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## Using simple indicators in fisheries: review and applications for INCOFISH WP7

Compiled by Amanda Stern-Pirlot in December 2005 for Work Package 7, "Simple Indicators for Sustainable Fisheries" of the INCOFISH Project (Integrating Demands on Coastal Zones with Emphasis on Aquatic Ecosystems and Fisheries), Contract INCO 003739

### Introduction

This paper provides a brief background on contemporary fisheries management and discusses how using fisheries indicators can help improve it. The focus is on simple indicators that have the potential to complement traditional stock assessment and allow stakeholders and the public to contribute to the management of the stocks. Indicators selected for implementation by INCOFISH WP7 and their accompanying rationale are presented.

### Fisheries management today

Fisheries management still works mostly through top-down control structures for which fisheries biology provides the knowledge base through stock assessments (Raakjær Nielsen et al. 2001). Management usually consists of authorities setting Total Allowable Catches (TACs), mesh-size and other gear restrictions, and controlling fishing effort (number of boats, days at sea, etc.). However, the effectiveness of this type of management is questionable in light of the fact that overfishing and the use of destructive fishing gears is a long-standing perpetual problem, dating back at least 500 years (Fulton 1891), that many of the world's fish stocks are at historically low levels, and that global catches are in decline (FAO 2005) (Fig 1.).

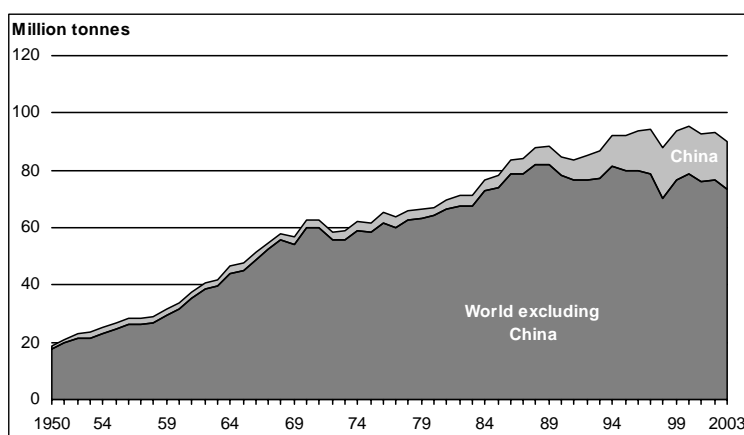


Fig. 1: Capture fishery production - World and China (FAO 2005). Catch reported by China is questionable.

The overriding failure of contemporary fisheries management can be attributed to two overarching factors:

- (1) The failure of regulatory authorities to adopt and enforce the recommendations of fisheries scientists. In “wealthy” countries, where the fisheries sector is small relative to the overall economy, this is termed “convenience overfishing”—legalizing of catches above safe levels because it is easier to risk the eventual collapse of fish stocks than to risk generating short term social or political conflict (Froese 2004). In developing countries, where fishing makes up an important income source and is often poverty-driven and an employment of “last resort” (Charles 2001), this has been termed “Malthusian overfishing” (Pauly 1990).
- (2) A lack of understanding and acceptance of management measures among fisheries stakeholders.

The significance of convenience overfishing is especially evident in Europe, where there is more fisheries research and advice than anywhere else in the world but many fish stocks are nevertheless heavily overfished and in danger of collapse. European fisheries-industry lobbies have an unjustifiable influence on policy given the relative unimportance of this industry economically. For example, between 1988 to 2001 about 77% of the scientific advice from the International Council for the Exploration of the Sea (ICES) regarding Total Allowable Catches (TACs) and quotas was correct or conservative (Anonymous 2003). However, this advice has almost always been ignored by policy makers due to interventions by the fish-industry lobbies. As a result, many stocks in North Sea and Baltic Sea continue to decline from overfishing, some even reaching historic lows while the TACs are nevertheless increased (European Commission 2005). This is all happening at the same time as 86% of European consumers prefer to buy sustainably caught seafood (Anonymous 2005). This clearly points to an undue influence of fish-industry lobbies and therefore the failure of top-down management in this region.

A lack of understanding and acceptance of prevailing management measures often stems from the fact that their scientific basis is opaque and highly technical. Fisheries biologists are making predictions and recommendations based on complicated models which require ever-more data and components as the importance of ecosystem interactions becomes more recognized (Raakjær Nielsen et al. 2001). This means that stakeholders and policy-makers are asked to accept recommendations of scientific bodies at face-value, without understanding or participating in the process. This alienates those directly involved in or influenced by

management decisions. For example, in most developing countries, fisheries management only exists on paper, with relationships between fishing communities and the Departments of Fisheries being distrustful or confrontational (Jentoft 2004, Vargas & Mata 2004). Fishing is usually an employment of last resort (Charles 2001), and destructive fishing methods are widespread. In Costa Rica, for example, small-scale fishers in the Gulf of Nicoya regularly ignore the official ban on shrimp fishing in the upper portion of the gulf, and thwart enforcement by contacting each other by mobile phone when a patrol boat is spotted on the water or leaving the port. Shrimp are the only “valuable” species in the area, and fishers need the money. De-facto fisheries management that actually functions in these countries is typically implemented by small non-governmental organizations or international projects working directly with selected coastal communities (e.g. Tawake et al. 2001, Martin-Smith et al. 2004, Wiber et al. 2004). The relative success of these projects is due largely to the fact that fishing communities are informed about their fishery and empowered to make management decisions on their own, based on knowledge, rather than being forced to blindly follow orders.

Other problems attributable to the increasing complexity of fisheries models are that the predictability and validity of such models are compromised (fisheries biologists concede that they are reaching a “complexity wall” (Wilson et al. 1994)), and the economic cost of making useful predictions is greatly increased – sometimes to the point where it even approaches or exceeds the value of the landed fish (Larkin 1997).

The major problems of modern fisheries management in the present-day context of rapidly declining stocks and a mandate for sustainability create the impetus for a fundamental change.

## **Indicators**

Using indicators is an important part of this change, as they mark a shift from a model- to a “common sense” data- and knowledge-based approach to management that is simple, transparent and easy to understand, thus overcoming the problems of opacity and complexity described above. Indicators can be briefly defined as variables (proxies, indices, values) that show the extent of completion toward predefined “performance” targets, which correspond to management objectives in fisheries (Garcia & Staples 2000).

Some possible management objectives include ensuring the following:

- Productive capacity of stocks sustained into the future at low level of risk. (stop unsustainable fishing practices)
- Ecosystem health not jeopardized by fishery practices
- Efficient resource use (no waste or bycatch)
- Management responsive to changes in ecosystem/fishery health
- Stakeholders and government fisheries administration sharing responsibility and involvement in management (co-management)

One problem in developing effective indicator systems is defining targets or reference points. Many authors (e.g. Hilborn 2002, Caddy 2004) have dealt with the issue of uncertainty in defining a threshold beyond which the indicator value is considered acceptable. For example, if one uses spawning biomass as an indicator, at what level should fishing effort be reduced or at what level can it be increased (Sejjo & Caddy 2000)? It is wise to steer clear of indicators which require such thresholds, especially since they are difficult to estimate accurately.

Focusing on reference *directions* rather than points or thresholds is recommended instead (Garcia & Staples 2000). This way, measures can be taken to ensure the indicator keeps moving in the right direction, regardless of what point it passes.

It is crucial to have a clear management response linked to *each* indicator. Therefore, indicators which provide a general sense of the overall situation, but for which the response is something vague, like “improve management,” should be avoided. This problem is especially important to remember when using “scores” which are aggregates of other indicators (e.g. Pitcher & Preikshot 2001). This can also be a problem when the response of the indicator cannot reliably be linked to changes in fishing pressure, as described by Piet & Jennings (2005).

Garcia & Staples (2000) suggest looking at indicators in a “Pressure-State-Response” (PSR) framework. Indicators of state reflect the current condition of the resource, while those of pressure reflect reasons why the state is as it is, and those of response reflect what is being done to change the state if it is undesirable. Ideally the PSR system works like a cycle—when the state is found to be undesirable, the corresponding response changes the negative pressure, which then improves the state... This is a useful framework in that it integrates causes and effects rather than merely diagnosing the situation. Note that the *Driver* used as a fourth category in similar frameworks is here incorporated into the *Pressure* category.

### *Simple indicator criteria*

For the purpose of evaluating and selecting simple indicators in INCOFISH WP7, the following criteria (after Raakjær Nielsen et al. 2001) have been agreed upon.

Simple indicators should be:

1. Observable by stakeholders, either directly or through a transparent process.
2. Understandable.
3. Acceptable to fishers and public at large.
4. Efficient and within economic resources for research on a sustained basis (especially in developing countries).
5. Related to management and have associated reference values and responding management measures.
6. Valid—accurately reflecting condition of the resource.
7. Based on easily obtainable and reliable data.

In both developed and developing countries, the public knows that fisheries are in trouble but has no means to intervene or even judge whether suggested measures are meaningful or not. For example, it has recently been shown that 86% of European consumers prefer to buy sustainably caught seafood (Anonymous 2005). Given the failure of governing bodies to move fisheries toward sustainability, the involvement and support of the public becomes crucial to the success of any management measure. This is why it's especially important for simple indicators to meet criteria 1-3 above; simple indicators can play the role of empowering the public to participate in fisheries management.

Indicators in general have been gaining attention among fisheries scientists and policy makers since the late 1990s. While ecologically valid and addressing the problems *within* fisheries biology (e.g. complexity and cost), many indicators that have been proposed are not sufficiently simple to meet criteria 1-3 in the above list. Therefore they cannot be used to bring fisheries management to the stakeholders and will not be considered within the context of INCOFISH WP7.

For example, Christensen (2000) explores ecosystem-based indicators—Odum's (1969) 24 attributes of ecosystem maturity and the Fishing-in-Balance (FiB) index—which are designed to reflect changes in ecosystem development over time as a result of (over)fishing. While these indicators appear robust and require readily available data, they are still only understandable to

those with a strong background in ecology. Appendix I contains several indicators which were considered for use, but not adopted because they either don't meet the agreed-upon criteria or don't fit into the scope of WP7.

INCOFISH WP 7 is focusing on indicators sufficiently simple to meet the minimum criteria and to involve the stakeholders directly in the monitoring and implementation of the indicators, thereby mobilizing the PSR cycle. We hope to help put "bottom-up" political pressure on those involved in the fish trade to stop destructive practices. In other words, it is our goal not just to develop indicators to evaluate the state of the fisheries (although we must test to ensure our indicators do this), but also to develop a means to use these indicators to improve the fisheries.

One PSR indicator set is already being implemented locally to address the capture of immature fish (Fig. 2). The indicator in this case is the percentage of mature fish in the catch, with the target being 100% (Froese 2004). Myers & Mertz (1998) provide sound evidence that fishing only mature fish makes overfishing impossible. The response is a public awareness campaign called "Let Them Spawn!" For this a *fish ruler* has been created, showing for several commercial fish species the length where 90-100% of the specimens have reached maturity.

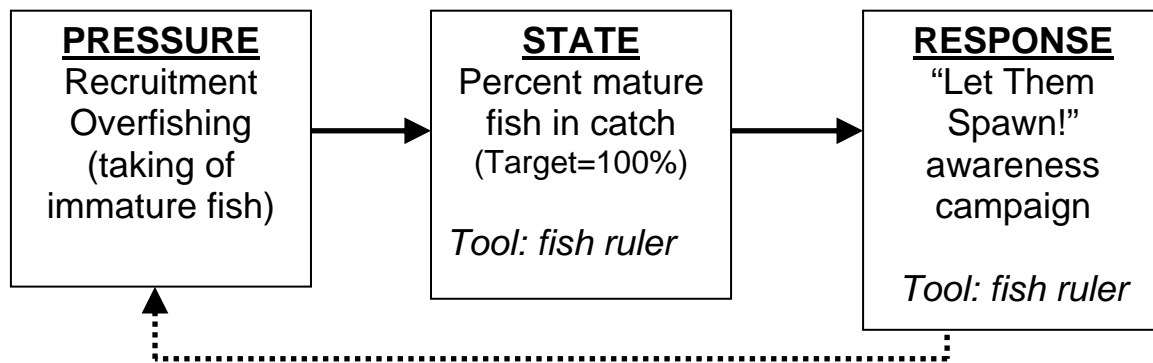


Fig. 2: Diagram illustrating PSR cycle using the maturity indicator as an example.

Fish buyers can bring the ruler to the market to make sure the fish they buy have had a chance to reproduce. Other stakeholders (industry, enforcement officers, scientists, etc.) can use the ruler to determine the percentage of mature fish in the catch. In this way, the ruler serves as a tool to calculate the state indicator, and also as a response—functioning to involve stakeholders and the public in enforcing a mature-fish-only campaign. We hope to employ the maturity indicator and fish ruler in all fisheries targeted by the members of WP 7.

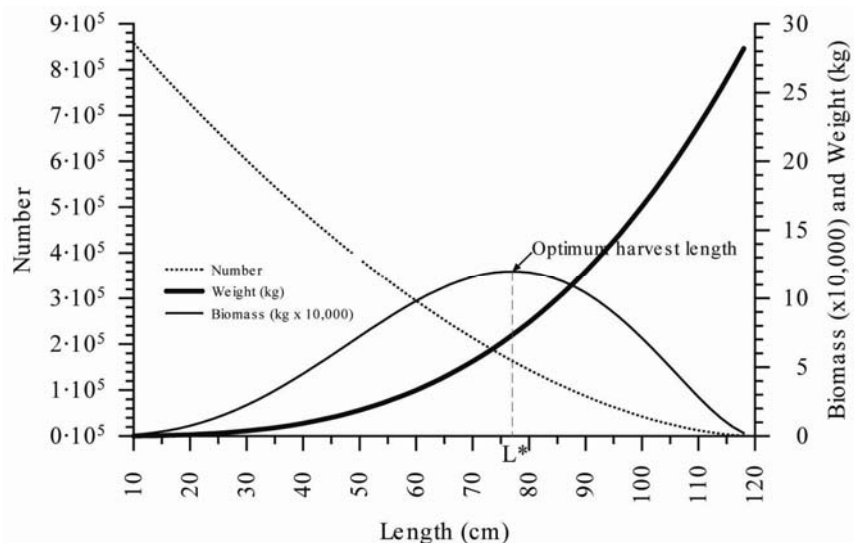
It is also becoming increasingly necessary, especially in developing countries, to develop simple social and economic indicators and corresponding PSR frameworks, because socioeconomic pressures are often the reason behind unsustainable fishing practices in these regions. Along these lines, Sumalia (2003) developed a “poverty index,” designed to assess the economic pressure on a given group of fishers to discount the future: the “poorer” the people are, the more likely they are to fish unsustainably now, risking future resource collapse. Although such economic indices and social and legal indicators are not being considered directly in WP7 (they are being developed in INCOFISH workpackages 8 and 10), synergies between these and WP7 indicators are being explored and put to work.

Indicators chosen for implementation by WP7 are listed with their corresponding data requirements in Table 1.

**Table 1. Indicators for use by INCOFISH WP7 with data requirements and possible responses. Note that indicator 1 is a special case of the more general ‘mean size in catch’ indicator; indicator 3 is similar to the ‘mean maximum length in catch’ indicator.**

Indicator	Required Data	Possible responses
1 % of mature fish in catch (goal 100%)	$L_m$ as length where 90-100% are mature  length frequency of catch	Promote capture of mature fish through fish ruler and info sheet for fish traders
2 % of ‘optimum’ size in catch (goal 100%)	Length-frequencies from catch or surveys Length-weight relationship for species	Same as above
3 % “mega spawners” in catch (% size above optimum length plus 10%) (goal 0%)	Length-frequencies from catch and surveys	MPAs; Campaign “Let Megaspawners live”; Only catch cohorts after 1st and before 2nd spawning
4 % Bycatch in total catch (goal 0%)	Bycatch biomass by fishery	Awareness campaign

Maturity (determined from size) indicators are targeted because they appear meet the set criteria best appear to have the potential to act as proxies for traditional stock assessment. Note that the “optimum” size indicator can also deal with semelparous fishes, which die and thus can’t be caught after spawning; here the optimum size is the length class where the minimum number of individual specimens needs to be taken to obtain a certain yield (see Fig. 3 for a sample calculation using the Leopard Coralgrouper, *Plectropomus leopardus*).



**Fig 3. Example of optimum harvest length for *Plectropomus leopardus***

The “mega spawners” indicator is included because there is evidence that older fish produce more and “better” eggs (Longhurst 2002), as well as pass on their successful genes. The bycatch indicator is included because the affects of bycatch on other fish populations is important, and a key issue being addressed in Ecosystem-based Fisheries Management (EBFM), but is not encompassed in the maturity indicators.

There is wide-spread agreement that fisheries need to be managed with consideration of overarching goals, such as restoring and maintaining healthy ecosystems and fisheries (i.e. EBFM) (FAO 1995, Garcia & Staples 2000). This is currently being implemented in many countries’ legislation. EBFM aims to minimize direct impact on the environment such as caused by destructive gears, and to minimize impact on species composition, abundances, and size (age) structures of populations. These goals are addressed by the chosen indicators as follows: destructive gears and methods such as bottom trawls, dynamite, or cyanide fishing typically have high bycatch (indicator 4) and are not size selective (indicators 1-3); indicator 4 minimizes impact on non-target species; indicators 1 and 2 minimize impact on abundance; and indicator 3 minimizes impact on size and age structure.

Sized-based indicators such as mean length and biomass and mean maximum length have been shown to be sensitive to changes in fishing pressure (e.g. Piet & Jennings 2005, Bianchi et al. 2000), suggesting that a sized-based approach is valid. Maturity percentages are directly related to average size in a single-species catch . Also, along with Marine Protected Areas, minimum size limits have been shown to be “highly accepted” management measures among stakeholder groups in small scale fisheries in developing countries (Martin-Smith et al. 2004), (Tawake et al. 2001). In contrast, Total Allowable Catches and reduced fishing mortality are only “moderately acceptable“(Martin-Smith et al. 2004).

WP 7 indicators also have the potential to be used in synergies between INCOFISH WP 7 and other INCO projects, which are currently being explored. For example, INCO project ECOST is working in two of the same geographic locations as WP 7: Senegal and Thailand. In these two locations, WP 7 can provide an estimate of the difference in catches between the currently overfished state, and after some years of fishing in accordance with the goals of our simple indicators. This difference can then be turned into a value (or ‘cost’ of unsustainable fishing) by the colleagues in ECOST, taking into consideration the necessary adjustments such as discount rate and subsidizing the fisheries in the few ‘transition’ years to sustainability.

The selected maturity indicators have been found by INCOFISH WP7 members to be those most closely meeting the established criteria and with the most potential for use directly with stakeholder groups. These indicators will be adopted and tested, in close collaboration with the other INCOFISH WPs, and INCO partner projects in a number of different fisheries in Africa, Asia, South America and Europe over the next three years.

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Candidate indicator	Indicates	Authority/Previous studies	Reasons not adopted
Fishing in Balance Index	Extent of ‘Fishing down the food web’	(Christensen 2000)	Not easily understandable Requires difficult to establish reference point
CPUE (better for smaller scale fisheries with uniform technology and fishing practices)	Changes in fish abundance	(Zenetos et al. 2002)	Requires difficult to establish reference point Changes not always linked to fishing pressure
Exploitation Rate	Amount of fishing mortality relative to total mortality	(Rochet & Trenkel 2003)	Not easily understandable Data not always reliable or easily attainable Requires difficult-to-establish reference point
Fishing mortality	Mortality rate due to fishing alone	Rochet & Trenkel (2003) Zenetos et al. (2002)	Data not always reliable or easily attainable Requires difficult-to-establish reference point
Scorecard	Overall “snapshot” of fisheries situation. Can be related to score at different dates	(Anonymous 2005) The Ocean Conservancy (Pitcher & Preikshot 2001)	No clear specific mgmt response to outcome
Spawning Stock Biomass or % unfished spawning stock	How much of the spawning stock is being removed	(Le Gallic 2002) (OECD) Zenetos et al. (2002)	Data not always reliable or easily attainable Requires difficult-to-establish reference point
Size-spectra of fish communities	Extent and effect of fishing down the food web.	(Bianchi et al. 2000)	Requires difficult-to-establish reference point Changes not always linked to fishing pressure
Poverty Index  P-index = $\frac{\text{Income}_{\text{fishing community}}}{\text{Income}_{\text{poverty line}}}$ Small scale  $\frac{\text{Debt}_{\text{commercial fishery}}}{\text{Debt}_{\text{business entities}}}$ Commercial	The economic pressure on fishers to “discount” the future and fish unsustainably now	(Sumalia 2003)	Outside the scope of WP 7 (see WP 8) Requires difficult-to-establish reference point
% Fisheries income in GDP	The economic importance of fishing industry to country	(Pitcher & Preikshot 2001)	Outside the scope of WP 7 (see WP 8) Requires difficult-to-establish reference point
Existence of subsidies? Amount of gov’t subsidies to fishery as a % of landed value of fish	Incentive for fishers to continue fishing or enter fishery even if it is not economically viable (without the subsidy)	(Pitcher & Preikshot 2001) (Zenetos et al. 2002)	Outside the scope of WP 7 (see WP 8 and 10)

