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Report of the

FAO WORKSHOP TO DEVELOP A FAO STRATEGY FOR ASSESSING THE STATE OF INLAND CAPTURE FISHERY RESOURCES

Rome, 7–9 December 2011

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Rome, 7–9 December 2011

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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PREPARATION OF THIS DOCUMENT

This is the Report of the Workshop to Develop an FAO Strategy for Assessing the State of Inland Capture Fishery Resources, held in Rome, Italy, from 7 to 9 December 2011. The Workshop was convened by FAO as part of an initiative to improve on the poor state of knowledge of the status of inland fishery resources.

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ABSTRACT

A Workshop was convened to develop a strategy to improve the state of information on the status of inland fisheries. Inland fisheries are a vital component in the livelihoods of people in many parts of the developed and developing world. Globally, lakes, reservoirs and wetlands cover a total area of about 7.8 million km^2 and provide a rich environment for inland fisheries. The Twenty-eighth Session of the FAO Committee on Fisheries observed that, "data and statistics on small-scale fisheries, especially in inland waters, were not always comprehensive, resulting in underestimating their economic, social and nutritional benefits and contribution to livelihoods and food security. The underestimation of the importance of inland fisheries can lead to policies and practices that further degrade resources and endanger food security". The marine capture fishery sector has, since 1974, reported on the state of major marine fish stocks. The percentage of marine fish stocks that are depleted, recovering, underexploited, moderately exploited, fully exploited and overexploited, along with their trends is extremely useful and widely cited in fishery, conservation and development literature. There is no equivalent information set for inland fisheries on which to make assessments. The Workshop identified several important differences between inland and marine capture fisheries that necessitate different approaches to the assessment of inland fisheries. A main difference is that the state of exploitation is usually the main driver determining the status in marine fisheries and is the principal indicator of management performance used by FAO for global assessment. The status of inland fisheries is also determined by rates of exploitation, but other influences that affect habitat quality and quantity can also be significant and often more important. Taking into account the special characteristics of inland fisheries, the Workshop identified ecosystem services provided by inland fisheries and some potential indicators and information that could be used for the assessment of inland capture fisheries. Indicators were identified for social and economic aspects of a fishery and for environmental and production aspects. Both aspects were judged important in the assessment of inland fisheries, and efforts were made to establish a composite indicator. The elements of a strategy to assess inland fisheries were not completely defined by the Workshop and further work was planned to determine the usefulness of the indicators and composite indicator.

CONTENTS

1. OPENING OF THE MEETING AND ARRANGEMENTS FOR THE SESSION

1. The Workshop to develop an FAO strategy for assessing the state of inland capture fishery resources was held in Rome, Italy, from 7 to 9 December 2011. The Agenda, list of participants, and background paper are reproduced in Appendixes 1, 2 and 3, respectively.

2. The meeting was called to order by Mr Devin M. Bartley, Senior Fisheries Officer responsible for inland fisheries in the Fisheries and Aquaculture Department.

2. BACKGROUND

3. Inland fisheries are a vital component in the livelihoods of people in many parts of the developed and developing world. Globally, lakes, reservoirs and wetlands cover a total area of about 7.8 million km^2 and provide a rich environment for inland fisheries (de Graaf *et al*., 2012). Inland capture fisheries are rooted in socially and culturally complex societies, operate in a large variety of environments, and are characterized by an extremely diverse range of gear types. They are generally not great creators of wealth for individual fishers, but may in aggregate be substantial suppliers of food and income, and are significant contributors to rural food security and income generation. However, inland fisheries do not usually provide an opportunity for taxation and levies and, thus, awareness of their socio-economic importance is often lacking in government development programmes (FAO, 2010). There are exceptions to this general statement as in Asia many fisheries are licensed and taxed. Inland fisheries also operate in many areas of high aquatic biodiversity where habitat degradation and irresponsible fishing could be conservation concerns, although the impact of fishing is sometimes small relative to other threats. As a result of the spatial dispersion of catches over thousands of lakes and rivers, along with the perception of low per fishery economic value, inland waters are usually neglected in discussions of global fisheries (Beard *et al*., 2011; Welcomme *et al*., 2010).

4. FAO and others have repeatedly commented on the poor state of knowledge on inland fishery resources and their ecosystems (Coates, 2002; FAO, 2010; World Bank, FAO and WorldFish Center, 2010). Reasons for the lack of good information include:

- the diffuse nature of the sector, with numerous landing sites and methods of fishing;
- the large number of people involved and seasonality of fishing effort;
- the subsistence nature of many small-scale inland fisheries that are not regularly monitored or that do not report catch;
- catch is often consumed or traded locally without entering the formal market chain;
- a lack of capacity and resources to collect adequate data;
- collecting information is too expensive and not worth the effort;
- deliberate misreporting.

5. The lack of accurate information has led to differing views on the actual status of many inland fishery resources. One view is that the catch from the sector is declining in quantity and quality because of the multiple uses of and threats to inland water ecosystems. Another view states that the sector is in fact growing, that much of the production and growth has gone unreported and that stock enhancement has played a significant role (FAO, 2010). Nonetheless, it is vitally important that an accurate assessment of inland fishery resources is attempted. The Twenty-eighth Session of the FAO Committee on Fisheries (COFI) observed that, “data and statistics on small-scale fisheries, especially in inland waters, were not always comprehensive, resulting in underestimating their economic, social and nutritional benefits and contribution to livelihoods and food security” (FAO, 2009). The underestimation of the importance of inland fisheries can lead to policies and practices that further degrade resources and endanger food security.

6. It is recognized that with such a complex and diffuse sector as inland fisheries, it will be impossible to collect information on all inland waterbodies. The marine capture fishery sector has, since 1974, reported on the state of major marine fish stocks. The percentage of marine fish stocks that

are depleted, recovering, underexploited, moderately exploited, fully exploited and overexploited, along with their trends is extremely useful and widely cited in fishery, conservation and development literature. There is no equivalent information set for inland fisheries on which to make assessments.

7. In recognition of the value of accurate information on the status and trends of all fishery resources (inland and marine), FAO adopted the Strategy for Improving Information on Status and Trends of Capture Fisheries (STF):

"Knowledge of the status and trends of capture fisheries and fishery resources, including socio-economic aspects, is a key to sound policy-making and responsible fisheries management. It is necessary at the national level for the maintenance of food security and for describing social and economic benefits of fisheries. Fisheries policymaking and management is a dynamic interdisciplinary process that needs to take account of the status and trends of fisheries. Information on the status and trends of fisheries is also essential for assessing the validity of fisheries policy and for tracking the performance of fisheries management." (FAO, 2003)

The STF further states:

> "Global efforts to assemble and disseminate comprehensive information (e.g. through the FAO Fisheries Global Information System [FIGIS]) on the status and trends of fisheries are currently hindered because a complete inventory of the fisheries and fish stocks of the world does not exist. A key element of the Strategy is to prepare such inventories, which would be implemented in FIGIS."

8. However, there is a real concern that inventories of inland fisheries, especially small-scale fisheries, are impractical. Therefore, alternative approaches may be needed. The following guiding principles of the STF should also guide the inland fishery sector assessment strategy:

- sustainability;
- participation and cooperation;
- objectivity and transparency;
- timeliness;
- flexibility.

9. This Workshop was convened to develop a strategy to improve the state of information on the status of inland fisheries. The Workshop was intended to build on the STF in a practical manner that would address the special needs of inland fisheries.

3. OBJECTIVES OF THE WORKSHOP

10. The main objective of the Workshop was to elaborate elements of a strategy for developing practical means of assessing the status and trends of inland fisheries resources. It was anticipated that elements of the strategy could include:

- an evaluation of potential "indicator fisheries" that can be monitored and assessed on a regular basis, and that provide a proxy of the global picture of the state of inland fisheries resources;
- defining data sources and survey methodologies to be used in the assessment, e.g. traditional fisheries data, frame surveys, geological and hydrographic data, consumption studies, and habitat data;
- indentifying partners to assist in the assessment on a long-term basis;
- other important elements that may arise during discussions.

4. POINTS RAISED IN DISCUSSION OF BACKGROUND PAPER

Definition of "inland fisheries"

11. The experts accepted that inland capture fisheries are defined as "fishing in inland waters" (FAO, 2011, Paragraph 24) and that inland waters are "the surface water existing inland, including lakes, ponds, streams, rivers, natural or artificial watercourses and reservoirs, and coastal lagoons and artificial water-bodies".[1]

Goal of the proposed strategy

12. The Workshop agreed on the following goal:

- Information on the status and trends of the ecosystem services provided by inland fisheries is sufficient to support policy and management and contribute to their global assessment.
- This implies that the information should be comparable among Members of FAO and scalable from local level data on individual fisheries to global summaries on the state of the world's inland fisheries.

Scope and scale

13. The STF already defines the scope of the strategy as being global (FAO, 2003) and designed to cover all capture fisheries in inland waters, including all industrial, commercial, subsistence and recreational fisheries.

14. The scale identified as most appropriate was the river basin as this includes associated rivers and streams, lakes, and wetlands. Moreover, in water management, river basins tend to be the scale on which data are collected and assessments made. However, this may not correspond to national boundaries requiring a regional or basin approach to data collection and sharing.

Special characteristics of inland fisheries

15. The Workshop participants stated that there were significant differences between the fisheries targeting major marine fish stocks and the majority of inland fisheries resources, and that the public view of inland fisheries is influenced strongly by marine fisheries performance and drivers. The differences between inland and marine fisheries, which underline the inappropriateness of this public view, include the following:

- The state of exploitation is usually the main driver determining the status in marine fisheries and is the principal indicator of management performance used by FAO for global assessment (Figure 1). The status of inland fisheries is also determined by rates of exploitation, but other influences that affect habitat quality and quantity can also be significant and often more important. Therefore, the state of exploitation may not be the best single descriptor of the status of many inland fisheries; a range of indicators is necessary.2
- Some 455 marine fish stocks are currently assessed, covering about 80 percent of reported global marine catch, whereas there is a dearth of information about the status of inland fish stocks. The delineation of very few inland fish stocks has been agreed upon.

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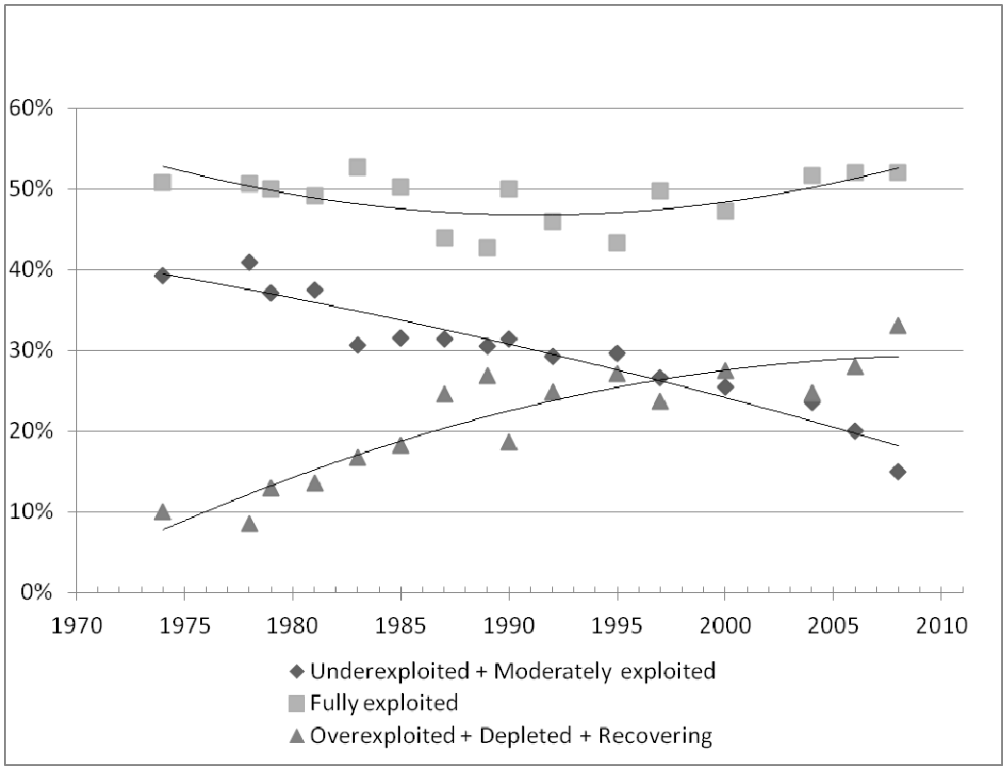
[1] FAO Fisheries Glossary (available at www.fao.org/fi/glossary/default.asp).

[2] At the Thirtieth Session of COFI, convened after this Workshop, several delegations recommended that FAO simplify the way that the status of fish stocks is reported (e.g. Figure 1) and establish only two categories: one indicating a biologically sustainable level of harvest, and another indicating a biologically unsustainable level of harvest.

- Inland fishery resources are tradable, i.e. they can be sacrificed (and often are) for other uses of freshwater, whereas major stocks of marine fisheries are not usually in that position. That is, there is often no other use, or not many other uses, for the marine ecosystem that compete with fishing. It is important that consideration be given to a broader suite of ecosystem services provided by inland aquatic ecosystems that demonstrates their true value when making such "trades".
- The relationship between aquaculture and inland capture fisheries is much more important than it is in the marine subsector, particularly in relation to the enhancement of fisheries.
- The quality of aquatic habitats is often more sensitive to changes in inland areas than in the marine environment.

Figure 1
Assessment of about 455 major marine fish stocks



Source: FAO (2010).

16. The changing status of a fishery in the marine subsector reflects its response to exploitation and production potential, which is whether it is not fully exploited, fully exploited or overexploited. The assessments are sometimes of stocks, in other instances of species, and in others of groups of species. Biomass, spawning potential, catch trends and size–age composition tend to be used as indicators of the status of the stock. However, the Workshop stated that for inland fisheries, the functional state of inland fisheries is important, i.e. whether or not the fishery is meeting its objectives. Catch alone may not provide the best indicator of whether an inland fishery is meeting management objectives.

17. Workshop participants considered the importance of including in the assessment the wide range of services delivered by inland aquatic ecosystems (Table 1). It is recognized that inland capture fisheries will provide a subset of these services. The assessment will be limited to the status of the fishery and how it meets the management objectives; not the status of the ecosystem.

Table 1

Ecosystem services provided by inland capture fisheries and possible indicators

Ecosystem services	**Indicators**[1]
Provisioning services	
Provision – extraction of aquatic organisms for human consumption, and for recreational and ornamental fisheries	Total catch; catch trends; value of catch by species; per capita availability of fish; contribution to animal protein intake
Contribution to employment and to income, also including non-food producing activities such as ornamental and recreational fisheries.	Fisher income; employment in whole sector; contribution to GDP and GNP; number of recreational fishers; sales of ornamental fish
Contribution of inputs to aquaculture production	Harvest of wild-caught seed for aquaculture growout; harvest of juveniles for fattening in aquaculture; harvest of wild adults for seed production
Contribution to culture-based fisheries.	Contribution of aquaculture stocking to capture fisheries
Regulation services	
Regulation of food web dynamics	Biodiversity assessments and species composition; water quality; the guild structure, i.e. the life history characteristics, of an aquatic community, and size composition of catch
Regulation of invasive species	Number or quantity of invasive species
Bioremediation of waste – effluent cycling and removal of pollutants; fish may maintain healthy aquatic systems that favour these processes	Habitat quality; fish as bio-indicators
Nutrient transport and cycling	Number of migratory species; trohpic structure of aquatic community
Control of pest organisms	Reduction in disease and disease vectors
Cultural services	
Religious symbols	Catch or presence of iconic species
Dietary symbols, particularly demonstrating wealth	Catch composition
Cultural heritage and identity – value associated with freshwater fisheries themselves	Catch composition
Cognitive values – education and research resulting from the fisheries	Number of studies, reports or papers from fishery
Leisure and recreation – ornamental, tourism, and recreational, fishing, human well-being	Number of recreational fishers; contingent valuation of fisheries; number of freshwater protected areas for non-commercial use
Support services	
Maintenance of genetic, species and ecosystem biodiversity	Catch composition, species, guilds, biodiversity assessments
Resilience and resistance – life support by the freshwater environment and its response to pressures, including maintenance of ecosystem balance	Stability of catch over time

[1] There was not sufficient time during the Workshop to indentify indicators for some ecosystem services, and, in others, to define them more precisely; some indicators have been added post-Workshop and agreed by participants.

Information needs and issues

18. The purpose of generating information must be to influence policy and inform management decisions. Therefore, the focus needs to be on generating information for use at a national level, which then might also be used regionally and globally.

19. Workshop participants discussed the types of information that should be collected for purposes of assessing the status of inland capture fisheries, keeping in mind that the drivers in most inland fisheries tend to be quite diverse and their relative importance different to the production orientation of marine fisheries.

20. Better use of existing information was identified as a first essential step. A range of data is often already collected for other purposes but can provide information that can be added to the fisheries knowledge base. Indicators and information used for more specific dimensions or activities at various scales is summarized in Table 2.

Table 2

Some indicators and information for the assessment of inland capture fisheries

Dimension	FAO management performance indicator	Model[1]	Data		
			Requirements	Scale/unit	Collection tools/methods
Conservation and sustainable resource use	percentage of Members reporting increasing, stable or decreasing total annual catch	GFDM[2]	total annual catch	national	CAS[3]; fish consumption surveys
	percentage of species exhibiting increasing, stable or decreasing total annual catches	GFDM	total annual catch by species	national	CAS; fish consumption surveys
	percentage of reported total catch from large (Lmax > 15 cm) and small species (Lmax < 15 cm)	ecosystem overfishing model[4]	total annual catch by species	national	CAS; fish consumption surveys
	percentage of fisheries judged to be underexploited, fully developed or overexploited fisheries by habitat	GFDM or surplus production model[5]	total annual catch or CPUA; fisher density by habitat	national or by habitat	CAS; fish consumption surveys
	fishing effort	GFDM	CPUE; numbers of fishers; gear types;	fishery	angler and gear surveys; Census; HH surveys
	percentage of countries or stocks showing increase or decrease in catch	none	historical and global catch data	global	national reports
	percentage deviation from maximum reported catch	none	historical and global catch data	global	national reports

Habitat	species catch by habitat	SPM[5]	total catch by species and habitat	habitat	CAS
Culture-based fishery	percentage contribution of enhancement to total production	none	identification of stocked fish; intensity of stocking/stocking quantity/recapture?		quantity stocked; recaptured; CAS
Value	global gross value of the inland fisheries sector (USD)	none	total catch; average price	national	CAS; fish consumption surveys, market surveys, other ministries
	per capita income from fishing		household income	local and national	household surveys
	non-commercial value, e.g. spiritual, existence, recreational	contingent valuation	willingness to pay	local and national	angler surveys
Food security	global average per capita inland fish consumption (kg)	none	per capita consumption; CAS and population estimate	national	CAS; fish consumption surveys
	percentage contribution to animal protein	none	per capita consumption, household diet	national	food balance sheet; household consumption survey
Employment	global employment in inland fisheries	none	number of persons in capture sector…	national	CAS; HH surveys, census
Trade	percentage global catch imported and exported from member states	none	imports and exports by species	national	Trade Ministries
Recreational	recreational fisheries (participation, value)	none	participation in recreational fishery	national	angler surveys; market studies

[1] For example, see Plagányi (2007).
[2] General Fishery Development Model (Grainger and Garcia, 1996).
[3] Catch assessment survey.
[4] Assemblage overfishing model.
[5] Spatially standardized (e.g. Halls *et al.*, 2006).

21. Other possible indicators also suggested include: the extent of full-time and part-time participation in a fishery; catch of a target species as percentage of total catch; a measure of the contribution of enhancement to the catch.

22. The Workshop participants emphasized the importance of using information sources such as consumption studies and household surveys as means of gathering data that could be used to estimate yield, other important aspects of the fishery and additional ecosystem services. Well-designed consumer and household sample surveys could be a cost-effective means of gathering reliable information that might not otherwise be available.

5. TOWARDS A STRATEGY TO IMPROVE THE STATE OF INFORMATION ON INLAND FISHERIES

23. The assumption has been that improved information will lead to improved fishery management and improved catch. However, experience has shown that this assumption is often not valid. Several major fisheries for which excellent information exists on the value of the fishery are threatened by development (e.g. the Mekong River fisheries) or poor policy decisions (e.g. the North Atlantic cod stocks). Is the right kind of information being collected, is it being understood by policy makers, is the fishery sector not presenting it in appropriate media or format, is the development perceived to be more valuable than the fish, or is the information simply being ignored?

24. Workshop participants discussed what information could practically be used to develop indicators for the delivery of ecosystem services listed in Table 1 and then how to convey that information to the appropriate audience. It was acknowledged that it would not be possible, owing to complexity and cost, to develop indicators that would provide an assessment of the full array of these services. The discussion thus focused on a limited set of indicators identified as providing information on the most important services from a fisheries perspective.

25. The indicators selected focus on income and the degree of economic dependence on inland fisheries, on the contribution of inland fisheries to the availability of animal protein and to food security, and on environmental and biological production aspects. Two broad set of indicators were identified: (i) social and economic; and (ii) environmental and production.

Social and economic indicators

26. The indicators identified to represent the social and economic dimension of the fishery relate to the importance of fisheries, or the degree of dependence on fisheries, for the communities and countries considered. Various measures of the importance of inland fisheries and income from fishing for the country were discussed:

- The proportion of the total population where the income from inland fisheries is a significant proportion of their total income (e.g. more than 50 percent). Related to this is the proportion of inland fishers engaged in fishing on a full-time, as opposed to a part-time, basis. The perception is that the more dependent a community is on fishing for livelihoods, the poorer it will tend to be.
- The mean income of those involved in fisheries could be calculated by dividing the total income from inland fisheries by the number of people engaging in the fisheries. A further refinement was also suggested of disaggregating by gender. Adjustments also would need to be made for part-time involvement in the fisheries. One such adjustment could be the number of “full-time equivalent” fishers. For example, two people fishing half time would be one full-time equivalent fisher.
- The value of inland fisheries as a proportion of GDP can be calculated by dividing the retail value of the fisheries by GDP. However, this often hides the significance of fishing for subsections of dependent populations. It was considered preferable to derive an estimate of the value of the fisheries for the dependent population and then relate it to the total population.

27. Household income rather than individual income could be used to include the family unit’s income from the full range of fishing-related income-generating activities (fish capture, processing and trading). In some countries, recreational fisheries are the most significant contributor to the economic value of inland fisheries, but this has nothing to do with first sale value as the catch itself is largely irrelevant.

28. By including the value of recreational fisheries, cultural services provided by inland fisheries would also be given recognition. Although possibly requiring a different scale, it would be possible to plot recreation and food fisheries on the same graph. By doing so, it would be possible to detect a shift in importance between food fisheries and recreational fisheries.

Environmental and production indicators

29. Environmental and production indicators included those based on the state of the resource, measures of habitat change (usually not as a result of fishing) and measures of ecosystem disturbance. The indicators under "Conservation and sustainable resource use" in Table 2 largely refer to this category of indicators. The value of many of the indicators could reflect both fishing impacts and environmental impacts, and it could be difficult to disaggregate the two. Nonetheless, management would need to be able to make decisions based on the reality of the joint influence of fishing and the environment.

30. The proportion of countries with increasing, stable and declining catches could be a global indicator of the status of inland capture fisheries. Consideration was give to normalizing present annual catch by dividing catch by the maximum historical catch for each country. However, reservations were expressed about the use of maximum catch as it may not provide a reliable means of normalizing the data.

31. In efforts to improve data quality, countries have updated their statistics, resulting in sizeable differences in catch between some years. In such cases, an assessment of the fishery may appear to indicate a rising catch trend when actually they are merely better estimates of existing level of catch. A five-year smoothing of data may eliminate large changes in reported catch data as is used for the General Fishery Development Model (Grainger and Garcia, 1996).

32. Possible measures of habitat change were discussed, many of which may only warrant assessment on a decadal basis. Dams, barriers or other water structures, for example, that may result in losses of connectivity within a river system would not change quickly enough for any impacts to be seen over the short term. Measures of fragmentation within a basin, however, cannot be applied to lakes forming part of the system.

33. AQUASTAT[3] and FAO land-use maps provide data sets that track water and land use, and these could provide information relevant to the assessment of ecosystem services. These facilities are updated periodically, but probably provide measurable changes over the longer time frame discussed above.

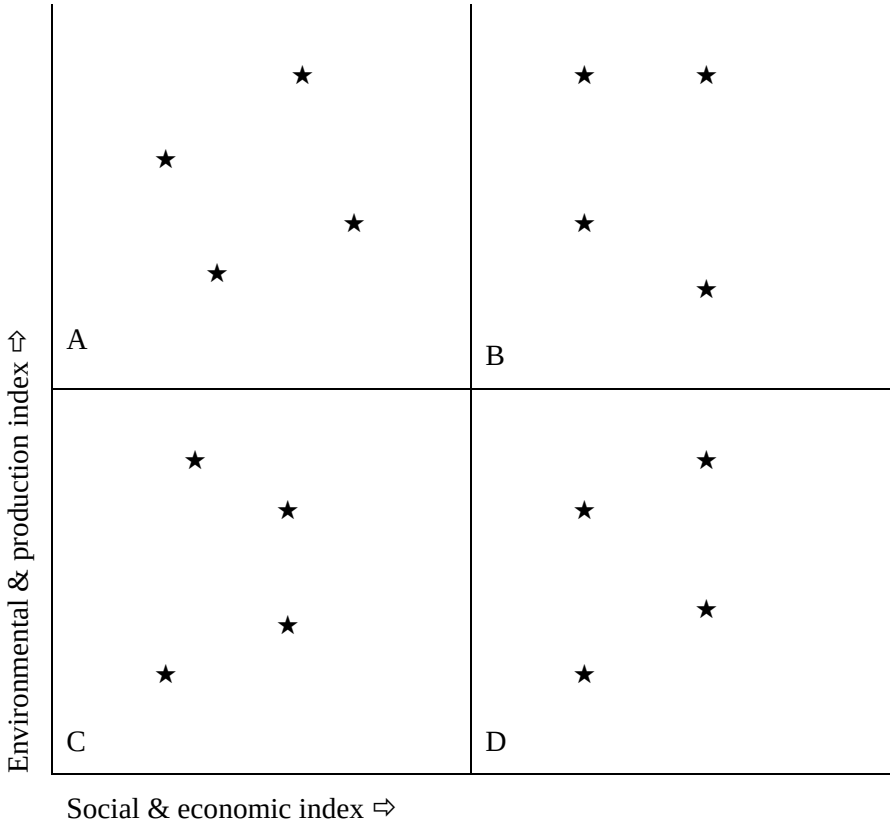
Possible use of a composite indicator

34. Given the complexity of inland fisheries, the Workshop recommended development of composite indicators, one representing the social and economic dimension and the other the status of resource and ecosystem. These could then be plotted as one point in a graph (Figure 2) and tracked over time so that status and trends are evident to policy-makers and managers.

[3] AQUASTAT may be accessed at www.fao.org/nr/water/aquastat/main/index.stm
For land-use databases, see www.fao.org/nr/land/databasesinformation-systems/en/

Figure 2

Conceptual diagram of assessment of the status of hypothetical inland capture fisheries



Note: ★ = a composite indicator for a specific fishery at a given time.

35. An alternative would be to plot several indicators individually and then derive a composite indicator for use in a single graphic. The use of Gapminder[4] was suggested for the provision of a more dynamic presentation of data. Some assessments could be updated every five years rather than every two years as is currently done in FAO owing to the enormity of the task and lack of adequate resources to do so more frequently.

36. The Workshop derived potential composite indicators for the social and economic dimension of a fishery and for the environmental and resource dimension. An indicator representing the social/economic dimension was defined as:

$$\frac{\text{numbers of inland fishers}}{\text{total population}} \times \frac{\text{income from inland fisheries}}{\text{total income}} \times \frac{\text{protein derived from inland fisheries}}{\text{total animal protein.}}$$

An indicator representing the resource/environmental dimension was defined as:

$$\frac{\text{current annual inland catch}}{\text{maximum inland catch}} \times \frac{\text{total fish} > 15 \text{ cm in length}}{\text{total inland catch}}$$

[4] Gapminder Web site: www.gapminder.org/

- "Numbers of inland fishers" is numbers of people (full-time equivalents) directly dependent on inland fisheries so as to include the primary sector, i.e. fishers, and the secondary sector, i.e. processors and traders.
- "Income from inland fisheries" should be the retail value of the fish caught in inland waters, so as to include processing and marketing aspects.
- "Total population" refers to the country as a whole, thus highlighting the importance of inland fisheries to the whole country (which might not be very significant, but would be consistent with FAO practice).
- "Total income" refers to the total income for the country as a whole, highlighting what the contribution might be to gross domestic product (GDP) (again consistent with FAO practice); or, to show local importance, it could refer to total income in inland areas to reflect the proportion of income arising from fishing for those communities.
- "Total animal protein" could refer to the total animal protein for the country as a whole (again be in keeping with FAO practice).
- "Total fish > 15 cm in length" refers to landed weight."

37. The Workshop noted that more work should be done on the indicators and potential composite indicators as to their usefulness and practicality. For example, for the social/economic indicator, it might be possible to have increased value from a fishery owing to an increase in people fishing as a result of failure in other food-producing sectors. Income from inland fisheries could rise if depleted stocks became more valuable owing to their rarity. The failure of other food production sectors, e.g. as a result of natural disasters or disease, could also lead to an increased proportion of fish protein in diets. These could temporarily raise the value of the indicator, but may not be sustainable. In any case, the rise in the indicator would signify the importance, at least in the short term, of the inland fishery. In regard to the resource/environmental indicator, there could be an increase owing to increased effort resulting in an increased catch and proportion of fish > 15 cm remaining constant because of restrictions on mesh size. As the indicators change over time, assessments of whether the fishery was meeting its objectives could be made.

38. Plotting the indicators as in Figure 2 would help inform management decisions. Fisheries in quadrant B would be performing well for both economic/social and production/environment criteria and probably would be meeting management objectives. Management of fisheries in quadrant C should be improved for both criteria. Fisheries in quadrant D may be providing social and economic benefits, but should be monitored to make sure production and environmental sustainability are maintained. Management of fisheries in quadrant A might be changed to make the fishery more important economically. Lake Victoria before the introduction of Nile perch was probably an example of a fishery in quadrant A, i.e. high productivity with minimal economic return. The introduction of Nile perch probably moved the fishery toward quadrant D. Management of fisheries that over time were tracking towards a specific quadrant could be assessed to determine if the trajectory was in the desired direction. It should be understood that the quadrants are not strictly defined and merely facilitate conceptualization of the idea.

6. IMPLEMENTATION OF PROPOSED APPROACH[5]

Pilot studies

39. The approach discussed above should be further explored though a set of pilot studies designed to test the ability to compile adequate indicators. Pilot studies are important as they may highlight difficulties (such as scaling up from the level at which data are collected nationally to river basin level) that might need to be overcome if the methodology is to be put to widespread use.

40. It was recommended that the pilot studies should be selected so as to provide a cross-section of circumstances and should include countries where data are difficult to obtain. It was also suggested that at least one of the case studies should be where there are both artisanal and recreational fisheries.

41. The following areas were proposed as possible case studies:

- Plate River Basin, which extends into five countries of Latin America;
- Amazon River Basin,
- recreational and small-scale commercial fisheries of Canada and the United States of America, e.g. the Great Lakes;
- Nile Basin;
- Lake Chad Basin;
- Lake Tanganyika Basin;
- Mekong River Basin;
- Cambodia;
- Yangtze River Basin;
- Indonesia;
- Central Asia;
- Zambia.

42. Many of the Workshop participants volunteered to facilitate the case studies. It was agreed that a first analysis to assess feasibility of the approach should be done within 12 months, with a more in-depth analysis within 18–24 months. Attention should be given the availability of existing data, the benefits or otherwise of alternatively using proxy data and to identifying what additional data might be needed in order to produce a useful assessment of the fishery. It would also be useful to identify any underexploited fishery resources that might be significant. Finally, the human-resource and financial capacity needs for maintaining the indicators ought to be assessed as part of the case studies.

43. Suitable partners will be sought among intergovernmental organizations, international non-governmental organizations and local non-governmental organizations that deal with inland fisheries and, more broadly, with the range of ecosystem services.

44. The pilot case studies are expected to reveal areas of research and development that would need to be pursued in the process of amending and refining the methodology in preparation for its more widespread use.

Priority actions/next steps

- The pilot studies should be undertaken.
- The group of experts who participated in the Workshop should maintain contact to assess progress, share information and evaluate the outcome of the pilot studies.

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[5] Following the Workshop, the concept of assessing inland fisheries on economic/social and environment/production indicators and the plotting of fisheries as in Figure 2 were presented in *The State of World Fisheries and Aquaculture 2012* (FAO, 2012).

- Guidance should be developed for undertaking case studies and for follow-up and tracking.
- A Web site with restricted access should be established as the medium though which information can be shared.
- Mr Devin M. Bartley, FAO's senior fisheries officer responsible for inland capture fisheries, should function as a focal point for the onward work of the group.
- Preparations should be made to engage with the World Water Forum, FAO Water Platform[6] and other appropriate fora to advance this initiative.
- A progress report should be prepared for the next edition of *The State of World Fisheries and Aquaculture*, which should be presented to the Committee on Fisheries in 2014.

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[6] For the World Water Forum, see www.worldwaterforum6.org/en/
For the FAO Water Platform, see www.fao.org/nr/water/who.html

APPENDIX 1

AGENDA

Session 1: Introduction and background

Welcome and Introduction
Background and Objectives of Workshop
Presentation of STF
Presentation of Background Paper
The Marine Experience
General Discussion

Session 2: Defining characteristics of information

Scope and Scale of Analysis
Types of Information
Identification of Indicators
Evaluation of existing approaches/models

Session 3: Elements of a strategy

Scope and Scale
Information Types
Indicators
Analysis/Models

Session 4: Implementation needs

Capacity
Research
Partners

Session 5: Guidance

Next steps
Priority actions

Session 6: Finalize and adopt report
Meeting adjourns

APPENDIX 2

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APPENDIX 3

BACKGROUND PAPER

FAO strategy for assessing the state of inland capture fishery resources

Working paper for the FAO Workshop to Develop a Strategy for Assessing the State of Inland Capture Fishery Resources[1], Rome, December 2011

INTRODUCTION[2]

Inland fisheries are a vital component in the livelihoods of people in many parts of the developed and developing world. Globally, lakes, reservoirs and wetlands cover a total area of about 7.8 million km^2 and provide a rich environment for inland fisheries (De Graaf *et al.* 2012, Beard *et al.*,). Inland capture fisheries are rooted in socially and culturally complex societies, operate in a large variety of environments and are characterised by an extremely diverse range of gears. They may not be great creators of wealth for individual fishers, but may in aggregate be massive suppliers of food and income and are significant contributors to rural food security and income generation. Inland fisheries do not, however, usually provide an opportunity for taxation and levies and thus awareness of their socio-economic importance is often lacking in government development programmes (FAO, 2010). As a result of the spatial dispersion of catches over thousands of lakes and rivers, along with the perception of low per-fishery economic value, inland waters are usually neglected in discussions of global fisheries (Beard *et al*., 2011).

The bulk or 90 percent of inland fish is caught in developing countries and 65 percent is caught in Low Income Food Deficient countries (Table 1). Although the numbers are still not well known it appears that at least 61 million people in developing countries are employed in the inland fisheries sector of which over 50 percent are women. Approximately 1 million people are employed in the larger scale commercial inland fisheries and 60 million in small scale inland fisheries and the majority of them (41 million) live in Asia (Table 2, World Bank *et al.,* 2010).

Table 1. Distribution of inland fisheries catch by economic status. LIFDC = Low income food deficit; WB = World Bank

LIFDC status	Production 2008 (ton)	percent of production	Water area (km2)	percent of water surface
LIFDC	6 528 000	65%	1 967 000	25%
Non LIFDC	3 557 000	35%	5 862 000	75%
WB income status				
Low	4 175 000	41%	1 222 000	16%
Lower middle	4 903 000	49%	1 589 000	20%

[1] This Background Paper appears here as delivered to the participants of the Workshop. It has not undergone complete editing and has not been peer-reviewed.

[2] This is an internal FAO document to initiate discussion that draws heavily from published material, sections of which are included here verbatim. References and citations resulting from this Workshop document should go to the original publications.

Upper middle	812 000	8%	3 493 000	45%
High	194 000	2%	1 516 000	19%
WB development status				
Developing	9 078 000	90%	2 811 000	36%
Developed	1 006 000	10%	5 009 000	64%

Recreational fisheries are the dominant use of fish resources in inland waters in the North and South temperate zones (particularly Europe, North America and Australia), for example the European inland fish stocks are exploited by about 30 million recreational anglers in 36 countries (Tillner, 2007). Global estimated expenditures by some 220 million recreational fishers are in the order of USD190 billion annually (World Bank *et al*., 2010). However, as with inland capture fisheries for food, information on catch, value and numbers of recreational fishers is not well known.

Table 2: Employment in inland fisheries in developing countries (WorldBank *et al.*, 2010)

	Inland small scale		Inland Commercial		Total
	Fishers	Other employment	Fishers	Other employment	
Africa	5 634 000	11 832 000	213 000	85 000	17 764 000
Americas	519 000	1 091 000	34 000	14 000	1 658 000
Asia	13 146 000	27 607 000	534 000	216 000	41 503 000
Oceania	9 000	19 000	500	500	29 000
Total by category	19 308 000	40 549 000	781 500	315 500	60 954 000
Total employment by sub sector	59 857 000		1 097 000		60 954 000
Total women employment by sub sector	32 921 000		342 000		33 263 000

FAO and others have repeatedly commented on the poor state of knowledge on inland fishery resources and their ecosystems (Coates, 2002; FAO, 2010; World Bank *et al*., 2010). The FAO strategy for improving information on status and trends of capture fisheries (FAO, 2003) made the following statement for small scale and multi species fisheries, which would also include the majority of inland fisheries:

States, relevant intergovernmental and nongovernmental organizations, and financial institutions should recognize that many small scale fisheries and multi species fisheries, particularly in developing countries are not well monitored and awareness needs to be raised on the importance of monitoring these fisheries. They are probably underestimated and therefore under-represented in current fisheries status and trends information and consequently they are not adequately considered in the development of plans and policies for fisheries.

Reasons for the lack of good monitoring and information include, *inter alia:*

- The diffuse nature of the sector, with numerous landing sites and methods of fishing;
- Large number of people involved and seasonality of fish effort;
- Subsistence nature of many small scale inland fisheries;
- Catch is often consumed or traded locally without entering the formal market chain;
- Lack of capacity and resources to collect adequate data;
- Too expensive and not worth the effort to collect information and
- Deliberate mis-reporting.

The marine capture fishery sector has since 1974 reported to FAO on the state of major marine fish stocks. The percentage of marine fish stocks that are depleted, recovering, under exploited, moderately exploited, fully exploited and overexploited, along with their trends are extremely useful and are widely cited in fishery, conservation and development literature (Figure 1). There is however no equivalent information set for inland fisheries.

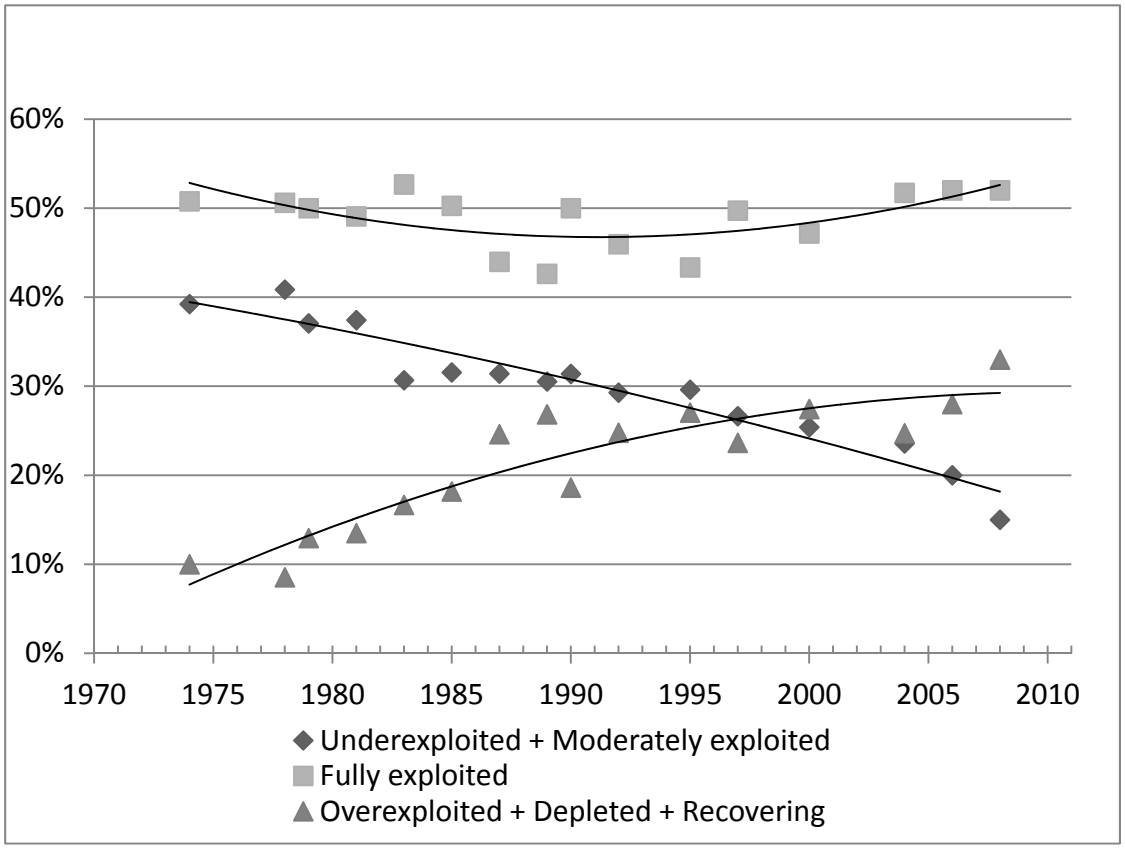

Figure 1: Global trends in major marine fish stocks: state of exploitation, 1974-2008. FAO, 2010

WHY A STRATEGY FOR THE ASSESSMENT OF THE STATUS OF INLAND FISHERIES RESOURCES

Given the importance of fresh water for humans and the competing uses of inland waters, FAO feels it is imperative that governments and resource managers have accurate information on the state of inland fisheries resources in order to make responsible decisions for management and policy development. This information will be needed on a regular basis in order to assess trends, to understand current status and to inform management decisions and policy. A first step in improving the availability of information is the development of a strategy for assessing the state of Inland capture Fishery Resources. The strategy should address questions such as:

- Is it possible to cost effectively collect accurate information on the state of world inland fisheries resources?
- If possible can this be done on a regular basis?
- Can new technologies (remote sensing and advanced geographic information systems) improve the situation?
- Are there novel more appropriate approaches to collecting information (Indicator fisheries, agriculture census, Global communities of practice) available?
- Are there specific requirements for the different subsectors or geographical areas?
- How should recreational fisheries be addressed?

This background paper will provide information to be considered in order to create a strategy for developing a practical means of assessing the status and trends of inland fisheries resources. Can standardized and regular assessments of inland capture fishery resources be conducted over the long term and in a practical manner?

THE AVAILABLE INFORMATION

Although statistics and information are improving in some countries, collecting accurate information on inland fisheries can be extremely costly. Catches are frequently not recorded by species or not recorded at all. Reported catch statistics are generally inadequate for use as a measure of stock status. Therefore, providing accurate statements on the status of inland fishery resources on a global or even regional level remains a challenge (FAO, 2008).

The lack of accurate information has led to differing views on the actual status of many inland fishery resources. One view is that the sector is in serious trouble because of the multiple uses of and threats to inland water ecosystems. The other view states that the sector is in fact growing, that much of the production and growth has gone unreported and that stock enhancement has played a significant role (FAO, 2010).

Reported statistics, information and data collection

Since 1950, FAO has requested its member countries to report inland fisheries capture statistics as part of their fisheries reporting, to enable the tracking of trends in global inland fisheries production. Members of FAO are obligated to report fisheries statistics to FAO under Article XI of the FAO Constitution. In 1950 reported yield from inland fisheries was about 2 million tonnes, in 1980 about 5 million tonnes, and, after a steady growth of between 2 and 3 percent per year 10 million tonnes in 2008 (Figure 2). About 50 percent of the total inland fish production is still reported as “freshwater fishes nei[3]”.

[3] Not elsewhere included

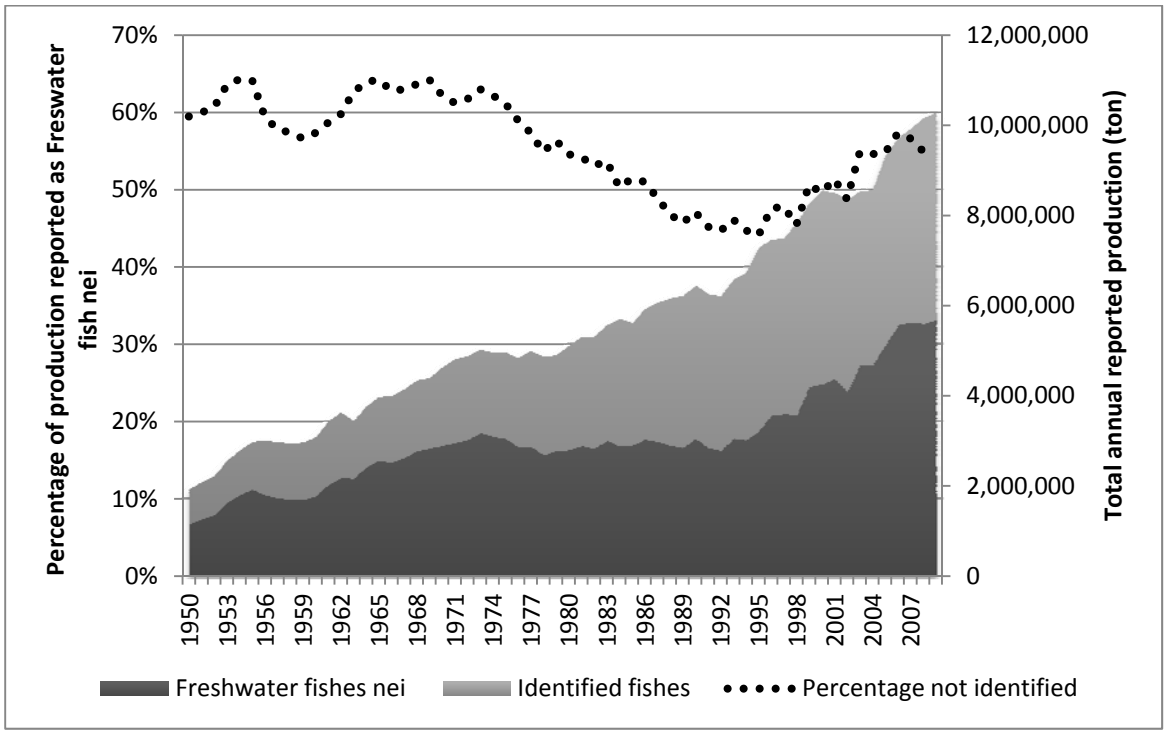

Figure 2: Production in inland fisheries reported to FAO since 1950

The significance of current reported trends in catches is difficult to assess. In most countries it is assumed that actual catches have been at a maximum level for some time. Analyses of reported catches in SE Asia indicated that large increases of reported catches are a relatively common occurrence and are due to deliberate revision of statistics, rather than a sudden change in the status of a fishery (Lymer and Funge-Smith, 2009).

The individual catch of fishers may be declining in a number of countries, but the aggregate catch can still increase, because overall the total number of fishers may be increasing. Therefore an increase in total capture production is not a contradiction to decreasing individual catches. For example, the catch in Tonle Sap (Cambodia) approximately doubled between 1940 and 1995, but at the same time the population tripled (Baran and Myschowda, 2008). Thus, the catch per fisher is less, even though the overall landings are higher; this leads to the impression among fishers that resources are declining.

Coates (2002) noted that national inland fisheries statistics for a number of countries in the Asia-Pacific region did not show the variations typically expected for inland fisheries as a result of variations in the annual monsoon rains, seasonal effects and dry versus wet years, all of which are known to affect fisheries productivity due to year-on-year variations in the area inundated which influence primary productivity, migration, breeding and recruitment success. In well monitored fisheries these significant annual variations in catch as a result of seasonal and climatic factors are clearly observed.

The majority of inland fisheries are not licensed; they operate at commercial, semi-commercial and subsistence levels and are widely dispersed along the lengths of all rivers and streams as well as in water bodies and wetlands of any size. There are often no centralised landing ports or major markets where data can be easily collected, and a large part of the catch is bartered locally or consumed by the fisher and his/her household. Catch size and composition, gears used and the number of fishers vary greatly seasonally. Data must therefore be collected several times per year, and poorly developed infrastructure in remote areas makes the collection of data both time-consuming and expensive.

Reported species

Identification of the organisms in the catch to species level is valuable for the management of fisheries as well as for fishery resource and economic assessments. Not only is the information of use internally in a country, but also for comparative purposes among countries that share river and lake basins, particularly to monitor the status of migratory fishes, other shared resources, and introduced and invasive species.

In their reporting to FAO, the countries report by species, by species group or as freshwater fish nei[4]. Figure 5 indicated that still about 50 percent of the total production is reported as Freshwater fish nei. From the early 70's till the mid 90's reporting improved, and in recent years there seems to be a slight detoriation again. However, this is most likely more related to the overall reported increase in the catch of "Freshwater fish nei" as reporting at species and at group level[5] improved globally with the exception of the Americas (Figure 3).

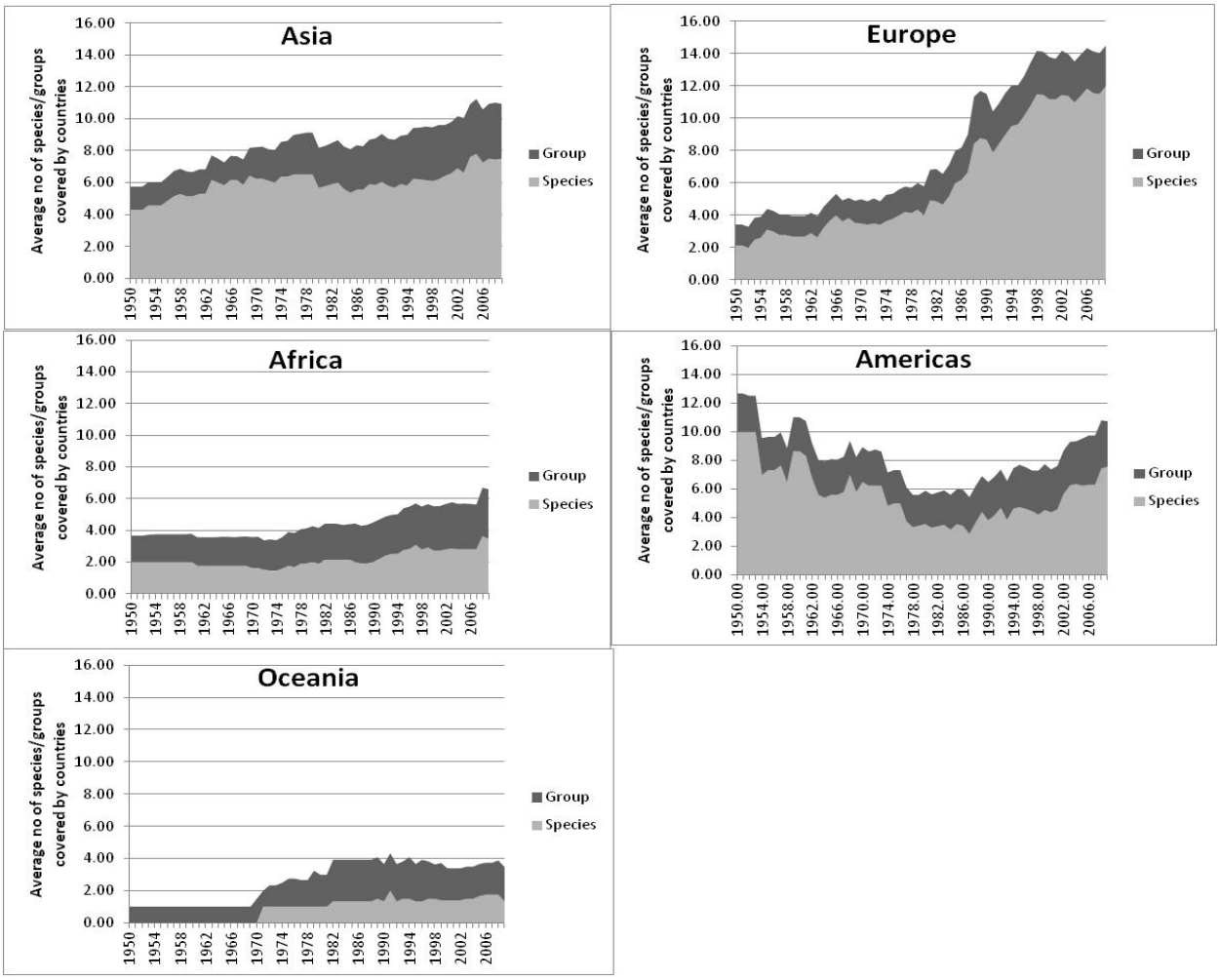

Figure 3: Average number of species/groups reported by the countries of the different continents.

[4] Not elsewhere included.
[5] For example: Tilapia spp, or carp.

Fishing down process or assemblage over fishing

Classical fisheries models for over fishing whereby the annual catch gradually rises with increasing fishing effort, until it reaches the peak of maximum sustainable yield and declines if the fishing effort further increases beyond this maximum are difficult to apply in tropical inland fisheries (Welcomme 1999). Over fishing is taking place in inland fisheries but it often masked by the fact that total catches remain stable over a long range of fishing pressure (Welcomme 1999). This mechanism, which is called "Assemblage over fishing" is mainly related to the strong resilience of inland fish communities and the opportunistic behaviour of the fishers.

With increasing fishing pressure the large target fish will be reduced due to over fishing and recruitment failure. However, in response, the fishers will gradually shift their effort to other target species of the assemblage by using different gears or, as over fishing reduces the mean size of individuals and species in the assemblage, fishers reduce the mesh size of gear they use. The resulting fishery mainly consists of smaller species, with a more rapid life cycle, and is often based on the young of the year (Figure 4).

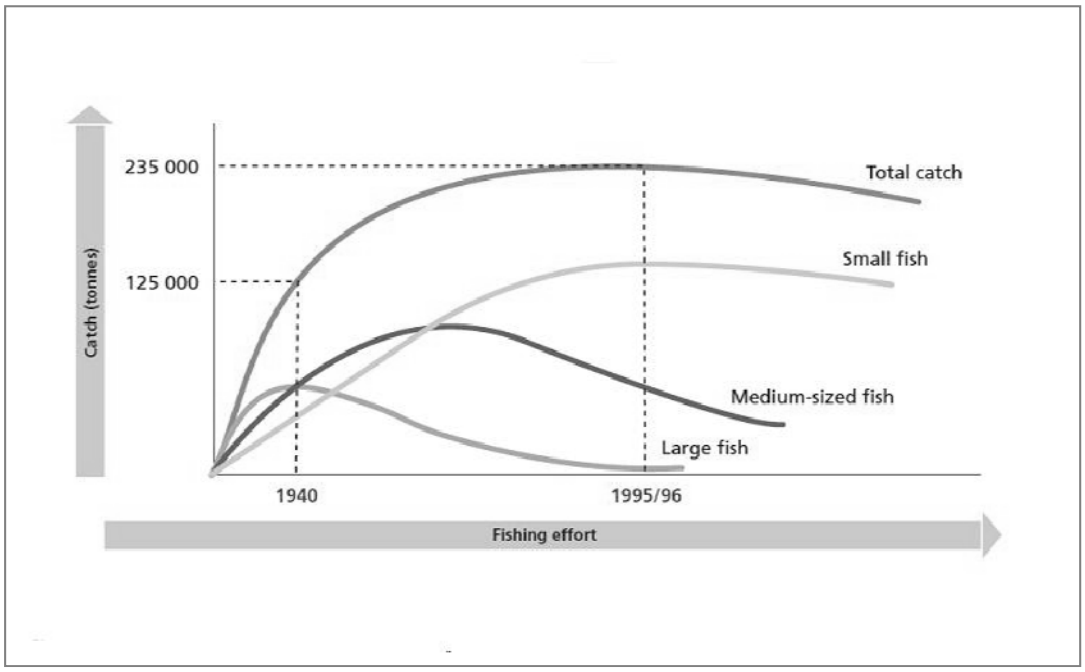

Figure 4: Fish production and changing composition in Tonle Sap (FAO, 2003)

Assemblage over fishing is most common in tropical areas with high species diversity and where local communities depend on a diverse inland fish harvest. It is an indication of the stability of inland fisheries productions, but it also creates the misleading impression that inland fisheries resources are limitless. This is especially the case if catches are not reported by species or species groups and internal processes in the fisheries are masked.

WHAT INFORMATION IS NEEDED FOR ASSESING THE STATUS OF INLAND FISHERIES RESOURCES

Knowledge of the status and trends of inland fisheries is key to sound policy-development, better decision-making and responsible fisheries management. It is necessary at the national level for the maintenance of food security and for describing social and economic benefits of fisheries. Such information is also essential for assessing the validity of fisheries policy, for tracking the performance of fisheries management and for assessing impacts of developments in other sectors of the economy on fisheries (FAO, 2003).

The types of information needed will depend on the intended uses of that information, that is, it will depend on the–objectives of fishery management. There are several possible objectives of inland fishery management that can be generally classified into social, economic, and conservation objectives. Priority objectives for collecting information on inland fisheries include:

- to obtain status and trend information on the fisheries and the environment;
- to ensure proper valuation of the fisheries;
- to formulate and assess management interventions concerning the fishery;
- to justify the requests for appropriate allocation of funding and other resources to the sector;
- to protect endangered and threatened species;
- to fulfil international obligations.

In the next paragraphs a number of key elements of inland fisheries are described which should be considered in the development of a strategy for assessing the status of inland fisheries resources.

Description of the fisheries

The inland fisheries sector is extremely diverse. The diversity in inland fisheries systems are related to hydrology/geomorphology of the system; ecological and geographical characteristics; social and economic characteristics and external drivers around the systems. It deploys a wide variety of fishing techniques, ranging from simple hand held gear to small trawls or purse seines operated by commercial fishing vessels. Moreover, the term 'fisheries' means not only the harvesting of fish – the actual fishing operations – but also include processing and other post harvest and supporting activities. These related activities add further layers of complexity to the compilation of global knowledge on the sector but will not be discussed here unless they can provide information on the state of fishery resources.

Inland fisheries include commercial/industrial fisheries, small scale fisheries and recreational fisheries, each with a different economic and social structure. Although these types of fisheries are difficult to define precisely, there are some general attributes that can be used to characterize them.

Commercial/industrial inland fisheries - Income is a primary motivation for many fishers, including at the small-scale level. This group is thus not limited to the large scale sector since modern small-scale fisheries can be economically efficient and produce high value products including for international markets. Commercial fisheries produce significant quantities of fish at localised sites, they often require specialized catch preservation and distribution, usually involving high capital input gears and often using significant inputs of professional labour. Commercial fisheries are usually found where resource availability and access to markets justify significant capital investment (financial, manpower and/or in the construction of gears) and where access can be controlled. Key fishing sites or opportunities are often allocated through well developed licensing and auction systems.

Small-scale inland fisheries- a dynamic and evolving sector employing labour intensive harvesting, processing and distribution technologies to exploit the fisheries resources. The activities are conducted: full-time, part-time, or occasional[6] Occasional fishers are a complex group, they fish for cash as the opportunities arise and for subsistence home consumption; they often outnumber full time and part time fishers. When referring to subsistence fishing, a more household centred activity is

[6] Fulltime fishers: receiving at least 90 percent of their livelihood or spending at least 90 percent of their working time from fishing. Part time fishers: fishers receiving at least 30 percent, but less than 90 percent of their livelihood from fishing or spending at least 30 percent but less than 90 percent of their working time in that occupation. Occasional fishers: those receiving less than 30 percent of their income from fishing or spending less than 30 percent of their working time on fishing. CWP Handbook of Fishery Statistical Standards, Section K: Fishers, available at http://www.fao.org/fishery/cwp/handbook/K/en.

implied rather than a more commercial activity. "Subsistence fisher" is more often concerned with lack of opportunity to derive income rather than a deliberate livelihood strategy. Subsistence fisheries are a subset of occasional small-scale fisheries.

Recreational fisheries - is 'fishing for reasons other than to satisfy essential nutritional needs and where fishing products are generally not sold or otherwise traded on markets. Recreational fishing constitutes the dominant use of wild fish stocks in all freshwaters of industrialized countries, and it is prominent in many coastal ecosystems[7]. It is a popular activity and pastime in many developed countries around the world, and has also started to gain popularity in developing countries. the subsector can contribute substantially to local and national economies through employment in secondary sectors. There is growing evidence that recreational fisheries are having significant impacts of stocks both from fishing pressure and stock dynamics (Cooke and Cowx 2004, 2006).

The habitats

Globally, lakes, reservoirs and wetlands important for inland fisheries cover a total of about 7.8 million km^2. Relatively high proportions of land are covered with surface waters in SE Asia, North America, East and Central West Africa, the northern part of Asia, Europe and South America (Table 3).

Table 3: Distribution by continent of major surface freshwater resources (Lehner et al., 2004)

Continent	Surface area in km^2							TOTAL	%
	Lakes	Reservoirs	Rivers	Floodplain	Flooded forest	Peat land	Intermittent wetland		
Asia	898 000	80 000	141 000	1 292 000	57 000	491 000	357 000	3316 000	42%
North America	861 000	69 000	58 000	18 000	57 000	205 000	26 000	1294 000	17%
Africa	223 000	34 000	45 000	694 000	179 000		187 000	1362 000	17%
Europe	101 000	14 000	5 000	53 000		13 000	500	186 500	2%
South America	90 000	47 000	108 000	422 000	860 000		2 800	1529 800	20%
Australia	8 000	4 000	500				112 000	124500	2%
Oceania	5 000	1 000	1 000	6 000			100	13100	0.2%
TOTAL	2 186 000	249 000	358 500	2 485 000	1 153 000	709 000	685 400	7825 900	100%

Fresh-water classification can also consider the interactions of the geological, physical, and chemical features along with the biota, the organisms that occur in an area. A number of different classification approaches are presented in the next paragraph.

[7] Draft Technical Guidelines for Responsible Fisheries: Recreational Fisheries. In prep. FAO, Rome.

Eco-regions

Ecoregions (Figure 5) are a widely recognized and applied geospatial unit for conservation planning, developed to represent the patterns of environmental and ecological variables known to influence production[8]. Abell *et al.*, 2008 define a freshwater ecoregion as a large area encompassing one or more freshwater systems with a distinct assemblage of natural freshwater communities and species. The freshwater species, dynamics, and environmental conditions within a given eco region are more similar to each other than to those of surrounding ecoregions, and together form a conservation or management unit. Ecoregion boundaries are not necessarily determined by the turnover of species ranges but are intended to describe broad patterns of species composition and associated ecological and evolutionary processes. The freshwater ecoregion map encompasses 426 units (Abell *et al.*, 2008 and are available on www.feow.org).

The distribution of the number of ecoregions over the geographical areas is presented in Table 4.

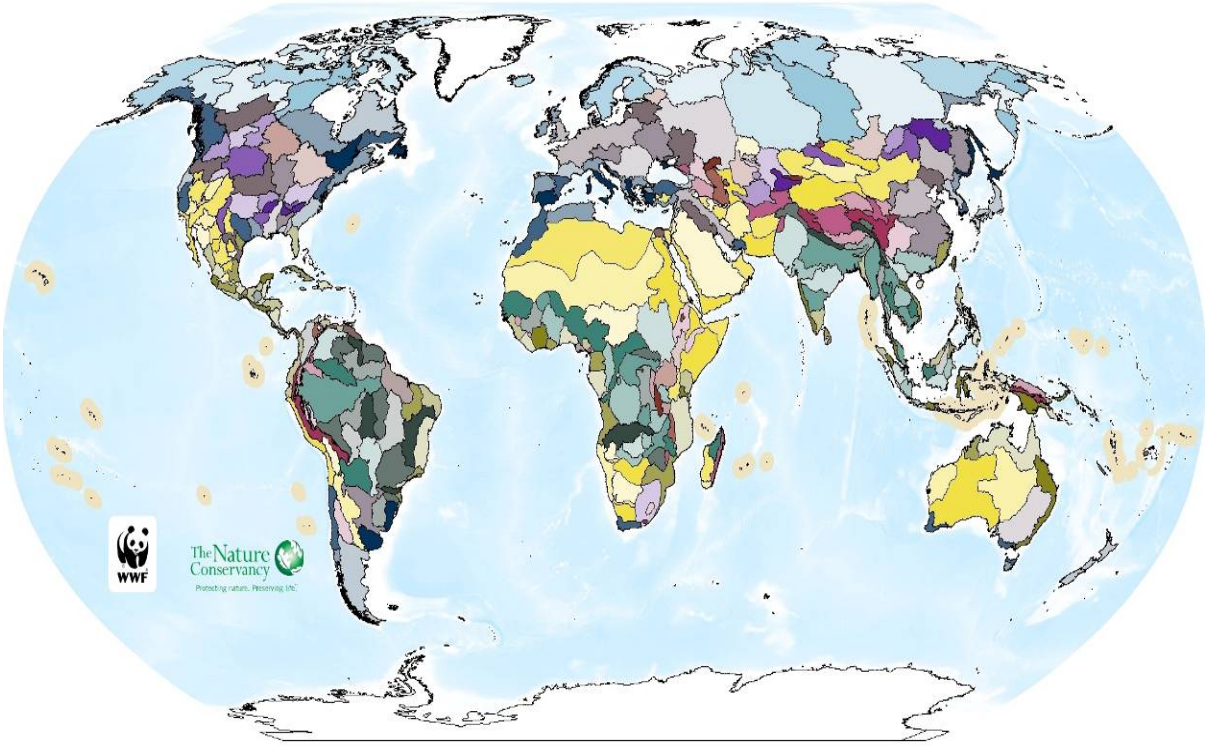

Figure 1: Global freshwater ecoregions (source: www.feow.org).

[8] A detailed description of the freshwater eco regions can be found at www.feow.org

Table 4: No of Ecoregions by geographical areas

Geographical area	No of freshwater ecoregions
North America	76
Central America	17
South America	52
Europe & Middle East	53
Africa & Madagascar	87
Northern Asia	43
Southern Asia	69
Australia & Pacific	30
TOTAL	427

Major freshwater habitats

The freshwater Major Habitat Types (MHTs) reflect groupings of ecoregions with similar biological, chemical, and physical characteristics (Figure 6). The MHTs refer to the dynamics of ecological systems and the broad habitat structures that define them, and these groupings can provide a structured framework for examining and comparing the diversity of life in freshwater systems. Because of the large scale of ecoregions, all contain patches of multiple habitat types. For instance, ecoregions in the large lakes habitat type can contain swamps, floodplains, and grassy savannas in addition to the dominant lake habitat. Smaller habitats cannot be mapped at the scale of the ecoregion map, but such habitat diversity contributes to species and ecosystem process diversity within ecoregions. For instance, globally 99% of lakes and ponds are less than 10 hectares in area.

River basin classification

Most inland fishery scientists recommend the "watershed" as the appropriate unit for fishery management and resource assessment. They do so because biological, ecological and physiochemical processes within the watershed are interdependent and will determine fishery production. Further, an appropriate freshwater management regime needs to integrate the complex biophysical interactions between ecosystems, and species with the political, economic and development objectives of each country or region. This requires that ecological units be managed in their entirety. Freshwater management thus imposes a river basin delineation to water management, including the management and consideration of the different habitat types and ecosystems in a particular basin.

There are 354 drainage basins throughout the world (Revenga *et al*., 1998). The drainage basin includes both the streams and rivers that convey the water as well as the land surfaces from which water drains into those channels.

APPROACHES TO DATA COLLECTION

There are two general approaches to obtain information on inland fisheries:

- direct measurement of the fishery through frame surveys, catch assessment surveys, census at landing sites, creel census, counting number of fishers, gears, boats, etc.; and
- indirect measurements such as yield per type of habitat and extrapolation, GIS and remote sensing, post harvest surveys such as consumption, financial, trade and household surveys.

Direct measurements

The sampling frame

The structural information on the number, characteristics and spatial distribution of vessels, gears, fishers, landing sites and fishing communities constituting the sampling frame, is traditionally obtained through a frame survey or fisheries census (Bazigos, 1974). Frame surveys should be updated regularly: however, this often does not happen due to the high costs involved, leading to unreliable total estimates.

Another main bottleneck of the sampling frame is the lack of information on how many people/households are engaged in subsistence fisheries. Structural information on subsistence fisheries is almost impossible be obtained through frame surveys. The most effective way to obtain a sampling frame on subsistence fisheries is to make use of external resources, e.g to include fisheries related questions in a census such as a population census or agricultural census.(Crispoldi, 2003).

Catch and effort

In general, information collection methods in many areas are based on the application of traditional methods of government fishery officers assessing catch and effort data. However, these methods are best suited for formal, large-scale fisheries and are inadequate or inappropriate for the many informal, small scale fisheries; many inland water bodies support both formal and informal fisheries, i.e. both large scale and small scale.

Thus, alternative approaches have to be developed and evaluated that attempt to include individual fishers, households, and communities. Additionally, indicators and proxy measures of fishery yield have to be developed and applied.

Indirect measurements

The use of indirect measurements has been successfully used in specific areas. Bayley, 1981 and Bayley and Petrere, 1989 describe methods of using average household fish consumption, census data and population increase rates to determine area fish consumption (Shrimpton *et al.,* 1979). These studies correlated well with data derived from fish recording (Petrere, 1978a *in*: Bayley, 1981), with a lower sampling error than conventional approaches, which often have high variances in daily catch/effort and total effort estimates (Bayley, 1989). They were also easier to implement than monitoring numerous scattered landing sites. In Guinea inland fisheries production was estimated using interviews with local focus groups (FAO, 2011). But further development and implementation of indirect measurements remains a challenge.

WHICH APPROACHES-MODELS CAN BE USED TO ASSESS THE STATUS OF INLAND FISHERIES RESOURCES?

Single species concept

In marine fisheries reporting on status of the stocks is usually based on single species stock concept, whereby fish stocks are subpopulations of a particular species of fish, for which intrinsic parameters (growth, recruitment, mortality and fishing mortality) are the only significant factors in determining population dynamics, while extrinsic factors (immigration and emigration) are considered to be insignificant. In general, a stock becomes over-fished when mortality from fishing and other causes exceeds recruitment and growth. In reporting on status of stocks for marine fisheries the following definitions are used;

Underexploited/Undeveloped or new fishery. Believed to have a significant potential for expansion in total production;

Moderately exploited. Exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production;

Fully exploited. The fishery is operating at or close to an optimal yield level, with no expected room for further expansion;

Overexploited. The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse;

Depleted. Catches are well below historical levels, irrespective of the amount of fishing effort exerted;

Recovering. Catches are again increasing after having been depleted.

There are a number of analytical tools/models, mostly coming from the marine sector, which can be used for assessing the state of a resource. Each model has its own information requirements (Table 5), concept and constraints.

The definition of a 'stock' however, can be decided by the managers of a given fishery, e.g. sub-population of a given species, the entire species, or an aggregation of species with similar characteristics. However, it must be realized that a watershed or eco-region may have one stock defined as a species that is in low abundance due to over-fishing, whereas other species may have become extremely abundant in the catch. Therefore, the identification of the 'stock' being assessed in inland fisheries becomes important.

Table 5: Information requirements for a number of models for assessing the status of a fisheries resource

Information types	Models					
	Swept area	Surplus production	VPA Thompson and Bell	Yield per Recruit	GIS	Individual Based
Fish Biomass	X					
CPUE		x			x	x
Fishing effort		x			x	x
Fishing capacity		x			x	x
Catchability		x	x			x
Species composition		x	x	x	x	x
Total annual catch		x	x	x		x
Growth			x	x		x
Natural mortality			x	x		x
Fishing mortality			x	x		x
Length at first recruitment			x	x		x
Recruitment			X			x
Catch distribution (age or Length)			x			x
Biological data						x
Habitat information					x	x
CPUA	X				X	

Swept area models

Data are obtained through standard experimental trawling, where by the Catch per Unit of Area is an index of stock abundance. Often, results are rather imprecise and difficult to apply in inland fisheries

Surplus production model

Surplus (harvestable) production models are the simplest analytical methods available that provides a full stock assessment. They are relatively simply to apply partly because they pool the overall effect of recruitment, growth and mortality into a single production model. The stock is considered solely as undifferentiated biomass, that is, age- and size-structure, along with sexual and other differences, are ignored. The models are based on the concept that Catch per Unit of effort reflects abundance of the stocks. The model is easy to apply in both marine and inland fisheries but major constraints are: 1) the assumption of equilibrium; 2) and system variability.

Fish stocks are rarely in equilibrium and nowadays it is even argued that ecosystems are in a constant and ever changing state of non-equilibrium due to considerable variation of variables external to the system. Assuming equilibrium and applying surplus production models consistently overestimate sustainable yield and can lead to the collapse of the stocks (Boerema and Gulland, 1973; Larkin, 1977; Hilborn, 1979).

Surplus production models are mainly based on the assumption that human intervention i.e. fishing or fishing effort is the only variable influencing the ecosystem/biomass. However, over the years a number of experiences, especially in inland fisheries indicated that this concept is too limited as other abiotic factors such as water level, water temperature proved to have an important impact on biomass and consequently on CPUE (De Graaf and Ofori Danson, 1997; de Graaf, 2001; Larsen *et al*, 2003).

VPA Thompson and Bell Model/ Yield per recruit model

These types of models are based on population dynamics whereby the total number of fish, their survival, natural and fishing mortality and growth is followed over time. Population models can be age-based or length based, in general it is believed that age based models are somewhat more accurate if compared to length based model. But length based models have the advantage that data collection is easier and cheaper, and this will certainly the case if small scale fisheries is considered. Population models have been successfully applied in Inland fisheries but a major constraint is the large data requirement.

Individual based models

Population dynamic models commonly used in fish stock assessment are straightforward but have some limitations as natural mortality is kept constant, recruitment over-fishing and biological interactions cannot be incorporated. However, the mathematics allows to incorporate these interactions in predictive population models. Interesting developments are Individual Based Models (IBMs) which have become popular for modelling fish populations as they apply the principle that properties of ecological systems can be derived by considering the properties of individuals constituting them. Individual based population models simulate the behaviour of each member of a biological population as an individual. These models differ from traditional state-variable models in which population size is described as an aggregated variable. The advantages of individual based models include the following:(1) A variety of types of differences among individuals in the population can be accommodated (2) complex decision making by individual processes can be simulated and (3) local interactions in space and the effects of stochastic temporal and spatial variability are easily handled (De Angelis *et al*., 1999).

However, information requirements for IBM models are even higher if compared to the standard model and will be a major constraint.

Geographical information systems

In inland fisheries, the bulk of the catch is taken by dispersed small-scale fishers, the fishing activities are of an informal nature and fishers operate in remote rural areas. Part-time fishing is the norm, especially mixed farming/fishing lifestyles on floodplains. Most inland fisheries produce is consumed domestically and much of it within the communities where the fishing occurs. Therefore estimation of total catch is cumbersome in inland fisheries.

However, taking into account these obstacles in collecting reliable data, one option is to apply habitat stratification, estimate for each type of habitat the fish production per unit of area (CPUA) and use GIS layers on habitat coverage to estimate the total production (de Graaf *et al.*, 2001).

Multi criteria concept

Are single species concepts as used in marine fisheries applicable in inland fisheries? Multi-species and their ecological interactions could be a key to assessing inland fisheries, especially in tropical rivers. Interactions between the fishery and multiple groups of fishers, households and communities could also assessed. Interactions among species, i.e. trophic relationships, can be important in determining stock compositions.

Major questions are: how to select the indicators needed for a multi criteria analyses of the state of the resource or the state of the ecosystem and how to quantify and analyse them.

This could be done through quantification of explicit key attributes within the system and presents the results in kite diagrams, as done by Pitcher and Preikshot (2001) in RAPFISH.

However, a major challenge will be the selection of the criteria for the development of a global comparable system. Should the criteria be based on a complex of fisheries, social and water characteristics (Figure 6A, or on a higher level of characteristics of the fisheries/ecological system (Figure 6B).

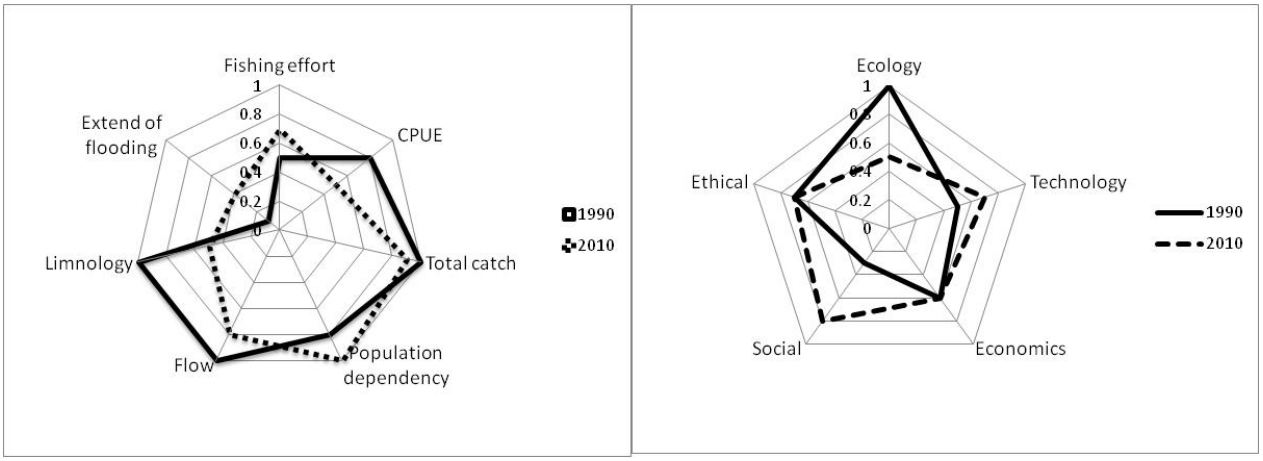

Figure 6: Theoretical examples of the application of kite diagrams in multiple resource assessment**.**

THE ASSESSMENT FRAMEWORK

The overall framework for the global assessment of inland capture fisheries is the FAO Strategy for improving information on status and trends in capture fisheries (FAO 2003) which stated:

States should participate in and support the development of cost-effective methods for acquiring and validating data on small scale and multi species fisheries, including rapid appraisal methodologies and other approaches for data poor situations and participatory processes that closely associate the fishers and their organizations to the data collection schemes. Regular surveys at appropriate

frequencies rather than continuous monitoring may be more feasible, particularly for some inland and small scale fisheries.

The FAO STF strategy deals with assessment only; the more management related issues are covered by the FAO Code of Conduct for Responsible Fisheries (CCRF) and the ecosystem approach to fisheries

ELEMENTS OF A STRATEGY – GUIDANCE SOUGHT FROM THE WORKSHOP

A strategy for Assessing the State of Inland Capture Fishery Resources should have an overall goal the strategy will aim to achieve. The goal could be: ***"Information on inland capture fisheries is sufficient to assess the variety of inland capture fisheries as to their yield, and long term sustainability[9]"***

Given the priority in STF to develop rapid appraisal methods, a global assessment and a strategy the following should be discussed;

Scale of assessment –how much can we assess?

As indicated in the previous chapters, the scale of the classification inland fresh water resources varies immensely from an individual water body of a few ha, to the largest river basin of the world, the Amazon, covering 7 million km^2 . It is clear that at a global scale we cannot assess the individual water bodies on a regular basis, so a certain global target grouping has to be made. However it must be realized that the scale of the target grouping and the scope of the assessment will determine if the assessment really can be carried out on a regular basis. The target grouping could be;

- The major habitats by geographical location;
- The 427 Freshwater global freshwater eco regions;
- The 354 river basins;
- Indicator fisheries by region;
- Indicator species groups.

Key questions for the Workshop include:

- Is it possible to cost effectively collect accurate information on the state of world inland fisheries resources?
- If possible can this be done on a regular basis?
- How to prioritize scale:
  - Region
  - Production
  - Diversity
  - Chance of success.

Scope of assessment – what fisheries and sectors can we include?

Key questions for the Workshop include:

- How to define the resource, and what are the possible states? overfished? depleted etc.; above carrying capacity, below carrying capacity etc.
- Do we focus on fisheries resources or on the overall status of the freshwater ecosystem?
- How to deal with small scale; commercial; large scale; part-time; occasional; recreational. Similar to the STF, the Strategy is global in scope and designed to cover all capture fisheries in inland waters, including all industrial, commercial, subsistence and recreational fisheries;

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[9] Within this statement, the contribution to economic and societal benefits, and impact on biodiversity are excluded, as these elements at the normative level, are covered by the overall FAO STF strategy.

- Can indicators be developed, e.g. similar to the major fish stocks assessed by the marine capture fishery sector:
  - Fisheries
  - Species
  - Other?

Type of information needed

- What are minimum information requirements or priority information;
- Identification of indicators for the different information uses, e.g. single species or ecosystems.

Existing approaches and models

- Can we use the models applied in Marine fisheries?
- Can new technologies (remote sensing and advanced geographic information systems) improve the situation?
- Are there novel more appropriate approaches to collecting information (agriculture census, Global communities of practice) available?
- Can we make use of Local Ecological Knowledge?
- Are there specific requirements for the different subsectors e.g. commercial, recreational and subsistence fishers, or geographical areas?
- How to improve involvement of key stakeholders and partners:
  - Fishers including recreational fishers
  - Water managers and users
  - Households
  - Supply chain.

How to implement the strategy

- Who are our potential partners?
- Should pilot areas be established?
- What are the next steps after this meeting?

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A workshop was convened to develop a strategy to improve the state of information on the status of inland fisheries. Inland fisheries are a vital component in the livelihoods of people in many parts of the developed and developing world. Globally lakes, reservoirs and wetlands cover a total area of about 7.8 million square kilometres and provide a rich environment for inland fisheries. The 28th Session of the FAO Committee on Fisheries observed that, "data and statistics on small-scale fisheries, especially in inland waters, were not always comprehensive, resulting in underestimating their economic, social and nutritional benefits and contribution to livelihoods and food security. The underestimation of the importance of inland fisheries can lead to policies and practices that further degrade resources and endanger food security". The marine capture fishery sector has, since 1974, reported on the state of major marine fish stocks. The percentage of marine fish stocks that are depleted, recovering, under exploited, moderately exploited, fully exploited and overexploited, along with their trends is extremely useful and widely cited in fishery, conservation and development literature. There is no equivalent information set for inland fisheries on which to make assessments. The workshop identified several important differences between inland and marine capture fisheries that necessitate different approaches to the assessment of inland fisheries. A main difference is that the state of exploitation is usually the main driver determining the status in marine fisheries and is the principal indicator of management performance used by FAO for global assessment. The status of inland fisheries is also determined by rates of exploitation, but other influences that affect habitat quality and quantity can also be significant and often more important. Taking into account the special characteristics of inland fisheries, the workshop identified ecosystem services provided by inland fisheries and some potential indicators and information that could be used for the assessment of inland capture fisheries. Indicators were identified for social and economic aspects of a fishery and for environmental and production aspects. Both aspects were judged to be important in the assessment of inland fisheries and efforts were made to establish a composite indicator. The elements of a strategy to assess inland fisheries were not completely defined by the workshop and further work was planned to determine the usefulness of the indicators and composite indicator.

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