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Review of ecolabelling schemes for fish and fishery products from capture fisheries

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Preparation of this document

This document is based on a background report prepared by Keith Sainsbury, Professor of Marine Science, University of Tasmania, for the Expert Consultation on Ecolabelling Guidelines for Fish and Fishery Products held at the Food and Agriculture Organization of the United Nations (FAO) in Rome, Italy, from 3 to 5 March 2008. The background report was reviewed by FAO Fisheries and Aquaculture Department Staff: Kevern Cochrane, Chief, Fisheries Management and Conservation Service; William Emerson, Senior Fishery Industry Officer; and Rolf Willmann, Senior Fishery Planning Officer. Minor changes were made to the background report following the Expert Consultation. Jean-Jacques Maguire, FAO consultant, reviewed this version. The author subsequently updated and revised the text to take account of more recent developments. This version was reviewed by Peter Manning, FAO consultant. Assistance from Tina Farmer, Anne Van Lierde and Françoise Schatto in the preparation of the final document is gratefully acknowledged.

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Abstract

This review is part of a process by the Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations (FAO) to refine the minimum substantive requirements of the FAO guidelines for ecolabelling of marine capture fisheries, and also to consider whether a single set of requirements could be developed that was adequate to assess both marine capture fisheries and inland fisheries. Ecolabels in this context are the International Organization for Standardization (ISO) Type I environmental labels, and so are voluntary with certification based on third party assessment of the environmental effects of the product. The minimum substantive requirements are the measurable or operational requirements for assessing whether a fishery can be certified and an ecolabel awarded, and they relate to the management system, the stocks under consideration and the relevant ecosystem.

This review summarizes the standards, requirements and practices for well-managed fisheries as applied through internationally-managed fisheries and through national management of fisheries. The standards, requirements and practices of existing fishery ecolabels are reviewed, including government-linked ecolabels, non-governmental ecolabels and seafood guides. Seafood guides are mostly ISO Type II or Type III ecolabels that provide self-declared claims or product descriptions against preset indices, and so are not strictly comparable to the ecolabels covered by the FAO guidelines. However, these guides are reviewed here because they are increasingly widespread, sometimes used in business procurement policies, a source of information on public expectations about sustainable fisheries and some use the results of third party assessments.

The special requirements of the assessment of small-scale fisheries and developing countries fisheries are considered. The primary difficulty in relation to ecolabelling of these fisheries is also the primary difficulty with their management, generally that the cost of monitoring, assessment and management can be out of proportion to the value of the fishery and/or beyond the human and infrastructure capacity that is available. However, ecolabelling requires evidence that is verifiable and auditable through third party assessment. Methods to develop, test and apply proxies, empirical indicators and risk-based assessments are available and have been applied in both small-scale and developing state fisheries. While these assessment and management approaches have not been widely applied, and they require further development, they provide promising methods to manage fishery performance in circumstances where formal (statistical) estimation of stock condition is not possible.

Inland fisheries often involve significant artificial enhancements and practices that are characteristic of aquaculture, such as species introductions and translocations, artificial breeding or feeding, disease control and animal husbandry, nutrient fertilization and intentional habitat modification. These practices are counter to the current norms and requirements of wild capture fisheries, which emphasize use of naturally occurring species and the maintenance of natural biodiversity, productivity and ecosystem processes. The importance of distinguishing between wild capture fisheries, enhanced fisheries and aquaculture in ecolabelling schemes is emphasized, because otherwise products with very different ecological impacts and performance standards could appear in the marketplace with the same ecolabel. Presently, the extent of aquaculture-like enhancements that would be acceptable in a capture fishery ecolabel is unclear, and this requires further development. But suggested interim criteria are provided for enhancements that are consistent with modern capture fisheries management and that could be acceptable in a capture fishery ecolabel.

Based on this review, minimum substantive requirements are suggested for the FAO guidelines on ecolabelling of marine capture fisheries.

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1. Introduction

Ecolabelling schemes in the context of this review, certify and promote labels of products from well-managed marine capture fisheries and focus on issues related to the sustainable use of fisheries resources. They are International Organization for Standardization (ISO) Type I environmental labels, and so are voluntary with certification based on third party assessment of the environmental effects of the product (ISO, 1999a; Wessells *et al.*, 2001). Third party ecolabelling for capture fisheries faces several challenges and tensions in delivering ecolabels that are genuinely transparent, voluntary and non-discriminatory. The ecolabel must be accessible to all fisheries that meet the sustainability standard and must not exclude sustainable fisheries because of arbitrary requirements or processes by the ecolabel, such as a requirement to prove sustainability in ways that are not feasible in some situations or use of management systems that are not appropriate or not used in some situations. Flexibility is therefore required. But ecolabelling also requires transparent and consistent demonstration of sustainable performance of the fishery through a third party assessment process. That demonstration is the basis of the credibility, reliability, fairness and truthfulness of the ecolabel. The performance must be transparently demonstrated for all participating fisheries. It is not sufficient for a fishery, industry, government, non-governmental organization (NGO) or certification body to simply state that a fishery is sustainable in its view, or for different standards of proof to be accepted from different fisheries participating in the same ecolabelling scheme. Otherwise there is scope for the ecolabel to become arbitrary and discriminatory in trade and fair competition. Imprecise or general specification of the criteria for assessment can result in arbitrary ecolabelling decisions being applied to different fisheries or by different third party certification bodies. There is, therefore, tension between the need for clear and specific sustainability criteria, including the evidence required to show that they are met, and the flexibility needed to encompass all the various circumstances and approaches in fishery management that can deliver responsible and sustainable utilization.

In addressing these issues it is important to ensure that the purpose and limitations of ecolabelling are recognized. Ecolabelling is not responsible for the management of fisheries – it is the role of governments and competent international bodies to manage fisheries. Ecolabelling identifies well-managed fisheries on the basis of stated criteria relating to sustainable use of the fisheries resources and related marine ecosystems. For the credibility of the ecolabel the criteria must have a high chance of identifying sustainable fisheries and screening out unsustainable ones. The credibility of an ecolabel, and fishery ecolabelling more generally, would rapidly suffer if certified fisheries collapsed or were found to be unsustainable in other important ways. The purpose is not to create an ecolabel that all fisheries can achieve, but rather an ecolabel that all sustainably managed fisheries can achieve. In this it is the sustainability outcome and its transparent demonstration that is paramount to the credibility and fairness of the ecolabel.

In 2005, the FAO Committee on Fisheries (COFI) adopted guidelines for marine fishery ecolabelling (FAO, 2005). These guidelines provide general considerations, definition of terms and principles, and the requirements for institutional and accreditation arrangements so as to ensure independent assessment, audit and verification in conformity with international standards (e.g. the ISO and the World

Trade Organization [WTO]). Ecolabels are required to be voluntary, market driven, transparent, non-discriminatory, not to create unnecessary obstacles to trade (e.g. Technical Barriers to Trade under the WTO) and to promote fair trade and competition.

FAO (2005) also provides an outline of the operational requirements and criteria for assessing whether a fishery can be certified and an ecolabel awarded. These are the minimum substantive requirements and are provided to ensure credibility of the ecolabel and, in particular, that the fishery is well-managed and sustainable. The minimum substantive requirements address each of three issues: the status of the harvested stocks, the impacts of the fishery on the ecosystem and the fishery management system. The minimum substantive requirements in FAO (2005) are based on agreed international instruments addressing fisheries, in particular the 1982 United Nations Convention on the Law of the Sea (UNCLOS), the 1995 United Nations Fish Stocks Agreement (UNFSA) and FAO Code of Conduct for Responsible Fisheries (FAO, 1995a), as well as the 2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem and related documents (FAO, 2001, 2003). The minimum substantive requirements in FAO (2005) are consistent with more recent United Nations General Assembly resolutions (UNGA, 2005, 2006 and 2007).

In adopting the 2005 guidelines, COFI recognized the need for further consideration and development of the minimum substantive requirements for fishery ecolabelling, especially in relation to:

- The stock under consideration and the impacts of the fishery on the ecosystem for both marine capture fisheries and inland fisheries. Inland fisheries often include greater human enhancement or modification of the species (e.g. translocations, introductions, hatchery rearing), food and habitats than is usual in marine fisheries. The minimum substantive requirements identified for marine capture fisheries (FAO, 2005) are provided in Appendix 2 and those proposed for inland fisheries (FAO, 2006) are provided in Appendix 3. Both are based on the FAO Code of Conduct for Responsible Fisheries.
- The criteria used by existing or developing ecolabelling schemes to assess the status of stocks and the ecosystem impacts of fishing.
- The elements of national, regional and international fishery management and arrangements that are relevant to the minimum substantive requirements for fishery ecolabelling, including the FAO Technical Guidelines for Responsible Fisheries Management and implementation of the ecosystem approach to fisheries.

This review of the ecolabels in fisheries was prepared for the Expert Consultation on the FAO Guidelines for Ecolabelling for Capture Fisheries, held in March 2008 (see Appendix 1 for the background and terms of reference), to help elaborate the minimum substantive requirements provided in the FAO (2005) guidelines. The recommendations of the Expert Consultation were considered by the FAO Sub-Committee on Fish Trade in June 2008 and by COFI in March 2009. At this meeting, COFI adopted revised minimum substantive requirements for the *Guidelines for the ecolabelling of fish and fishery products from marine capture fisheries* (FAO, 2009; Appendix 2).

This report first reviews the standards, requirements and practices for well-managed and sustainable fisheries. The standards, requirements and practices are reviewed for several different situations and applications:

- international agreements and management arrangements;
- national management arrangements;
- national and regional government-based ecolabels;
- non-government-based ecolabels; and
- non-government seafood consumer and business procurement guides.

The particular situations of enhanced fisheries, small-scale fisheries and developing State fisheries are specifically examined, and recommended minimum substantive requirements for fishery ecolabelling are provided. There are some differences between the recommendations made through this review and the minimum substantive requirements that were ultimately adopted by COFI (FAO, 2009 and Appendix 2).[1]

[1] The minimum substantive requirements recommended by the author in this Technical Paper refer to capture fisheries generally and were proposals for consideration by FAO, initially by a workshop of experts organized by FAO (see FAO Fisheries Report No. 864). Not all of the recommendations in this Technical Paper were endorsed, and the minimum substantive requirements adopted in the revised Guidelines for the ecolabelling of fish and fishery products from marine capture fisheries (FAO, 2009; Appendix 2) show some differences to these original recommendations.

2. Standards, requirements and practices for well-managed and sustainable fisheries

2.1 INTERNATIONAL AGREEMENTS AND MANAGEMENT ARRANGEMENTS

Over the past decades, especially since the 1982 United Nations Convention on the Law of the Sea (UNCLOS, 1982) established the basis for extended jurisdiction by coastal States and for the sustainable exploitation of the high seas, there have been many changes in the expectations of fishery management. Some of these changes have been reflected in "hard" law, for example, the United Nations Fish Stocks Agreement (UNFSA, 1995). Other changes have been manifest in "soft" law, such as FAO's Code of Conduct for Responsible Fisheries (FAO, 1995a, 1997) and international guidance documents on the precautionary (FAO, 1996) and ecosystem approaches to fisheries (FAO, 2003). These reaffirm the goal of optimal utilization of fishery resources and promote the responsible fishing practices that have been found to be necessary in order to achieve sustainable resources and human benefits. The international impetus to achieve sustainable fishing has also been strongly reinforced by the 2002 World Summit on Sustainable Development (WSSD) and by General Assembly resolutions (UNGA, 2005, 2006, 2007). These call for responsible governments and regional fisheries management organizations (RFMOs) to prevent overfishing and to restore and maintain stocks at levels capable of producing maximum sustainable yields (MSYs), to reduce or eliminate bycatch, to protect endangered species, to protect vulnerable marine ecosystems (e.g. some sea bed habitats) and to apply the ecosystem approach to fisheries. The United Nations General Assembly will review progress on WSSD and General Assembly resolutions in 2009.

UNFSA provides principles for the management of fisheries on highly migratory and straddling stocks beyond national jurisdiction. These principles are wide-ranging and include the use of the precautionary approach in adopting and implementing conservation and management measures. The Agreement also requires that the principles relating to these measures should be applied consistently and compatibly to highly migratory and straddling fish stocks under national jurisdiction. Furthermore, the 2006 UNFSA Review Conference agreed that these principles should apply to discrete or other stocks in the high seas. Thus, the principles of precaution, conservation and management established by UNFSA have very wide applicability to fish stocks on the high seas and within national jurisdiction. The principles provided by UNFSA in relation to the precautionary approach and to conservation and management measures stipulate the requirement to:

- Adopt measures to ensure long-term sustainability.
- Ensure that such measures are based on the best scientific evidence available and are designed to maintain or restore stocks at levels capable of producing MSYs.
- Apply the precautionary approach.
- Assess the impacts of fishing on target stocks and species belonging to the same ecosystem.
- Adopt conservation and management measures for species belonging to the same ecosystem.

- Protect marine biodiversity.
- Ensure that fishing capacity and fishing effort do not exceed those commensurate with the sustainable use of fishery resources.
- Collect and share in a timely manner complete and accurate data concerning fishing activities.
- Promote and conduct scientific research in support of conservation and management.
- Implement and enforce conservation and management measures through effective monitoring, control and surveillance.

UNFSA also includes more detailed guidance on the implementation of the precautionary approach and conservation and management measures:

- Management shall be more cautious when information is uncertain, unreliable or inadequate.
- Precautionary target and limit reference points shall be established for stocks. Fishery management strategies shall ensure that the risk of exceeding a limit is very low. A minimum standard for a limit reference point is the fishing mortality giving MSY, and the biomass giving MSY is an appropriate target for recovering overfished stocks.
- When reference points are approached, they will not be exceeded; and if they are exceeded, there will be action without delay to restore the stocks.
- New or exploratory fisheries shall use cautious conservation and management measures until there are sufficient data to allow the identification of measures for the long-term sustainability and gradual development of the fisheries.
- If natural phenomena have a significant adverse impact on the stocks, conservation and management measures shall be adopted to ensure that fishing activity does not exacerbate that impact.
- It will be ensured that fisheries do not have a harmful impact on living marine resources as a whole.

The changed expectations in fisheries management in recent decades as reflected by these "hard" and "soft" law agreements are very significant, especially when compared with the previous simpler and target species-focused objectives of most RFMOs and other international fishery management arrangements. The more recent expectations have changed the previously accepted level of depletion of target species. They extend management responsibility to the impacts of fishing on the structure and processes of the broader ecosystem (e.g. the ecosystem-based approach to fisheries management [FAO, 2003]) and require the application of a precautionary approach when information or understanding is insufficient for scientific certainty about the effects of fishing. In addition, the United Nations General Assembly (2007) raised particular concerns about the impact of bottom trawling on sea bed habitats and called for an assessment of whether there were adverse impacts on vulnerable marine ecosystems and, if so, that the fishery be managed so as to prevent such impacts or not be authorized to proceed.

The ecosystem-based approach to fisheries management emphasizes that a whole ecosystem perspective is needed, not just a focus on the species directly utilized. This aims to maintain healthy ecosystems in order to support fishery production and other human activities, to minimize the risk of irreversible or very slowly reversible change, to attain high long-term human benefits and to maintain future options for use and sustainable development. This approach is consistent with the goals of sustainable development more generally (e.g. UNCED, 1992) and, in this context, "slowly reversible" could be taken to mean not reversible on a human generation time and not therefore limiting intergenerational equity and development options. It is also consistent with scientific results on the importance of ecosystem health, including genetic, species and community biodiversity, in sustaining ecosystems that can continue to provide the full range of ecosystem services and that are resilient to

natural variability and anthropogenic change (e.g. Hughes, 1994; Holling and Meffe, 1996; Rapport *et al.*, 1998; Costanza *et al.*, 1997; Hughes *et al.*, 2005).

RFMOs have responded variously to the challenge of these changed expectations. Mooney-Seus and Rosenberg (2007) provide an extensive review of the way in which different RFMOs are addressing the UNFSA, ecosystem-based management and the precautionary approach to fisheries management. From these and other comparisons, Lodge *et al.* (2007) developed a summary of best practices by RFMOs (see Appendix 4). These are measures that are in practical operation in at least one RFMO so as to achieve the stock utilization and ecosystem conservation goals set out in FAO's Code of Conduct for Responsible Fisheries, the UNFSA and the ecosystem approach to fisheries. These measures provide a good guide to the requirements of a well-managed and sustainable fishery. The points of particular relevance to the minimum substantive requirements for fishery ecolabelling are:

- Target and limit reference points are used for fishing mortality and population size of commercially targeted and retained stocks.
- Target reference points are consistent with achieving long-term optimum utilization.
- The limit reference point for fishing mortality is no greater than the mortality giving maximum long-term sustainable yield, as specified in UNFSA.
- The limit reference point for stock size is the size below which it is known or expected that there is a much greater probability of significantly reduced recruitment but at which the probability of significantly reduced low recruitment is still small. This could be at a size that has been historically shown to be safe and/or below which stock dynamics are unknown.
- Key prey species are identified and the reference points are modified to account for dependent predators.
- There are identified limits of acceptable impact for non-target or bycatch species, and for habitats, with management measures to ensure these limits are not exceeded. These limits may be determined through risk-based considerations rather than direct assessment of the populations.
- The management system includes agreed strategies or rules to vary the level of fishing depending on the state of the stock and, in particular, to maintain the stock in the vicinity of the targets, to avoid the limits and to recover overfished stocks in a defined period. Recovery of overfished stocks is to levels that can provide long-term MSYs.
- There are effective mechanisms for collecting the information necessary for assessing and managing the fishery, recognizing that information requirements can be very different for different management systems and measures.
- All sources of mortality are accounted for in assessment of the status of the stocks.
- The fishing capacity is commensurate with long-term optimal and sustainable utilization.

These measures are generic, in that they can be applied to all stocks and fisheries, although there may be a wide range of different ways to achieve the intent. For example, fishing mortality or stock size reference points may be reformulated in terms of other more directly measured quantities (e.g. catch rate, fish density, length distribution in the population or catch, tag recovery rates, area of the fishery in relation to the area of the stock) that are sometimes called empirical indicators or empirical reference points (e.g. Hilborn *et al.*, 2002; Kelly and Codling, 2006). Strategies and rules that vary fishing activities can be triggered by these empirical reference points in the same way that they can be triggered by fishing mortality or biomass reference points. The advantage of empirical indicators and reference points is their simplicity. Their disadvantage is that the easily measured indicators for a fishery are often difficult to interpret uniquely and

so they may not provide reliable guidance in management of the quantities that are of fundamental interest and concern, which are usually related to stock biomass and fishing mortality. This disadvantage may be overcome by simulation testing (e.g. Butterworth and Punt, 1999; Sainsbury *et al.*, 2000) or by observed real-world performance over a long period that demonstrates adequate performance of a management strategy based on empirical reference points and decision rules. A key requirement in the use of empirical reference points and decision rules, particularly in a third party ecolabelling context, is transparent demonstration that they have a good chance of achieving the intended management outcomes despite the uncertainties of fishery assessment and management.

Further guidance on the minimum substantive requirements for a fisheries ecolabel can be drawn from the criteria relating for listing under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The aim of CITES is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. A fishery or fishery product that meets the CITES Appendix I or Appendix II criteria would not be expected to be sustainable. The criteria for listing (CITES, 1994) are provided in Appendix 5, and further elaboration and consideration of their application to fisheries is provided by Mace *et al.* (2002). The CITES criteria provide a standard that is lower (i.e. more depleted) than that appropriate for a fisheries ecolabel. Therefore, the criteria for an ecolabel for sustainable fisheries must exceed the requirements that:

- Populations are not depleted below 5-20% of their historical levels (i.e. the levels prior to fishing or that would be expected in the absence of fishing). The range 5-10% is applicable to species with high productivity, 10-15% to species with medium productivity, and 15-20% for species with low productivity. A natural mortality rate in the range 0.2-0.5 per year may indicate medium productivity.
- The recent rate of decline of a population, if it is likely to continue or resume, is not projected to reduce the population below 5-20% of its historical levels within a ten-year period. The same productivity ranges as above apply to this range of depletion.

The CITES criteria are provided in generic terms and specifically allow for different kinds of empirical evidence to be used for their evaluation (e.g. changes in spatial range, change in the quality or area of habitat, general vulnerability because of the pattern of exploitation, life history characteristics or ecological circumstances of the species).

Further guidance on the international standards is likely to come from the ISO soon. In early 2007, the ISO established Technical Committee 234 to develop standards for sustainable fisheries and aquaculture (ISO, 2007). The Technical Committee has met but as yet there are no draft standards publicly available from that process.

2.2 NATIONAL MANAGEMENT ARRANGEMENTS

The national requirements for fishery management are based on national laws, policies and plans. They vary greatly (e.g. see OECD, 2005 and the related annually updated Country Notes on National Fisheries Management Systems; Schmidt, 2003; Marco and Quesada, 2005). Most express an intent similar to that embodied in the United Nations Convention on the Law of the Sea (UNCLOS, 1982) and the FAO Code of Conduct for Responsible Fisheries (FAO, 1995a): to achieve the social and financial benefits of fishing, including attaining the highest or otherwise optimal long-term yield, and to maintain the productive capacity of the fished stocks and their supporting ecosystems. Most provide general and high-level goals, but few provide specific and detailed measures for the adequacy of performance against those goals. Usually, with exceptions that will be discussed further below, there is no description of what is acceptable or unacceptable performance that could be transparently and objectively used as the minimum substantive requirements in a third party assessment for a fisheries ecolabel.

The operational (i.e. measurable) management requirements for sustainable fisheries are very similar across all the jurisdictions where detailed operational requirements are specified, such as the United States of America (NMFS, 1998, 2005a, 2005b), the European Union (ICES, 2003a, 2003b), the Republic of Namibia (MFMR, 2004), the United Mexican States (Alvarez-Torres *et al.*, 2002), Australia (DEWHA, 2001; DAFF, 2007) and New Zealand (NZMF, 2007a, 2008a). These and other approaches were reviewed recently by Sainsbury (2008) and NZMF (2008). They all make use of reference points as operational benchmarks to provide targets and limits and to trigger management responses, as recommended by the FAO Code of Conduct for Responsible Fisheries (FAO, 1995a, e.g. the management system should determine stock specific target and limit reference points and, at the same time, the action to be taken if they are exceeded). The United States of America national standards for fishery conservation and management and related provisions are probably the most comprehensive operational description of the requirements of fishery management to address the issues raised by recent agreements and guidelines (i.e. maintaining or recovering fished stocks to provide an optimal yield not greater than the biological MSY, protecting the productive capacity of the ecosystem, minimizing impacts on vulnerable elements of the ecosystem and endangered species). While the specifications are described in terms of target and limit reference points for fishing mortality and stock biomass they can be replaced by appropriate proxies of these quantities, or different quantities entirely (e.g. empirical indicators and reference points), which achieve the same intent. This point is elaborated in Appendix 16.

The requirements and approaches to the operational specifications for a sustainable fishery are summarized below for (i) target or retained species; (ii) ecosystem considerations; and (iii) the management system.

2.2.1 Target or retained species

The target fishing mortality and consequent catch should be chosen to provide an optimum long-term yield. In fisheries where more than one species is targeted or retained the optimum will involve balancing the exploitation across these species so as to give the best outcome. The exact interpretation of the optimum in balancing economic, social and ecological issues is flexible within the constraints provided by the limit reference points. It is expected and accepted that the stock will vary through time above and below the average stock size associated with the long-term optimal yield. But the target fishing mortality is selected so as to result in a low chance of violating the limit reference points in the long term and in the context of the uncertainties, vulnerabilities and limitations of the particular monitoring, assessment and management arrangements used in the fishery (e.g. a probability of violating the limit reference point of less than 0.9 over at least two fish generation times is commonly used in implementing the US National Standard, is required in implementing the Australian Harvest Strategy Policy, is required in implementing the New Zealand Harvest Strategy Standard, and is a criterion for the acceptance of several harvest strategies of the Convention on the Conservation of Antarctic Marine Living Resources [CCAMLR]). Other things being equal, greater uncertainty in monitoring, assessment and management implementation would require a greater safety margin between the target fishing mortality and the limit fishing mortality.

The maximum or limit fishing mortality should be the fishing mortality giving long-term MSY (i.e. F_{MSY}). Treating F_{MSY} as a limit reference point is consistent with the UNFSA (1995) recommendation and is now also implemented in many national management arrangements. There are several proxies for F_{MSY} in common usage, including the fishing mortality giving a specified reduction in the "spawners per recruit" which can be calculated from life history information alone. The appropriate reduction in the "spawners per recruit" depends upon the productivity of the stock,

with smaller reductions being appropriate for less productive stocks. A proxy with a good general scientific and practical basis (Clark, 2002) is the fishing mortality that reduces the "spawners per recruit" to 40 percent of its unfished level, or $F_{40\%}$. General guidance on the relationship between population productivity and the "spawners per recruit" proxy for F_{MSY} is provided by Sainsbury (2008) and NZMF (2008), with guidelines from NZMF (2008) as shown in Table 1.

Table 1: Relationship between population productivity and the "spawners per recruit" proxy

[illegible]	[illegible]	[illegible]
High productivity	F30%	25%
Medium productivity	F40%	35%
Low productivity	F45%	40%
Very low productivity	≤ F50%	≥ 45%

This combination of targets and limits on fishing mortality is expected to result in the average stock/population size or stock biomass being greater than the average biomass giving the MSY (i.e. B_{MSY}). Sustainability advantages are expected from maintaining a high stock size because most of the ecological and fishery properties that are of interest and concern to sustainable fisheries relate to biomass. These include stock productivity, risk of serious or irreversible harm to recruitment and genetic integrity, stock resilience to natural and anthropogenic impacts, recovery time from overfishing, role in ecosystem functions (e.g. food webs), and robustness to uncertainty in fishery assessment and management implementation. Economic efficiency and profitability advantages are also usually expected from maintaining higher stock size.

The minimum or limit stock size, usually the spawning stock size, should be above that at which recruitment overfishing or other irreversible or slowly reversible damage is thought likely (i.e. B_{lim}). This limit is commonly set at 20-30 percent of the initial or unfished biomass (and a higher percentage for low productivity stocks) or 50 percent of the biomass giving on average the long-term MSY (i.e. $0.5B_{MSY}$). Another common practice is to set this limit so that it represents the state of the stock and fishery at some time in its history where depletion had occurred but had not caused recruitment overfishing. In some management contexts, especially the International Council for the Exploration of the Sea (ICES), a buffer is used (i.e. B_{pa}) to trigger management measures to rebuild the stock and avoid reaching the limit. The size of the buffer depends on the reliability of the estimation of stock size; in practice B_{pa} is often about 1.4 B_{lim}. Similarly, New Zealand has established a "soft limit" at which stock rebuilding measures are triggered with the intention to avoid reaching the "hard limit" of B_{lim}, with $B_{soft\ limit}$ being 2 B_{lim}.

In some situations, there is sufficient information available to estimate the fishing mortality and/or stock size periodically, to check the status against the relevant targets and limits, and to trigger appropriate management responses to maintain a desired status or correct an undesirable one. This is the approach taken to many of the larger and more valuable fisheries. There are many instances, however, in both developed and developing country fisheries where the information necessary to do this is not available and/or could not be provided at a cost commensurate with the scale of the fishery. Two approaches have been developed and applied to achieve the outcomes specified by the fishing mortality and stock size reference points in situations where these quantities are not specifically measured or estimated.

(i) Empirical or proxy indicators and reference points

Empirical indicators are directly measurable aspects of the fishery (e.g. catch per unit effort or sex ratio, proportion mature, size distribution in the catch) in contrast to