requirements for Progress in Fishery Statistics: Approaches to statistical development and a global advocacy for the Coordinating Working Party on Fishery Statistics. CWP20/5. Considered at the Twentieth Session, Victoria, Seychelles, 21-24 January 2003.

[15] Coordinating Working Party on Fishery Statistics. Report of the Twentieth Session, Victoria, Seychelles, 21-24 January 2003

Division. The web page of the project (http://faostat.fao.org/abcdq/) provides information on the sources and methods of national agriculture data collection and dissemination and on their quality. Quality is defined by the project as Relevance, Accuracy, Timeliness and Punctuality, Accessibility and Clarity, Comparability, Coherence and Completeness, and sound Meta Information.

- The lack of recognition by many governments of the need for reliable statistics as a basis for fisheries policy making and management. It was agreed that a 1-2 day workshop on this topic should be held prior to CWP-21. The workshop could focus on implementation of the Strategy-STF with a focus on the national level, and on the needs of developing countries in particular.

CWP20 also noted that 1) many elements of the Strategy-STF fall within the remit of the CWP; 2) it supports the proposed Strategy as a overall framework within which its own aims clearly lie; and 3) it is prepared to actively facilitate implementation of the Strategy for those elements of the Strategy which fall under its mandate. It also noted that a new version of the “Handbook of Fishery Statistics”, first published in 1990, has been renamed the “CWP Handbook of Fishery Statistical Standards” and has been extended to all oceans.

Issue focus

- **The Ecosystem Approach to Fisheries[16] and the Precautionary Approach**

Opportunities and challenges for coordination between marine regional fishery bodies (RFBs) and regional seas conventions (RSCs) have been identified[17]. Ecosystem considerations and indicator frameworks are increasingly factored into fisheries management, particularly since the decisions of UNCED 1 and 2 (Rio in 1992 and Johannesburg in 2002) and the outcomes from the Conference on Responsible Fisheries in the Marine Ecosystem[18].

The functionalities of regional fisheries bodies (RFBs) and Regional seas conventions (RSCs) will need to be adapted in a practical, cost-effective way to meet future needs. This could be done in a way that would not overburden either RFBs or RSCs, and build on current programmes. Some examples of activities, which could form a basis for practical cooperation, are suggested.

In preparing to adopt the precautionary approach, ICES held a Working Party on the Precautionary Approach at the 11th ICES Dialogue Meeting, which concluded[19]:

> *"The PA 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."*

Thus, just as largely recognised by other institutions, this conclusion notes;

- the need for information requirements to assess risk and decide management;
- to use information for appropriate strategies and with statistical confidence;
- the expanded scope and information needs of the precautionary approach and the ecosystem
- stakeholder inclusion.

- **Data inclusion**

The scale and quality of fisheries and related environmental data is very large at all levels. Stock assessment, management, ecosystem, socio-economic, and other domains require increasing quantities. For reference to the many domains and information responsibilities, refer

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

[17] UNEP/FAO. 2000. "Ecosystem-based Management of Fisheries: Opportunities and Challenges for Coordination between Marine Regional Fishery Bodies and Regional Seas Conventions (RSCs)," UNEP Regional Seas Reports and Studies No. 175. UNEP, 2001. ISBN 92-807-21-5-4.

[18] Conference on Responsible Fisheries in the Marine Ecosystem, Reykjavik, Iceland, 1-4 October 2001

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

to the footnoted FAO document[20].

In addition to the numerous domains that need information inclusion, as stated elsewhere about user needs, there are also management approaches that recognise information availability.

The US NMFS, in its Congressional Report, sets its fisheries management advice according to a wide variety of indicators and the data used to derive them. The use of 6 tiers of control rules that are used in the US is according to the availability of information. The use of such tiers is both a reflection of reality and a way of coping with uncertainty. The NMFS control rule list submitted with the report, in which the highest tier uses *pdf's* (probability density function) as the measure of uncertainty, is as follows. (In the given example, the control rules tiers apply for a particular purpose i.e. the definition of overfishing for a species group in a management area.)

Six Tiers comprising the Overfishing Definition for Gulf of Alaska and Bering Sea/Aleutian Islands Groundfish

1) Information available: Reliable point estimates of B and BMSY and reliable *pdf* of FMSY.
2) Information available: Reliable point estimates of B, B_{MSY}, FMSY, $F_{30\%}$, and $F_{40\%}$.
3*) Information available*: Reliable point estimates of B, $B_{40\%}$, $F_{30\%}$, and $F_{40\%}$.
4) Information available: Reliable point estimates of B, $F_{30\%}$, and $F_{40\%}$.
5) Information available: Reliable point estimates of B and natural mortality rate M.
6) Information available: Reliable catch history from 1978 through 1995.

Thus, the issue of data inclusion as a measure of data quality is largely dependent on the number of stakeholders, from those that generate the data to those that need it for their analytical tasks.

Further attention to full fishery data inclusion in all aspects of fisheries is reviewed in Annex 7[21].

• Confidentiality and Partnership

Defining what data is to be made available, and convincing people that it is needed and must be supplied, is one of the most difficult tasks of fishery managers. One of the main problems is the tensions that arise between required transparency and improved confidence on one side and commercial confidentiality on the other. Given that source fishery data often comes from unverified or unverifiable sources (all catches cannot be independently inspected), fishery managers must resolve this tension in a satisfactory way, which should ensure compliance with information requirements while also obtaining it in detail sufficient for their purposes.

Applicable confidentiality is an issue that appears repeatedly in agreements, frameworks, contracts and administrative instruments. Even within information domains, institutions and when shared between partnerships, it is not clear exactly what applicable confidentiality rules need to be adhered to. Given that one data quality criterion will be concerning measures of transparency (See Annex 3. IMF The IMF Generic Data Quality Assessment Framework), it seems important that defining a framework for the application of applicable confidentiality would be useful to all present and potential data and statistical derivative users.

One approach to the implementation of partnerships has been the Fisheries Resources Monitoring System (*FIRMS*) (developed at FAO/FIGIS). This will be established, be maintained by a Steering Committee and be subject to agreed and adaptable information management policies.

• Data use records and metadata

Data use records (and hence the issue of metadata) are important elements of quality control in fisheries. Part of the quality approach to data is one of the ISO 9000 principles, key elements of which are as follows:

- Informed decisions are required and maintained through 1) an increased ability to

[20] FAO. Guidelines for the Routine Collection of Capture Fishery Information. Fisheries Technical Paper, No. 350. Rome, FAO. 1999.

[21] Drawn from FAO Guidelines for Responsible Fisheries no. 4: Fisheries Management. Rome, FAO. 1997.

demonstrate the effectiveness of past decisions through reference to factual records; 2) an increased ability to view, challenge and change opinions and decisions.

- Applying the principle of factual approach to decision making typically leads to 1) ensuring that data and information are sufficiently accurate and reliable; 2) Making data accessible to those who need it; 3) analysing data and information using valid methods; and 4) making decisions and taking action based on factual analysis, balanced with experience (history) and intuition (intellectual efforts towards change). (see Box 2)

Part of this requirement was addressed by the ACFR. Analysis of the approach is summarised in Annex 5. Developing and maintaining approaches to knowledge about fisheries data quality.

• Cost-effectiveness

One example of the lack of understanding about cost-benefit/cost-effectiveness because of information uncertainty is in the review of the fisheries agreements between the European Community upon behalf of Member Fishing States and jurisdictions with fishery management responsibilities[22]. (See Box 15 below)

Box 15. Fisheries Data and International Fisheries Agreements

In a special audit report of the European Communities the Court of Auditors addressed the cost-benefit ratio of the fisheries agreements, noting particularly the following with regards to 'Indispensable information':

- The Commission could not draw up a complete balance sheet of the costs and benefits of international fisheries agreements. Although it was able to supply costs (Commission to Auditors) it could not supply the value of the catches, nor the direct and indirect impacts (e.g. jobs). It noted that figures for these are absolutely vital.
- The European Parliament called on the Commission to draw up a set of guidelines to enable a uniform procedure when evaluating the implementation of expiring protocols or fishing opportunities or preparing for negotiations on new protocols or agreements.

The Court of Auditors report concluded:

- the introduction of technical data sheets for international fisheries agreements in 1999 has not enabled either ongoing monitoring or detailed cost-benefit analysis for each agreement.
- Weakness detected included lack of good quality information on the fish stocks situation, the financial compensation, which is calculated without taking into account the rate of utilization of the agreement or the returns obtained or expected from the agreements.

The Court report also noted that previous evaluations of fisheries agreements contained reservations concerning the quality, completeness, relevance and reliability of the information available. These reservations provoked the following call; that the Commission needs to improve its collection of data from Member States. Clearly (other sections of this report) the EC, including Eurostat, have much improved the information process that is required to monitor fisheries agreements and to take all things into account, including the state of stocks and the costs and benefits of taking fishing opportunities.

Cost-effectiveness evaluations of fishery statistics in relation to improved science and better fishery management have almost never been analysed. Indeed, the most comprehensive recent analysis of the whole issue of fisheries data "*could find no existing analyses of the costs and benefits of data collection and management for specific fisheries, particularly of the ratio of marginal costs and marginal benefits for each additional dollar spent on data collection"* [23]. Nevertheless, demonstrating cost-effectiveness would be extremely useful in persuading policy makers and planners of the relative value of data collection in meeting their science and management performance targets.

A few approaches to the analysis of the benefits and costs of fisheries management have been

[22] Court of Auditors. 2001. Special Report No. 3/2001 concerning the Commission's management of the international fisheries agreements, together with the Commission's replies. Official Journal of the European Communities. 2001/C 210/1.

[23] Improving the collection, management and use of marine fisheries data. National Research Council. National Academy Press, Washington, D.C. 2000. page 132, Matching data collection costs to benefits from fisheries.

undertaken in the past, both formally (e.g. Powers and Restrepo[24]) and informally.

What is clear from this and from other sources is that cost-effectiveness (as a measure of the relationship between data costs and data benefits) is a continuing issue and one that needs an assessment methodology in a particular framework that applies to fisheries and aquatic ecosystem use. Research, assessment and publication of such a methodology will enable many countries and institutions to evaluate the fisheries statistical methodologies that they use, both currently and for future information needs. This is proposed under next steps in the following section.

The overall issue and some selected approaches to cost effectiveness are presented in Annex 8.

[24] Powers, J.E. and V.R. Restrepo. 1993. Evaluation of Stock Assessment Research for Gulf of Mexico King Mackerel: Benefits and Costs of Management. North American Journal of Fisheries Management 13:15-26, 1993.

Conclusion

The general conclusion of this review is that the world community is moving towards the goal of a full knowledge base for the sustainable conduct of fisheries. The recent advances in communications and analytical capacity have accelerated the speed of data acquisition and dissemination. The major advantage of these developments is that data types (including metadata), standards, dissemination methods, analytical and presentational criteria and many other information characteristics are accelerating across all domains.

It is therefore appropriate to seek and establish a wide range of data quality criteria for all fisheries purposes; for raw data, for developed indices and common statistical derivatives, among others. Fisheries and aquatic environmental science, fisheries management and control, fisheries production and economics, all require data sharing but also demand a range of data quality measures for their own analytical purposes.

When data sources are needed by a domain (or stakeholders) but they are not structured or identified in ways that are common for all their purposes, data quality characteristics should become more apparent and standard. Therefore, the voluntary adoption of such fisheries standards, and other standards in 'non-fisheries' domains, needs to be available to all stakeholders.

Information capacities of some countries are limited across the board or limited in scope for a variety of reasons; political, scientific, economic or environmental. Developing country capacities in fisheries statistics are recognised at diverse stages of development. Fortunately there are moves to assist all countries in meeting their apparent data requirements in all sectors, including natural resources.

Fisheries institutions have developed many data quality frameworks, often within information management policies that they have adopted. Regional fishery bodies have addressed the issue significantly in recent years, especially in RFBs that have been established for many years and which have responded to fishery production, fishery science and fishery management changes. New RFBs and those with changed memberships can draw on the experience of other RFBs in developing information management policies and mechanisms. The differences in data requirements can be significant across RFBs and between countries for a variety of reasons, including the status and trends of fish stocks, environmental considerations, economic influences and the historical knowledge base.

Nevertheless, the capacity to store information and to make it accessible to all stakeholders is becoming increasingly available. This has been well-recognised by many institutions. For fisheries the FAO has started several accessible work programmes, including the Fisheries Global Information System (FIGIS). Partnerships with other institutions - national, regional and international in both the fisheries and the environmental domains - are also developing for FAO.

The adopted Strategy-STF for Improving Information on the Status and Trends of Capture Fisheries, which was developed by the Advisory Committee on Fisheries Research, recognises the following;

Part 5, *Required Actions*, of the Strategy are summarised as follows:

1. Need for capacity-building in developing countries
2. Data collection systems in small-scale fisheries and multispecies fisheries
3. Expanding the scope of information on status and trends of fisheries, including consideration of the needs for ecosystem based fisheries management.
4. Global inventory of fish stocks and fisheries
5. FIGIS participation, structuring and capacity-building
6. **Development of criteria and methods for ensuring information quality and security**
7. Development of partnership arrangements
8. The role of working parties to assess the status and trends of fisheries
9. Sustaining data collection, information on the status and trend of fisheries

This paper briefly reviews the scale of the data quality issue and makes a number of recommendations on what needs to begin as a backbone for the implementation of the Strategy-STF in relation to Required Action No. 6. Notwithstanding this focus, some of this issue will contribute to all the Required Actions.

Next steps

The terms of reference of this paper included a requirement to *'prepare an approach to the data quality issue as required by the Strategy, including an Expert Consultation, which would assist Component 1 of the Strategy in the further development and introduction of data quality indicators, metadata and data systems and methodologies for an evaluation and assessment approach'*.

This brief review, including some institutional summaries, developments and approaches, is not complete in the sense that a full review needs an approach that starts from a wider base of experience, taking all needs into account. There are some standards and identifiers of data quality issues, but there is not yet full coverage of all fisheries information sub-domains, whether focussed exclusively on fisheries or because of its role in other areas, such as on natural resource sustainability, ecosystems stability and integrated water/land practices (coastal zones, borders, etc). There is a clear recognised need to further develop socio-economic data and other fisheries sub-domains.

The following is a suggestion on preliminary ways to implement one of the *Required Actions* of the COFI-adopted Strategy-STF, i.e. to address the *Development of criteria and methods for ensuring information quality and security.*

Work Programme to implement the Strategy-STF:

The final preliminary result of achieving a globalised approach to this issue through this work programme would contribute further to the other *Required Actions* of the Strategy. The outcome of that would lead to, or contribute further to, programmatic, project and practical approaches to the issue.

The following phased work programme framework is suggested:

Phase 1. Working Group (WG)

Establish a small WG drawn from wide fisheries disciplines, regions and experiences to develop a detailed programme to begin the *Required Action*. The WG would address the following:

- *Data quality indicators, metadata and data systems* – approaches to both fisheries data quality standards and practical systems for defining and maintaining the quality of fisheries data using standards;

- *Methodologies for an evaluation and assessment approach to data quality issues* – develop a first approach to the methodologies, and define an interim work programme that would enable institutions and States to plan for, and contribute to, the final phase – the ACFR Review; and

- *Assessment of cost-effectiveness as a means to improving fisheries research and management* – develop a first approach towards an appropriate method that would enable institutions and States to evaluate the cost and benefits, and to recognise the cost-effectiveness of, data collection and dissemination.

The WG might be managed and supported by the FAO FishCode programme. The results of the WG and any interim tasks would then be submitted to the next phase.

Phase 2. Expert Consultation (EC)

Following preliminary work conducted during the working group and as a consequence of interim work an EC (appointed and managed by CWP) would contribute the following:

- *Further develop objectives and outcomes* - would include criteria, methods and practical guidelines for quality assurance, transparency and security, i.e. meeting the requirements of the CCRF.

- *Assistance in the capacity building and training role* - towards the Strategy's Required Action: *Need for capacity-building in developing countries.*

The results of the EC would formulate a work programme and approach to the following phase.

Phase 3. ACFR Review of Progress to implement the required action

In advance of a review by the Advisory Committee on Fisheries Research, FAO and other institutions and individuals would undertake a work programme (defined by the EC) to prepare 1) appropriate papers, 2) practical efforts to achieve the goal (including systems tests), and 3) the means to achieve the ACFR Review. These would be submitted to ACFR (or to an appropriate ACFR Working Party)

At the end of Phase 3, the results of the ACFR Review would contribute to:

- implementing the Strategy-STF in further directions, or in parallel to other activities;
- international obligations and resolutions; and
- bringing all stakeholders to a better understanding of their responsibilities and information accessibility, and to their participation in partnerships.

The review would arrive at an agreed set of standards and any work programme to develop further ativities to meet future needs, as required.

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CAESAR: Key data quality papers

Chair: R. GRAINGER (FAO)

D. CROSS (EUROSTAT) Norms and standards for co-ordinated fishery statistics gathering

R. RECIDE (Department of Agriculture – Philippines) Sustaining fishery statistics programmes in developing countries

A. CRISPOLDI – C. STAMATOPOULOS (FAO) Sustainable statistical development for fisheries: role of the international institutions

P. LÜBKERT (OECD) Information management and dissemination – Offering access to a comprehensive cross-section of statistical data and meta-data in support of multidisciplinary projects

G. REICHERT (Statistics Canada) Electronic mapping utility – A solution to geographic process

G. BRADY (Central Statistical Office – Ireland) Lower census costs through the use of administrative sources

E. CARFAGNA (University of Bologna – Italy) Cost-effectiveness of remote sensing in agricultural and environmental statistics

D. DESJARDINS (U.S. Bureau of the Census) Graphical methods in editing

Annexes:

Annex 1. Terms of Reference

This paper has been prepared in response to the request of the CWP and FAO/FI/FIDI to address both partnerships and fisheries data quality. This was recognized by CWP in support of changes to understandings about the value of developing and disseminating important data sets that are required to undertaken major management strategies for the world's fisheries demand. For this paper the following terms of reference apply:

Task 1: Data Quality Indicators

a. Review the issue of data quality and indicators of data performance, including statistical cost-effectiveness, at national, regional and global levels of attention.

b. Address the data quality concept components and sub-components that are generally accepted as necessary to meet statistical needs.

c. Focus on data quality as part of the Guiding Principles of the *Strategy-STF for Improving Information on Status and Trends of Capture Fisheries* (the 'Strategy'), which stated under the principle of Best Scientific Evidence that:

- Arrangements for assembling and disseminating information on the status and trends of fisheries should contribute to the best scientific evidence available; and

- Protocols for assuring the quality of scientific information should be applied wherever and whenever practicable and appropriate.

d. Prepare an approach to the data quality issue as required by the Strategy, including an Expert Consultation, which would assist Component 1 of the *FishCode*[25] project, which will implement the Strategy through the further development and introduction of data quality indicators, metadata and data systems and methodologies for an evaluation and assessment approach.

[25] FAO FishCode programme introduced to assist in the implementation of the Code of Conduct for Responsible Fisheries.

Annex 2. Australia - Oceans Policy: Principles and Practices

The recent Australia's Oceans Policy[26] notes the full range of principles and practices required to ensure the sustainability of that nation's ocean heritage, its complementary and conflicting use by stakeholders, and the benefits to be derived from and responsibilities towards the oceans. Throughout the policy there are references to information at all levels and on all issues that are required to enable the implementation of these principles and practices. These are reviewed and summarized as follows:

Summary of information principles in the policy.

All stakeholders shall have access to sound and comprehensive information through clear and transparent mechanisms.

Mechanisms required for the assessment of management performance shall include *inter alia*:

- Expert multidisciplinary information sources.
- A *Framework for the Application of Ecosystem-based Management*, including the necessary information to underpin different decisions at different scales of management.
- *Regional Marine Planning*, incorporating national ecological and socio-economic data, which are currently being collected to underpin future regional planning processes.

The Policy established an institutional setting for information through the *Oceans Policy Science Advisory Group*, which has adopted a work programme for biophysical and socio-economic information and analysis.

The following are being developed:

- *The establishment of an Integrated Ocean Process.*
- *Guidelines on the Application of Ecosystem-based Management in the Oceans.*
- *Guidelines for Assessing and Using Socio-economic data in Oceans management.*

It also provides *Policy Guidance for Ocean Planning and Management*[27] by noting the Policy's intention to provide *'the basis for reporting and performance assessment'* which shall be *'on the basis of the best available information available on assessment of''*, on a wide range of issues, including;

- Natural ecosystem variability, and the sensitivity or resilience of ecosystem use.
- *'Ecosystem change likely from proposed uses and other impacts, levels of acceptable change or incompatible change to ecosystem health'*; and
- *'Gaps or uncertainties in information on resources, use and ecosystem processes and the capacity to monitor, detect and assess change in indicators of ecosystem health.'*

These desiderata of the Policy recognise that assessment shall be *'through an objective, transparent and open analysis of risk, costs and benefits'*. Furthermore, that regimes should be adaptive to *'accommodate uncertainty in the accuracy of assessments of resources'* and allow for *'improvements in information that may alter risk assessment'*. There is an application of the precautionary principle that requires the *'assessment of the risk-weighted consequences of various options'.*

Another important element of the Policy is the *Principles for ecologically sustainable ocean use*, that states:

'Ocean planning and management decisions should be based on the best available scientific and other information, recognizing that information regarding ocean resources will often be limited.'

The processes for assessing the ocean resources are to be justified, certain, and accountable and are to balance all considerations. The user-pays instrument is to apply with the costs of monitoring borne by development proponents. The policy section on *'Reporting, monitoring and assessment'* lists the following key pre-requisites:

- The development of outcome based performance indicators and performance assessment procedures;
- 'Monitoring and assessment programs should be structured so that they provide sufficient statistical power for detection of potential impact, including design for replication and appropriate control of reference areas. Such programs should be subject to public and independent peer review';

[26] Australia's Ocean Policy

[27] Appendix 1, vol. 1, Australia's Ocean Policy, 1998

- '… Effective linkages to national and international ocean monitoring programs should be maintained';
- Ocean managers shall have data access and users a responsibility to provide 'information in the form and at the level of detail required for good management'.

Lastly, in relation to reporting, the Policy states that *'Ocean managers have complementary responsibilities:*

- to communicate clearly what information is required and the form in which it is to be provided;
- to recognise and minimize the transaction costs of requiring information from resource users; and
- to provide feedback on the use made of information and its management value.'

The above summary is brief but indicative of the information needs that the Australia's Ocean Policy considers to be a necessary requisite to assess ocean use. The summary of data coverage and quality notes that all stakeholders are to have appropriate access and that data management requires transparency, certainty and accountability. All three reinforce the importance of data quality, whilst recognising that;

> *'Governments and industry should cooperate to ensure cost-effective access to high-quality information about resources, environmental baseline and monitoring information required for managing existing industries, and for the identification of new opportunities'*

This applies, of course, to all ocean use, not only fisheries, but it has implementation implications in relation to data quality and statistical cost-effectiveness that is addressed in this paper.

Annex 3. The IMF Generic Data Quality Assessment Framework

Quality Dimensions	Elements	Indicators
Prerequisites of quality	**0.1 Legal and institutional environment -** *The environment is supportive of statistics*	0. 1. 1 The responsibility for collecting processing, and disseminating statistics is clearly specified. . 0. 1.2 Data sharing and coordination among data producing agencies are adequate. 0. 1.3 Respondents' data are to be kept confidential and used for statistical purposes only. 0. 1.4 Statistical reporting is ensured through legal mandate and/or measures to encourage response.
	0.2 Resources- *Resources are commensurate with needs of statistical programs.*	0.2.1 Staff, financial, and computing resources are commensurate with statistical programs. 0.2.2 Measures to ensure efficient use of resources are implemented.
	0.3 Quality awareness - *Quality a cornerstone of statistical work.*	0.3.1 Processes are in place to focus on quality. 0.3.2 Processes are in place to monitor the quality of the collection, processing, and dissemination of statistics. 0.3.3 Processes are in place to deal with quality considerations, including trade-offs within quality, and to guide planning for existing and emerging needs
1. Integrity *The principle of objectivity in the collection, processing, and dissemination of statistics is firmly adhered to*	**1.1 Professionalism -** *Statistical policies, and practices are guided by professional principles.*	1. 1. 1 Statistics are compiled on an impartial basis. 1. 1.2 Choices of sources and statistical techniques are informed solely by statistical considerations. 1. 1.3 The appropriate statistical entity is entitled to comment on erroneous interpretation and misuse of statistics.
	1.2 Transparency - *Statistical policies and practices are guided by professional principles*	1.2.1 The terms and conditions under which statistics are collected, processed, and disseminated are available to the public 1.2.2 Internal governmental access to statistics prior to their release is publicly identified. 1.2.3 Products of statistical agencies/units are clearly identified as such. 1.2.4 Advance notice is given of major changes in methodology, source data, and statistical techniques.
	1.3 Ethical standards - *Policies and practices are guided by ethical standards*	1.3.1 Guidelines for staff behaviour are in place and are well known to the staff.
2. Methodological soundness *The methodological basis for accepted statistical framework.*	**2.1 Concepts and definitions -** *Concepts and definitions are used in accord with internationally accepted standards, guidelines, or good practices.*	2.1.1 The overall structure in terms of concepts and definitions follows internationally accepted standards, guidelines, or good practices: see dataset-specific framework
	2.2 Scope - *The scope is in accord with internationally accepted standards, guidelines, or good practices*	2.2.1 The scope is broadly consistent with internationally accepted standards, guidelines, or good practices: see dataset-specific framework.
	2.3 Classification/sectorization - *Classification and sectorization are in accord with internationally accepted standards, guidelines, or good practices.*	2.3.1 Classification/sectorization systems used are broadly consistent with internationally accepted standards, guidelines, or good practices: see dataset-specific framework.
	2.4 Basis for recording - *Flows and stocks are valued and recorded according to internationally accepted standards, guidelines, or good practices.*	2.4.1 Market prices are used to value flows and stocks. 2.4.2. Recording is done on an accrual basis. 2.4.3 Grossing/netting procedures are broadly consistent with internationally accepted standards, guidelines, or good practices.

Quality Dimensions	Elements	Indicators
3. Accuracy and reliability *Source data and statistical techniques are sound and statistical outputs Sufficiently portray reality.*	**3.1 Source data** - *Source data available provide an adequate basis to compile statistics.*	3.1 .1 Source data are collected from comprehensive data collection programs that take into account country-specific conditions. 3.1.2 Source data reasonably approximate the definitions, scope, classifications, valuation, and time of recording required. 3.1.3 Source data are timely.
	3.2 Statistical techniques - *Statistical techniques employed techniques conform to sound statistical procedures*	3.2.1 Data compilation employs sound statistical 3.2.2 Other statistical procedures (e.g., data adjustments and transformations, and statistical analysis) employ sound statistical techniques
	3.3 Assessment and validation of source data *Source data are regularly assessed and validated*	3.3.1 Source data-including censuses, sample -Source data are surveys and administrative records-are routinely regularly assessed and validated assessed, e.g., for coverage, sample error, response error, and non-sampling error; the results of the assessments are monitored and made available to guide planning.
	3.4 Assessment and validation of intermediate data and statistical outputs - *Intermediate results and statistical outputs are regularly assessed and validated.*	3.4.1 Main intermediate data are validated against other information where applicable. 3.4.2 Statistical discrepancies in intermediate data statistical outputs are regularly assessed and validated. 3.4.3 Statistical discrepancies and other potential indicators of problems in statistical outputs are investigated.
	3.5 Revision studies - *Revisions as a gauge of reliability are tracked and mined for the information they may provide.*	3. 5.1 Studies and analyses of revisions are carried out routinely and used to inform statistical processes.
4. Serviceability - *Statistics are relevant, timely, consistent, and follow a predictable revisions policy.*	**4.1 Relevance -** *statistics cover relevant information on the subject field.*	4.1.1 The relevance and practical utility of existing statistics in meeting users' needs are monitored.
	4.2 Timeliness and periodicity - *Timeliness and periodicity follow internationally accepted dissemination standards.*	4.2.1 Timeliness follows dissemination standards. 4.2.2 Periodicity follows dissemination standards.
	4.3 Consistency - *Statistics are consistent within the dataset over time, and with major datasets*	4.3.1 Statistics are consistent within the dataset (e.g., accounting identities observed). 4.3.2 Statistics are consistent or reconcilable over a reasonable period of time. 4.3.3 Statistics are consistent or reconcilable with those obtained through other data sources and/or statistical frameworks.
	4.4 Revision policy and practice - *Data revisions follow a regular and publicized procedure*	4.4.1 Revisions follow a regular, well established and transparent schedule 4.4.2 Preliminary data are clearly identified. 4.4.3 Studies and analyses of revisions are made public.
5. Accessibility *Data and metadata are easily available and assistance to users is adequate.*	**5.1 Data accessibility -** *Statistics are presented in a clear and understandable manner, forms of dissemination are adequate and statistics are made available on an impartial basis*	5.1.1 Statistics are presented in a way that facilitates proper interpretation and meaningful comparisons (layout and clarity of text, tables, and charts). 5.1.2 Dissemination media and formats are adequate. 5.1.3 Statistics are released on the preannounced schedule. 5.1.4 Statistics are made available to all users at the same time. 5.1.5 Non-published (non-confidential) sub-aggregates are made available upon request.
	5.2 Metadata accessibility - *Up-to-date and pertinent metadata are made available.*	5.2.1 Documentation on concepts, scope, classifications, basis of recording, data sources and statistical techniques is available, and differences from internationally accepted standards, guidelines or good practices are annotated.5.2.2 Levels of detail are adapted to the needs of the intended audience.
	5.3 Assistance to users - *Prompt and knowledgeable support service is available.*	5.3.1 Contact person for each subject field is publicised. 5.3.2 Catalogs of publications, documents, and other services, including information on any charges, are widely available.

Annex 4. Approaches to Data Quality – IMF

New approaches continue to emerge among national and international statistical offices on macroeconomic data quality, but a discernible consensus is forming around a multidimensional concept of data quality. Papers and reports on data quality assessments are described and referenced below.

- The evaluation of the Swiss Federal Statistical Office (FSO) and of the Swiss statistical system, by Ivan P. Fellegi and Jacob Ryten, constitutes the first known example in which the management of a national statistical office voluntarily requested counterparts from another country to conduct a review. The resulting report, "A Peer Review of the Swiss Statistical System (2000)," identifies and describes the strengths and weaknesses of the Swiss statistical system and draws up proposals and recommendations for improvement. Fellegi and Ryten conducted a large number of interviews, both of insiders and outsiders of the system, centered around the following three general questions: how *adaptable* is the system in adjusting to evolving needs; how *effective* is the system in meeting existing client needs; and how *credible* is the system in terms of quality and objectivity. To answer these questions, the reviewers assessed the *solidity* of the legal and institutional environment, the *trustworthiness* of the quality of the FSO's products, the *masse de manoeuvre* (i.e., budget, personnel, access to authority) at its disposal, and the *adequacy* of the instruments developed by the FSO to carry out its mandate.

- G. Brackstone, in his paper "*Managing Data Quality in a Statistical Agency,* (1999)" underscores attention to quality as a central preoccupation of a National Statistical Office (NSO). The author defines quality as embracing those aspects of statistical outputs that reflect their fitness for use by clients and suggests six dimensions of quality about which NSO's need to be concerned. He reviews each of the quality dimensions and, within each dimension, identifies what needs to be managed, what approaches might be used for managing it, and how performance can be assessed. Integrating the six quality dimensions identified, Brackstone suggests the corporate systems necessary to provide a comprehensive approach to managing quality in an NSO.

- W. de Vries, in his paper "*How Are We Doing? Performance Indicators for National Statistical Systems,* (1998)" proposes a system approach to evaluating the performance of national statistical offices (NSOs) and takes the view that there is a high correlation between the quality of a statistical system and the quality of its products. De Vries uses the United Nations Fundamental Principles of Official Statistics as a general framework to assess the performance of NSOs, provides a brief explanation of each principle, and raises several operational questions related to each principle.

- In the paper "*Quality Work and Conflicting Quality Objectives,* (1998)" T. Holt and T. Jones underscore the multifaceted aspect of the concept of data quality and describe the various facets, identified as accuracy, relevance, coherence and consistency, continuity, timeliness, accessibility, and revisability. The authors highlight some of the conflicts that arise between different facets of data quality, such as those between consistency and timeliness and underscore that trade-offs must be made.

- The chapter on "Data Quality" in the Australian Bureau of Statistics (ABS) publication entitled *Balance of Payments and International Investment Position, Australia: Concepts, Sources, and Methods,(1998)* is an example of data quality assessment undertaken by a data producer. The chapter lists ABS dimensions of quality in statistics as accuracy, revisability, timeliness, relevance, comprehensiveness, and accessibility. The concept of each dimension is briefly developed and the quality of data for the 1998 Australian balance of payments and international investment position is assessed against these dimensions.

- E. Elvers and B. Rosén, in their chapter on "*Quality Concept for Official Statistics* (1997)," published in the *Encyclopedia of Statistical Sciences*, define quality of statistics by referring to how well statistics meet user's needs and expectations for statistical information, once disseminated. The authors suggest that to allow users to assess the quality of the statistics they utilize, producers of official statistics provide neutral, descriptive information about all aspects of statistics that affect users views on how well the statistics might meet their needs and expectations. They suggest that this information be organized by main quality components, identified as contents, accuracy, timeliness, coherence (especially comparability), availability, and clarity. The authors provide definitions for the main quality components and their subcomponents. They highlight that, although there is wide agreement among the statistical community on what the subcomponents should be, there is no universal consensus on how to group them under the main quality components.

Annex 5. Developing and maintaining approaches to knowledge about fisheries data quality

The issue of fisheries data quality has been addressed worldwide and with significant intensity, particularly by the ACFR in recent years. The following has been prepared as part of the approach to the issue, some drawn from ACFR working documents and discussions, and from other FAO documents. Four areas are considered appropriate to the data quality tasks: 1) a method to record and make available a simple history of institutional stock assessment, 2) the role of the scientific working group, 3) practical approaches to standards and uncertainty and 4) some discussion of information processes that are the tasks of fishery managers.

1) A practical means to maintain institutional memory on information quality issues: records of data source, selection, comparability and experience

The scientific analysis of fishery ecosystem populations, mainly in the domain of fish stock assessment, often requires the maintenance of records of the approaches taken over time. Such approaches vary considerably; from the work of individuals through to large working groups, all of which may be subject to peer review at different stages and timeliness. Maintaining a detailed record of analytical approaches that applied to a particular result is a useful tool both to individuals and to working groups, both at primary analysis and subsequent review.

It is proposed to develop:

- a toolkit that assists in continuity and replicability, itself a data quality issue;
- a user system to enable the toolkit's use at individual, team or collective levels; the information to be individually retained (say, in a model development phase), or shared between associates (say, an institutional or international Working Group), or submitted (say, for consideration by a scientific or management committee, or for peer review);
- a transparency system that publishes data and analytical approaches in the required way, whether under national institutional rules or international collective rules, both of which protect *applicable confidentiality*.

This approach was detailed in Appendix 1: Systems and templates for reporting in the FAO Status and Trends Reporting in Fisheries[28] and in working documents of the ACFR (1999).

2) The role of the Working Group and Peer Review

The transparent and collective analyses of fish populations are often undertaken by Working Groups. The key biological sustainability process (stock assessment) requires a direct and quantifiable understanding of population responses, both to harvest with production precaution and to ensure ecosystem sustainability.

The Working Group often takes place for fisheries where ecosystem geographies and fish stock ranges overlap with multinational (or bilateral) responsibilities, or within States at federal or provincial levels of responsibility. Indeed, community co-management as an integrated means to sustainability will almost certainly mean extension of the Working Group networks as time progresses. Seas, highly migratory species and large marine ecosystems (LMEs) are often collective responsibilities. The institutional arrangements (Scientific Committees and Working Groups) for collective scientific analysis have been established by most Regional Fishery Bodies (RFBs), whose growing oceans (and freshwater) coverage and global distribution now includes countries with capacities that require building.

As improved institutional arrangements develop, the history of how analyses were conducted will benefit newcomers. Newcomers may be individual or institutional and their learning of past practices and methods will encourage their participation in collective analysis and decision-making. Under modern fisheries management processes the acceptability by all participants of analytical decision-making assists in 1) the collective acceptance and implementation of fishery control rules and 2) implementing the socio-economic (and other) responses required for compliance and hence sustainability.

Naturally, the outputs of scientific Working Groups (methods, range of results, statistical interpretations and decisions) are largely available to be referenced in reports. Peer review is acceptable but it is difficult

[28] FAO (2001) Status and Trends Reporting in Fisheries: a review of progress and approaches to reporting the state of world fisheries. FAO Fisheries Circular No. 967 (FIDI/C967). Rome, FAO. (Chapter 5: Recommendation for information sharing and global research communication - A Database for Users. pp 57-64.)

and time consuming to extract the key elements of analyses (methods and data sources) for replication and review, and for learning (capacity building), Maintaining an accessible record of analytical approach, dataset sources (and their metadata) and results assists in appropriate review, continuity and further development. As natural resource and environmental data time series expand it may be that discarded or sidelined analytical approaches could be reintroduced.

The theoretical aspects and complexity of population dynamics is developing and improving rapidly. Its application to datasets can vary greatly as time series grow. There may be different theoretical approaches, choices of analytical model and decision method, and the selection of datasets for model or other analytical application. Therefore, a Working Group of experts in a multinational session will often bring new approaches from scientists with new ideas and expertise. In recent years some Working Groups have succeeded with new approaches that are selected. Some approaches are discarded, and some do not meet collective approval but are supported by the expert as an alternative view. Models and general statistical calculations are often designed to take into account data or dataset uncertainties, including the use of appropriate measures of uncertainty or error, i.e. quantifiable data quality.

Fisheries mathematical sciences have growing information demands that have widened stakeholder contributions and are increasingly subject to normative processes of transparency and correctness. The science is often conducted through a Working Group and subjected to Peer Review. Peer Review experts need access to everything. Part of the information quality process is the capacity to undertake review and to replicate analyses. Such replication includes access to coherent datasets (data quality dimension) that have identified quality indicators.

3) Theoretical and practical approaches to standards and uncertainty

The following summarises the discussion held by ACFR in relation to data quality, in particular focussing on stock status assessment[29].

Fisheries science is continually developing in theoretical, mathematical and model-processing directions. One of the key elements is sensitivity analysis and the effect of highly influential observations. Some different parameters are not equally sensitive to all observations, i.e. an X% change in an observation does not affect all elements of the estimated stock status equally. This is explored in fish stock assessment through sensitivity analysis in two contexts:

- Exploring how a change in an observation, e.g. a survey result, affects the estimate of the elements in the stock status; and
- Exploring how a change in a parameter, e.g. the natural mortality will affect both the estimates and the projection of the stock

- **Standards**

Several problems of standards exist within stock assessment. One of the key needs is **uncertainty**, as standard, including what to do when information quality is unquantifiable. Problems also include nomenclature, reference points and control rules, briefly addressed below.

- **Information uncertainty**

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 (*pdf's*), not point estimates. Fuzzy logic is a similar conceptual method, which spreads a variable between states (or sets) rather than assume 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.

The common interpretation using probability may allow quite terse summary of risk depending on the type of indicator and the choice of appropriate precaution. 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 $F_{CURRENT} > F_{MSY}$). One major advantage with probability, where it can be calculated, is that it presents a common dimensionless measure, that can also be interpreted both subjectively/intuitively as well as formally.

As a minimum, it should always be possible to record a standard error with any estimate, if any measure of uncertainty is possible. Where a risk assessment is possible, it should be possible to summarise results by attaching a probability to defined fishery states (see nomenclature below), even if more complete information is not required.

[29] FAO (2001) Status and Trends Reporting in Fisheries: a review of progress and approaches to reporting the state of world fisheries. FAO Fisheries Circular No. 967 (FIDI/C967). Rome, FAO. (Chapter 4. Approaches to Meeting Information Standards, Quality and Accessibility. pp 31-51.)

Recommendation*: some measure of uncertainty should be included in all stock assessments in future and provision should be made to allow and encourage this through records of analysis.*

- **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 *pdf's*, 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, a state of understanding that should be recorded as such.

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 groups. 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, etc, could form additional questions (and records) tailored to the data and methods used.

Recommendation*: a checklist method of basic data quality criteria and scores should be developed to enable databases to hold at least some uncertainty values associated with data.*

- **Nomenclature and definitions**

There is a small but significant problem in the fisheries assessment domain with nomenclature; overfished, overexploited, overutilized - are these the same thing? In a specific study on the definition of overfishing, Rosenberg[30] voiced consensus that *"advice on management strategies (could be improved) by recommending more comprehensive overfishing definitions and rebuilding schemes".* The recent Committee on Ecosystem Management for Sustainable Marine Fisheries defined it thus:

> *"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."*

Recommendation*: Some attention to standardisation of nomenclature with regard to fishery status and the underlying stock assessments need to be addressed, including estimates of reliability/uncertainty.*

- **Reference points**

The issue of reference points is briefly included here for completeness. It seems clear that the list of reference points will remain open and expand to cover a whole range of indicators. Often, fixed-type reference points in stock assessment applications are inadequate to establish a register of reference points and thus cannot offer flexibility. Of particular important in many fisheries and countries is the need to devise and adopt reference points that reflect data poor situations. Caddy[31], extends the earlier work on reference points to develop simpler ones, such as based on past fishery yields, survey data, and other empirical methods, e.g. Maximum Allowable Yield (MAY) and Current Annual Yield (CAY). It also shows the use of such indicators to develop management control rules.

- **Control Rules**

The formulation of control rules that describe management decisions in terms of indicators is included here for completeness, since data quality and estimation uncertainties are parts of the understanding about how well control rules meet their purposes. For example, the US NMFS, in its Congressional Report, sets its management advice according to a wide variety of indicators and data used to derive them. The main point of note here is the use of 6 tiers of control rules that are used in the US according to the availability of information. The use of such tiers is both a reflection of reality and a way of coping with uncertainty. In the NMFS reports the highest tier uses pdf's as the measure of uncertainty.

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[30] Defining overfishing - Defining Stock Rebuilding. Report of the Second Annual National Stock Assessment Workshop. NMFS, La Jolla. NOAAA Tech. Memo. NMFS-F/SPO-8, July 1993.

[31] Caddy, J. A short review of precautionary reference points and some proposals for their use in data-poor situations.

Recommendation: *training materials in the nature and scope of reference points, and management control rules, in particular in data-poor situations, should be prepared.*

4) Information Processes

Fishery managers rely entirely on the data and information they receive from many sources; from the fishery, from researchers and from policy makers. Ensuring that data is appropriate and sufficient for the complex task of transforming it into information, from which fishery management decisions can be made, involves the careful analysis of information requirements according to the particular management objectives of a fishery. Of particular importance is the choice of performance indicators that are used to assess or diagnose a fishery and its condition, and the changes in these, which indicate their trends and prompt corrective or supportive management decisions. (A detailed analysis of the processes involved in choosing performance indicators against management objectives, and on the nature and selection of reference points may be found in the footnoted references[32] [33]).

1. Data collection and compilation

a. Data quality and standardisation

Part of the planning process for information collection, once the management objectives and indicators have been decided, requires definition of the data standards and coding to adopt for different classes of variables. The use of standards assist in a range of issues from data form design to database comparability and non-redundancy and will typically cover species and their fisheries, fishing vessel and gear types, product types and commodities, meteorological and oceanographic standards and others as appropriate. Where possible the use of standardised and internationally recognised units of measurement (particularly dimensions and mass) and nomenclature can be adopted.

The following international systems form the basis for many useful standards:

- **Species**: International Standard Statistical Classification for Aquatic Animals and Plants (ISSCAAP) or the FAO 3-alpha species codes developed for commercial fish
- **Fishing Vessels:** International Standard Statistical Classification for Fishery Vessels (ISSCFV)
- **Fishing Gear:** International Standard Statistical Classification for Fishing Gear (ISSCFG)
- **Products:** Harmonised Commodity Description and Coding System (ICU)
- **Oceanography:** Committee for International Oceanographic Data Exchange (IODE)

b. Data aggregation

Data is often most useful when it is presented in summary form to reveal the information that it contains, particularly when viewed as time series. In many cases, fishery managers are required to aggregate data for presentational purposes, but also to mask the fishery data that stems from individuals that often consider information on their activities as commercially confidential.

The level of aggregation is usually dependent upon the use of the data. Ocean fisheries data is most often aggregated by broad geographic area (say 1^o or 5^o sq.) because the environmental variability across large spaces is often not significant. On the other hand, coastal fisheries data may need to be aggregated by specific geographic reference (bay, estuary, etc) or by user group or other stratum. For most circumstances of analysis it is often more appropriate to aggregate and transform data into rates (catch/vessel, CPUE, etc) to allow comparison across space and time. Aggregated data is also more amenable to graphic representation.

c. Data sampling

Statistical sampling by surveys where complete enumeration of fishery data is not feasible complicates the data transformation process in that it introduces at the start some elements of bias and uncertainty to the raw information. To assist in avoiding or minimising uncertainty it is usual to undertake frame surveys or fishery censuses (complete enumeration or 100% coverage) to describe the basic structure of the fishery sector, from production, through infrastructure, employment and community dependence, to environmental baselines.

From these surveys, decisions can be made whether to maintain complete enumeration or conduct sample surveys in such a way that the estimate from the data samples is as close as possible to the true value for the data population. The difference between these two is the bias of the estimate, and it is extremely important to calculate and account for this bias by statistical methods. Reducing bias can be undertaken by increasing sample size but also in other ways, partly by random sampling to avoid sampling error and partly at the design stage of the programme.

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[32] FAO Guidelines for the routine collection of capture fishery data. FAO Fisheries Technical Paper, No. 382. Rome, FAO. 1999. pp 83-85.

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

The main problem of data from sample surveys, quite apart from sample error and accuracy, is that the data population from which they are taken may not be evenly distributed across the location (strata) of the data, whether this is in geographic space, time or other dimension. Therefore, sub-dividing a data population into groups or strata, and then randomly sampling those, can reduce the data variability to that which represents real differences between the strata, which are then amenable to comparative analysis. The major strata in fisheries are usually one or a combination of space, time, landings, vessels, gears, enterprises, trade, people, the environment and the specific requirements of at-sea fishery-independent research. Subdividing the data population into minor strata, and then randomly sampling those, will enable further reduction of data variability.

2. Data analysis

The whole subject of fishery data analysis is too large for treatment in this paper. Any one analysis may be used to represent empirical data, which is then either used directly for making decisions, and can then form the basis upon which modelling and simulation are undertaken to test hypotheses and suggest other management solutions. The problem for fishery managers is to cope with uncertainty, both in the data itself (as mentioned above) and in the results of analyses.

Fishery management measures are usually defined as fixed limits: the absolute value of a TAC or quota; the precise boundary of a controlled zone; or the dimensions of a fishing gear. But, the very nature of the data and the analyses performed make these precise definitions impossible to make in a purely objective way. All statistical analyses that define limits can usually be challenged by alternative analyses, using slightly different transforms and analytical methods. Therefore, it is always important to offer and support analyses upon which decisions are made by the analysis of confidence in the estimate. This is usually calculated as a distribution of estimates at different levels of probability, and expressed in terms of, say, 99% or 95% confidence limits. The choice of a point estimate within the distribution - in particular with regard to stock assessments and yield estimates and the determination of a TAC - is then a matter of decision. This decision, since it is a prediction of the results of future fishery conditions and performance of an ecosystem, will always contain this uncertainty. However, support for decisions can be undertaken through risk analysis, which is now being increasingly used in fishery yield estimation, and should be applied where appropriate.

3. Institutional processes

The complexity of fisheries information and its transformation into fishery management decisions is further complicated by the range of sources of the data. For the information to be channelled from all these sources - the fishery; biological, environmental and operational research; public and private - into a form that is amenable to analysis requires attention to the institutional processes for its success. At each level, from fishing vessel to company to fishery management authority (or other pathway), the transfer of data is usually a subset of the sum of information available at that level. Clarity about the nature of required information subsets is an important task that is driven by the needs of its destination. Hence fishery managers must, as part of the data transformation process, pay attention to the nature and extent of data requirements and the means by which it is transferred.

Defining what data is to be made available, and convincing people that it is needed and must be supplied, is one of the most difficult tasks of fishery managers. One of the main problems is the tensions that arise between required transparency (and therefore improved confidence) on one side and commercial confidentiality on the other. Given that source fishery data often comes from unverified or unverifiable sources (all catches cannot be independently inspected), fishery managers must resolve this tension in a satisfactory way; that both ensures compliance with information requirements, while also obtaining it in detail sufficient for their purposes.

Annex 6. Code of Conduct for Responsible Fisheries and the UN Fish Stocks Agreement

The following are the articles relating to data quality extracted from the CCRF and the UNFSA.

CCRF

Article 7: Fisheries management …

7.4 Data gathering and management advice

7.4.1 When considering the adoption of conservation and management measures, the *best scientific evidence* available should be taken into account in order to evaluate the current state of the fishery resources and the possible impact of the proposed measures on the resources.

7.4.2 Research in support of fishery conservation and management should be promoted, including research on the resources and on the effects of climatic, environmental and socio-economic factors. The results of such research should be *disseminated* to interested parties.

7.4.3 Studies should be promoted which provide an understanding of the *costs, benefits and effects* of alternative management options designed to rationalize fishing, in particular, options relating to excess fishing capacity and excessive levels of fishing effort.

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.

7.4.5 In order to ensure sustainable management of fisheries and to enable social and economic objectives to be achieved, sufficient knowledge of social, economic and institutional factors should be developed through data gathering, analysis and research.

7.4.6 States should compile fishery-related and other supporting scientific data relating to fish stocks covered by subregional or regional fisheries management organizations or arrangements in an internationally agreed format and provide them in a timely manner to the organization or arrangement. In cases of stocks which occur in the jurisdiction of more than one State and for which there is no such organization or arrangement, the States concerned should agree on a *mechanism for cooperation to compile and exchange such data.*

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.

7.5 Precautionary approach

7.5.1 States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.

7.5.2 In implementing the precautionary approach, States should take into account, inter alia, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities, including discards, on non-target and associated or dependent species, as well as environmental and socio-economic conditions.

7.5.3 States and subregional or regional fisheries management organizations and arrangements should, on the basis of the best scientific evidence available, inter alia, determine:

- stock specific target reference points, and, at the same time, the action to be taken if they are exceeded; and
- stock-specific limit reference points, and, at the same time, the action to be taken if they are exceeded; when a limit reference point is approached, measures should be taken to ensure that it will not be exceeded.

7.5.4 In the case of new or exploratory fisheries, States should adopt as soon as possible cautious conservation and management measures, including, inter alia, catch limits and effort limits. Such measures should remain in force until there are *sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks*, whereupon conservation and management measures based on that assessment should be implemented. The latter measures should, if appropriate, allow for the gradual development of the fisheries.

7.5.5 If a natural phenomenon has a significant adverse impact on the status of living aquatic resources, States should adopt conservation and management measures on an emergency basis to ensure that fishing activity does not exacerbate such adverse impact. States should also adopt such measures on an emergency basis where fishing activity presents a serious threat to the sustainability of such resources. Measures taken on an emergency basis should be temporary and should be based on the best scientific evidence available.

7.6 Management measures

7.6.1 States should ensure that the level of fishing permitted is commensurate with the state of fisheries resources.

7.6.2 States should adopt measures to ensure that no vessel be allowed to fish unless so authorized, in a manner consistent with international law for the high seas or in conformity with national legislation within areas of national jurisdiction.

7.6.3 Where excess fishing capacity exists, mechanisms should be established to reduce capacity to levels commensurate with the sustainable use of fisheries resources so as to ensure that fishers operate under economic conditions that promote responsible fisheries. Such mechanisms should include *monitoring* the capacity of fishing fleets.

2. UNFSA

2.1 Annex I: Standard Requirements for the Collection and Sharing of Data

Article 1 General principles

1. The *timely collection, compilation and analysis of data* are fundamental to the effective conservation and management of straddling fish stocks and highly migratory fish stocks. To this end, data from fisheries for these stocks on the high seas and those in areas under national jurisdiction are required and should be collected and compiled in such a way as to enable statistically meaningful analysis for the purposes of fishery resource conservation and management. These data include catch and fishing effort statistics and other fishery-related information, such as vessel-related and other data for standardizing fishing effort. Data collected should also include information on non-target and associated or dependent species. All data should be verified to ensure accuracy. Confidentiality of non-aggregated data shall be maintained. The dissemination of such data shall be subject to the terms on which they have been provided.

2. Assistance, including *training* as well as financial and technical assistance, shall be provided to developing States in order to build *capacity* in the field of conservation and management of living marine resources. Assistance should focus on enhancing capacity to implement data collection and verification, observer programmes, data analysis and research projects supporting stock assessments. The fullest possible involvement of developing State scientists and managers in conservation and management of straddling fish stocks and highly migratory fish stocks should be promoted.

Article 2 Principles of data collection, compilation and exchange

The following general principles should be considered in defining the parameters for collection, compilation and exchange of data from fishing operations for straddling fish stocks and highly migratory fish stocks:

(a) States should ensure that data are collected from vessels flying their flag on fishing activities according to the operational characteristics of each fishing method (e.g., each individual tow for trawl, each set for long-line and purse-seine, each school fished for pole-and-line and each day fished for troll) and in sufficient detail to facilitate effective stock assessment;

(b) States should ensure that fishery data are verified through an appropriate system;

(c) States should compile fishery-related and other supporting scientific data and provide them in an agreed format and in a timely manner to the relevant subregional or regional fisheries management organization or arrangement where one exists. Otherwise, States should cooperate to exchange data either directly or through such other cooperative mechanisms as may be agreed among them;

(d) States should agree, within the framework of subregional or regional fisheries management organizations or arrangements, or otherwise, on the specification of data and the format in which they are to be provided, in accordance with this Annex and taking into account the nature of the stocks and the fisheries for those stocks in the region. Such organizations or arrangements should request non-members or non-participants to provide data concerning relevant fishing activities by vessels flying their flag;

(e) such organizations or arrangements shall compile data and make them available in a timely manner and in an agreed format to all interested States under the terms and conditions established by the organization or arrangement; and

(f) scientists of the flag State and from the relevant subregional or regional fisheries management organization or arrangement should analyse the data separately or jointly, as appropriate.

Article 3 Basic fishery data

1. States shall collect and make available to the relevant subregional or regional fisheries management organization or arrangement the following types of data in sufficient detail to facilitate effective stock assessment in accordance with agreed procedures:

(a) time series of catch and effort statistics by fishery and fleet;

(b) total catch in number, nominal weight, or both, by species (both target and non-target) as is appropriate to each fishery. [Nominal weight is defined by the Food and Agriculture Organization of the United Nations as the live-weight equivalent of the landings];

(c) discard statistics, including estimates where necessary, reported as number or nominal weight by species, as is appropriate to each fishery;

(d) effort statistics appropriate to each fishing method; and

(e) fishing location, date and time fished and other statistics on fishing operations as appropriate.

2. States shall also collect where appropriate and provide to the relevant subregional or regional fisheries management organization or arrangement information to support stock assessment, including:

(a) composition of the catch according to length, weight and sex;

(b) other biological information supporting stock assessments, such as information on age, growth, recruitment, distribution and stock identity; and

(c) other relevant research, including surveys of abundance, biomass surveys, hydro-acoustic surveys, research on environmental factors affecting stock abundance, and oceanographic and ecological studies.

Article 4 Vessel data and information

1. States should collect the following types of vessel-related data for standardizing fleet composition and vessel fishing power and for converting between different measures of effort in the analysis of catch and effort data:

(a) vessel identification, flag and port of registry;

(b) vessel type;

(c) vessel specifications (e.g., material of construction, date built, registered length, gross registered tonnage, power of main engines, hold capacity and catch storage methods); and

(d) fishing gear description (e.g., types, gear specifications and quantity).

2. The flag State will collect the following information:

(a) navigation and position fixing aids;

(b) communication equipment and international radio call sign; and

(c) crew size.

Article 5 Reporting

A State shall ensure that vessels flying its flag send to its national fisheries administration and, where agreed, to the relevant subregional or regional fisheries management organization or arrangement, logbook data on catch and effort, including data on fishing operations on the high seas, at sufficiently frequent intervals to meet national requirements and regional and international obligations. *Such data shall be transmitted*, where necessary, by radio, telex, facsimile or satellite transmission or by other means.

Article 6 Data verification

States or, as appropriate, subregional or regional fisheries management organizations or arrangements should establish mechanisms for *verifying fishery data*, such as:

(a) position verification through vessel monitoring systems;

(b) scientific observer programmes to monitor catch, effort, catch composition (target and non-target) and other details of fishing operations;

(c) vessel trip, landing and transshipment reports; and

(d) port sampling.

Article 7 Data exchange

1. Data collected by flag States must be shared with other flag States and relevant coastal States through appropriate subregional or regional fisheries management organizations or arrangements. Such organizations or arrangements shall compile data and make them available in a timely manner and in an *agreed format* to all interested States under the terms and conditions established by the organization or arrangement, while maintaining *confidentiality* of non-aggregated data, and should, to the extent feasible, develop database systems which provide efficient access to data.

2. At the global level, collection and dissemination of data should be effected through the Food and Agriculture Organization of the United Nations. Where a subregional or regional fisheries management organization or arrangement does not exist, that organization may also do the same at the subregional or regional level by arrangement with the States concerned.

Annex 7. Scope of information requirements for fishery management

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

The following tables describe the fishery information requirements by information group and then by each level. (* means optional, otherwise the information is desirable or required) These have been derived from the FAO Guidelines for Responsible Fisheries no. 4: Fisheries Management. Rome, FAO. 1997.

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. commercial 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

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 *
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

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

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

Annex 8. Cost-effectiveness of data collection[34]

Introduction

In a recent report by the World Humanity Action Trust[35] the problem of uncertainty is raised - in similar fashion to many other documented views, although it has long been recognised - that *'… information about the status of fishery resources is uncertain because of statistical variability associated with the problem of sampling organisms over vast areas of ocean'.* Given the perceived state of world fisheries, there has not been a previous time when *Informed Decision-Making* (under which key header this statement is made in WHAT's report) was more urgently needed. Yet, in almost all countries the availability of resources to enable this through better data collection has been static or declining. It also appears to have low priority in development projects, e.g. in EU aid projects, only 5.5% of total fisheries budgets are attributable to information.

Part of the problem is confidence and credibility; confidence (and its diametric opposite, uncertainty) being both statistically demonstrable and a qualitative judgement, credibility being the acceptability of advice stemming from confident analyses. When science-based advice is given with a high level of uncertainty, it is hardly surprising that credibility falls, the value of the data already obtained is discredited and the money spent on it seemingly a waste. Under these circumstances, and particularly at times when fisheries are perceived to be in crisis, or when catches fall or fisheries are closed, calls for more data at increased cost can be easily resisted. The management response to such resistance for more money will always need to be justified, including demonstrations of cost-effectiveness.

Unfortunately, cost-effectiveness and cost-benefit are very difficult to measure for reasons outlined earlier in this report, and discussed in more detail below. During the conduct of this study, no evidence could be found of direct cost-effectiveness studies that could quantify the relationship and then, perhaps, provide some model guidance on how statistical programmes and projects might be evaluated in terms of improved science and better fishery management.

To reiterate the findings quoted in this report's Executive Summary. The NRC Committee on improving the collection and use of fisheries data *"could find no existing analyses of the costs and benefits of data collection and management for specific fisheries, particularly of the ratio of marginal costs and marginal benefits for each additional dollar spent on data collection"*[36].

Notwithstanding this recognised deficiency, it seems clear that better methods to address cost-effectiveness and cost-benefit should be developed and this is addressed in the programme and project proposal.

Measures of effectiveness

To be effective fisheries data must be good enough to enter analyses that provide the basis for informed decision-making. Some data may need to be transformed and become part of a model, such as fishing effort parameters in stock assessment. The same data may enter decision-making directly, such as fishing effort information and management decisions about capacity reduction or quota allocation. Thus, data may often be used for different purposes and may have different levels of effectiveness according to its use.

Effectiveness need not always be a quantifiable variable. Qualitative assessments of effectiveness based on subjective judgements may also be acceptable, particularly where these judgements can be operationalised using panels or rating systems to produce rank-ordered categories, itself a form of quantifying judgements. Bayesian approaches to fisheries analysis use informed but perhaps subjective expectations (priors) as real variables in quantitative models. Other approaches such as rapid appraisal methods, which typically have lower data requirements, may also be able to make effective assessments, useful to managers and policy-makers.

If data types are divided into broad bands (biological, environmental, catch, fleet, compliance and economic), and set against broad bands of fishery governance (science, management decision-making, economic planning and compliance control), contributions by each data type to the effectiveness of each 'role' within governance is likely to be different. Better biological data is highly effective in improving scientific advice, but may be only marginally important to compliance control. Better quality catch data is likely to be equally important to all roles, although its effectiveness in meeting their tasks may be perceived differently. Economic data will be absolutely essential for economic planning, but only of marginal utility to stock assessment science. As with all multidisciplinary enterprises, effectiveness depends on what you

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[34] This section is drawn from the CWP paper, Review of the Requirements for Progress in Fishery Statistics: approaches to statistical development and a global advocacy role for the Coordinating Working Party on Fishery Statistics, Rome, FAO. 2002. 1p.

[35] WHAT. Governance for a Sustainable Future. A report by the World Humanity Action Trust. UK. 2000 ISBN 0-9539041-0-5

[36] NRC. Improving the Collection, Management and Use of Marine Fisheries Data. National Academy of Sciences, Washington, D.C. 2000. p160.

want to use the data for.

Thus, the adequacy of data can be evaluated only in the context of the purposes for which they are used. Each use implies a set of users and a suite of requirements that the data must satisfy, including timeliness, level of detail and precision, accuracy, accessibility to users, coverage or completeness, and credibility of the data collection process and the management process that uses the data.

In addition to these differences according to data use, where should we expect the lowest/highest cost-effectiveness of statistical investment to be, in any case? 'Target' cost-effectiveness will almost certainly vary by issue, whether for science, licence administration, or economic planning. For example, the utility of obtaining detailed biological data for a stock assessment model might be guaranteed to offer a particular percentage improvement in confidence levels, but because of its complexity and cost of collection, it may not also offer similar improvements to other benefits.

Measures of costs and their comparability

The cost of fisheries data can often be very large, for both direct and indirect costs. The direct costs of maintaining logbook, observer and inspection systems, and investing in surveillance and survey systems, usually form the largest budget items in fishery administrations. All the subsequent analytical processes combined usually cost much less than obtaining the data in the first place.

Required data and its costs may also impact indirectly on the economics, profitability and/or operating efficiency of the industry. For example, in some fisheries it is only allowable to land at designated ports to ensure monitoring (i.e. fish cannot be transhipped at sea, and not landed just anywhere). This landing site requirement may not be the best way of first transportation of catch to market and may increase the costs of production for a vessel, and decrease the economic position of the fleet. Vessels may be tied up longer than for a simple unloading time while inspections or biological sampling are undertaken.

It might be considered a general rule that the closer the fishery can be managed to approach the 'real' sustainable yield, the higher the data requirements to estimate necessary precaution will be, and hence the higher the costs. The inverse is probably also true; the lower the data quality (hence costs), then the higher the likelihood that over-exploitation will result, causing lost benefits, both present and future. In addition, as mentioned above, in the future with the precautionary approach the lack of data will result in lost opportunity for harvest and perhaps under-utilization of the available resource.

Most costs of data collection, of course, relate to human resources. Where labour costs are low, choices can be made on the form of data collection, i.e. labour intensive as against technology intensive systems. In countries where the marginal cost of labour greatly exceeds technical solutions (to achieve the same data), the latter will be more cost-effective. Namibia has an Observer system consisting of more than 300 people, continuously employed across most vessels in the fishing fleets. Their effectiveness in a range of tasks, including catch monitoring, biological sampling and general deterrence, is largely due to the low cost of observers in providing that level of coverage. In one way or another, fishing industries carry the cost of data collection anyway, either directly or through taxation. The fact, that in Namibia the industry directly contributes to the operation of the Observer system, has little to do with overall cost-effectiveness for the industry or the government since Observer costs are included in company expenditures and hence tax deductible.

Methods to address cost-effectiveness

- Cost-effectiveness of sampling

During the design of statistical sampling surveys it is usually recognised that variation in sample estimates fall as sample size increases (Figure 1). At some point the costs of increased sampling outweigh the advantage of reducing variance.

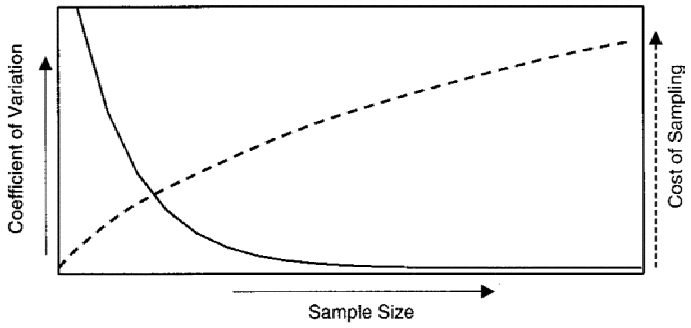

Figure 1. Coefficient of variation and cost as a function of sample size. Note that certain levels of precision are unattainable for limited cost levels. Above certain sample sizes not much additional precision is obtained while costs continue to rise.[37]

[37] NRC Improving the collection, management and use of marine fisheries data. National Research Council. National Academy Press, Washington, D.C. 2000. p83.

Surveys, particularly at-sea fishery independent surveys, often conduct adaptive sampling in ways that enable surveys to be curtailed to save costs, or to better target information needs as new information becomes available. Prior to surveys, the minimum level of bias that satisfies the conditions of an assessment model or hydro-acoustic survey can be estimated. Continuous calculation of standard error and coefficient of variation during surveys, based on current information rather than past information, enables cost-effective application of survey resources.

Calls for the evaluation of cost-effectiveness of surveys are often made in scientific papers when the results of analysis indicate uncertainties on survey utility, e.g. whether surveys should be intensified or scaled down, or whether additional types of surveys should be conducted[38].

- Management method simulation of cost-effectiveness

Choosing a fishery management method can make a real difference to information requirements, both in terms of data costs and their characteristics (timeliness, etc). Some fisheries can be managed through a method involving real-time analyses of stocks, by obtaining expensive real-time data and applying stock assessments continuously until reference points are reached and control rules are activated. Alternatively, the same fishery might be managed by post-fishery assessment (the usual management method) for which data requirements, quality and costs are generally lower. Simulation studies have demonstrated that arguments for the choice of management method (say, between real-time and post-fishery) can be quantified through the estimation of benefits, such as total allowable catch and hence income[39]. Cost-effectiveness can thus be demonstrated.

- Retrospective analysis of cost-effectiveness

It may be possible to undertake retrospective stock assessment analyses of fisheries where details of the methods of analysis, data availability and other factors lead to a known outcome. In this analysis some form of simulation might be undertaken that uses the then-known models or analytical methods and applies better information. Such better data might have been subsequently discovered or collected, or the data itself could be simulated.

[38] Butterworth, D.S., J. De Oliviera and K. Cochrane. Current initiatives in refining the management procedures for the South African anchovy resource. In *Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations*, Alaska Sea Grant College Program, 1993.

[39] In one case known to the author but which remains unpublished, simulation of real-time and post-fishery solutions to management clearly demonstrated that the more expensive and complex method would allow a higher total allowable catch, with a similar level of precaution, and greater income. The difference to incomes under the two management solutions far exceeded the additional data collection and analysis costs. Managers and politicians were thus persuaded, and real-time monitoring was implemented.