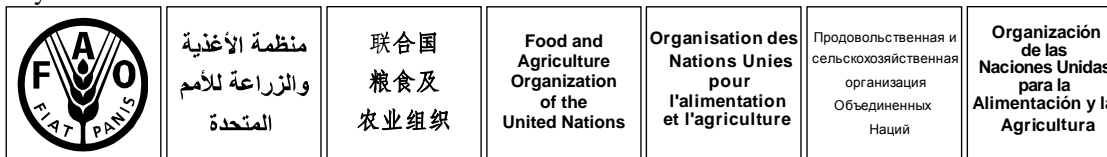


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COMMITTEE ON FISHERIES

SUB-COMMITTEE ON AQUACULTURE

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THE ROLE OF THE SUB-COMMITTEE IN PROMOTING RESPONSIBLE CULTURE-BASED FISHERIES

Executive Summary

This document focuses on the role the COFI Sub-Committee on Aquaculture can play in the development and management of responsible culture-based fisheries.

The Sub-Committee is invited to:

- 1) Approve the revised definitions in Annex 2 or provide advice on how to revise the existing terms in the FAO Glossary;
- 2) Call on Members to increase and standardize reporting on culture-based fisheries using appropriate terminology and definitions;
- 3) Provide advice on the relevant sections of the FAO questionnaire on how to improve reporting with regard to stocking;
- 4) Consider the need for an expert consultation on culture-based fisheries addressing the aforementioned issues;
- 5) Provide advice on how to assure the fisheries and aquaculture sector is appropriately considered in water development and management discussions;
- 6) Provide other guidance, as necessary, including how the Sub-Committee could assist in promoting culture-based fisheries as a means to enhancing food security, alleviating poverty and improving nutrition.

Introduction

1. In 2003, FAO analyzed some of the major issues associated with culture-based fisheries. These issues, which were discussed at the Second Session of the COFI Sub-Committee on Aquaculture (Annex 1), comprised *inter alia* efficacy, cost-effectiveness, environmental impacts, conservation, monitoring and reporting, and social and economic considerations. A decade later, there

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has been very little progress in understanding the contribution that culture-based fisheries make to global fish¹ production and economic development. Lack of standard terminology and inconsistent reporting are still pervasive and hinder accurate evaluation of culture-based fisheries as a viable fishery management option.

2. Moreover, advances in breeding technologies that are conducive to increased fry production in hatcheries, coupled with the rising importance of ecolabelling as well as certification of fish and fish products and the establishment of measures facilitating adaptation to and mitigation of the impacts of climate change, will all greatly influence the role of culture-based fisheries in the future. For these reasons, it is essential that the Sub-Committee deliberates further and provide its guidance on the issue of culture-based fisheries.

Need for standardized and consistent terminology

3. Although FAO previously addressed the issue of standard terminology and reporting, there is confusion and inconsistency on the terms that are being used to describe stocking hatchery-raised fish for culture-based fisheries. The FAO Glossary should be an authoritative source for terms used in fisheries and aquaculture. However the definitions in the Glossary need some refinement in light of current use and practice. Annex 2 contains a list of important terms that require revision along with the suggested revisions.

Culture-based fisheries: aquaculture or fishing?

4. There is also inconsistency in how production from culture-based fisheries is reported; some Members report it as aquaculture whilst others report it as capture fishery production. At present, FAO does not have a separate category representing culture-based fisheries production; Members must report as either 'aquaculture' or as 'capture fishery' production. How should production from culture-based fisheries be classified?

5. FAO's definition of 'Aquaculture' is, The farming of aquatic organisms in inland and coastal areas, involving intervention in the rearing process to enhance production and the individual or corporate ownership of the stock being cultivated. Clearly, producing fish in a hatchery is an 'intervention in the rearing process', and therefore the critical distinction is whether there is 'individual or corporate ownership' of the fish. Thus, production from a system where hatchery fish were released into a reservoir that was 'owned', for example, by an individual or fishing association, i.e. the individual or fishing association had exclusive harvest rights, should be considered as aquaculture. If those same hatchery fish were stocked in a reservoir with open access to the fishery, production should be considered as 'fishery' production.

6. Some countries have clearly defined the inclusion of culture-based-fishery production in aquaculture or capture fisheries as part of the established national statistics standard, whilst for some other countries the choice depends on the officers assigned to data collection and reporting. The water surface area of inland water bodies is used in some cases as the metric criterion to distinguish between capture fisheries and aquaculture, regardless of the release of fish from hatcheries and ownership. Occasionally, community and even private owned extensive aquaculture production in coastal lagoons in some Mediterranean countries is reported as capture fishery production.

Problems in reporting

7. Overall, the reporting on culture-based fisheries is not adequate enough to assess the contribution that culture-based fisheries makes to fishery production and livelihoods. Worldwide there are only a few countries that collect and report statistics on culture-based-fishery production separately from aquaculture. When clearly reported to FAO, cultured-based-fishery production is conveyed as capture production in the annually published global fisheries and aquaculture statistics. At present, the FAO questionnaire requests Members to report on larval production by species and numbers of larvae (or other early life-history stages) produced in hatcheries. Further, Members are asked to report on the

¹ 'Fish' is used here as a generic term to include fin fish, mollusks, crustaceans, echinoderms and other aquatic animals.

numbers of these larvae stocked into contained environments, which would signify aquaculture, and numbers stocked into open environments, which would signify stocking in the wild (e.g. coastal areas or rivers) or modified habitats (e.g. reservoirs). However, as previously mentioned and in spite of calls for improvements, this data set is extremely incomplete and inconsistent and does not consider the issue of ownership.

8. The numbers of organisms released from a hatchery is a good indication of ‘hatchery’ production, but possibly not such a good indicator when referring to the fishery benefits from the stocking programme. Some analyses have shown correlations between releases of hatchery fish and fishery production, whereas others have not. Simple correlations do not always indicate causation and other factors such as climate change, migration and fishing pressure, can also contribute to changes in the abundance of fish. With the current structure of the FAO questionnaire on fishery production, i.e. no separate category for culture-based fishery production, such correlations combined with other information regarding the fishery production are the only means to assess the contribution of hatcheries to fishery production and to evaluate the state of the culture-based fishery.

9. The public sector usually plays a leading role in promoting and developing culture-based-fisheries. The selection of sites, species, planning and release are often overseen by government authorities or systematically monitored. Would it be difficult for the appropriate government authority to keep records and collect annual data on (1) the total water area used for stock enhancement; and (2) the number (or weight), type and species of the released seeds?

Management issues

10. There are several issues that are associated with the management of culture-based fisheries (see also Annex 1). The purpose of this document is not to review all the issues, but rather to raise the awareness of their importance and subsequently assist the Sub-Committee on Aquaculture in assessing how to facilitate resolving them. The following questions have been identified as being of major importance:

- Carrying capacity – how many fish can be stocked into one area;
- Size of release – what is the optimum size of release; smaller fish are cheaper to stock, but larger fish have a better survival rate;
- Use of introduced species – often are of high value, but will they survive and what is their environmental impact;
- Genetic resource management – what stocks or strains should be used and what kind of breeding programme should a hatchery follow;
- Criteria for success – how to assess the efficacy of the management programme including monitoring and reporting aspects (see above);
- Disease transmission – would introduced species or species raised in hatcheries promote the transmission of disease;
- Trophic interactions – what are the impacts on potential predators and prey organisms;
- Habitat changes – some species such as common carp, tilapia, some aquatic plants, and crayfish can significantly alter the habitat and water quality where they are introduced;
- Stocking in degraded environments – can the development of culture-based fisheries be an option for degraded habitats where native fishes are no longer viable;
- Stocking for enhancement – where good fishery production already exists, is there need or the potential to increase production through stocking;
- Access to stocked fish – who has fishing rights to stocked fish;
- Rights of local fishers – how will traditional users of the fishing area be impacted by the development of culture-based fishery and how will the development of culture-based fishery impact the traditional users;
- Marketing and processing - are appropriate facilities in place and is there the capacity to handle a new fishery and fishery products;
- Conservation hatcheries – are appropriate management measures in place to ensure that hatchery fish are appropriately produced and given time to re-establish themselves in nature.

11. Several of the above issues would be best addressed through regional or sub-regional collaboration, especially where international or shared waters and trans-boundary waters are stocked. Joint management plans, reporting, monitoring and access agreements which are agreed by all parties would be required. However, at present, such joint management and collaboration is limited to only a few areas. Several of the above issues will require expert advice from technical specialists.

New opportunities

12. Since the preparation of Annex 1 in 2003, there have been developments which culture-based fisheries will need to address, namely, increased capacity to produce large numbers of fish in hatcheries, the need to mitigate and adapt to climate change, the emergence of ecolabelling and certification as forces for market access and improved sustainability and the increased demand for freshwater which presents opportunities for further use of culture-based fisheries.

Increased capacity to produce hatchery fish

13. Despite the lack of complete information, there are more areas, both inland and marine, now being utilized for stock enhancement or for re-stocking. The number of species used for release has also increased, thanks to the development of improved breeding, hatchery and nursery techniques. As numbers of stocked fish increase, it will be important to understand how they increase production, affect the environment and impact the fisheries and the people that depend on them for their livelihoods.

Climate change

14. Culture-based fisheries can address at least two climate-change threats to fish production; i) restricted availability/access to freshwater, including changes in rain patterns and drawdown schemes in watersheds,² and ii) limited availability of aquaculture feed sources.

15. There are an increasing number of hydro-electric dams and reservoirs built to adapt to climate change, specifically the changed availability of freshwater and the need for energy not derived from fossil fuels. The grow-out phase of CBF in freshwaters often utilizes these reservoirs thus allowing for the multiple uses of water bodies that will produce fish along with providing reliable sources of drinking water and electricity.

16. Fed aquaculture can be a source of green house gas (GHG) emissions through the burning of fossil fuels to capture small pelagic fish to make fish oil and fish meal, the manufacturing of feeds and the GHG emissions from uneaten food from fish cages. However, species used in most culture-based fisheries only require feeding during the hatchery phase and rely on naturally available food once released from the hatchery, thus reducing the carbon footprint fish production.

17. Climate change will also impact culture-based fisheries primarily through changes in rainfall, salinity and temperature. However, through the appropriate selection of species for stocking, such changes can be accommodated, e.g. through the stocking of species with short generation times or greater salinity or temperature tolerances.

18. Culture based fisheries as an adaptation to climate change will require planning and possible changes in current practices of water management, species selection and introduction of non-native species. New or revised legislation and policies may be needed to accommodate these changes.

Ecolabelling and certification

19. Ecolabelling and the certification of fish and fish products have seen a tremendous increase over the last decade³. Consumers are demanding fish that are sustainably produced in both fisheries and aquaculture. However, culture-based fisheries are usually not well addressed in ecolabelling and

² De Silva, S. & Soto, D. 2009. Climate change and aquaculture: potential impacts, adaptation and mitigation. In K. Cochrane, C. De Young, D. Soto & T. Bahri, eds. Climate change implications for fisheries and aquaculture: overview of current scientific knowledge, pp. 151–212. FAO Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO. 212 pp. Available at www.fao.org/docrep/012/i0994e/i0994e00.htm

³ Sainsbury, K. Review of ecolabelling schemes for fish and fishery products from capture fisheries. FAO Fisheries and Aquaculture Technical Paper. No. 533. Rome, FAO. 2010. 93p.

certification schemes. Although the FAO guidelines on the ecolabelling of inland fisheries and fish products specifically addressed culture-based fisheries⁴, the FAO ecolabelling guidelines on marine fisheries⁵ and many private standards do not provide relevant guidance or standards for culture-based fisheries. One of the constraints faced by the marine sector in establishing guidelines on culture-based fisheries was that the international guidelines on aquaculture certification had not yet been established. However, this is no longer the case since the adoption of the guidelines on aquaculture certification⁶ in 2011. As culture-based fisheries gain importance and become more common there will be a greater need to ensure that they are socially and environmentally responsible and that consumers and markets have accurate information on their sustainability.

Increasing demand for freshwater

20. Competition for freshwater is predicted to increase dramatically in the next decades; culture based fisheries will need to have access to adequate supplies of freshwater and functioning ecosystems in order to be productive, especially in inland waters, but also in many coastal areas. Currently agriculture uses approximately 70% of the world's surface waters and this percentage is expected to increase⁷. Hydro-power and municipal and industrial water uses are also expected to increase. Due to the fact that the other users of freshwater are perceived to be more important, the fisheries sector is often neglected or marginalized in water-management fora. Thus, development and management decisions which are taken adversely impact the fishery and aquaculture sector, e.g. draining wetlands, diverting water for irrigation and damming rivers.

21. Culture-based fisheries is a mean to add value to aquatic ecosystems. The value of the ecosystem services provided by inland waters needs to be promoted more widely and included in the development and management of fresh waters. Numerous international initiatives and river basin authorities deal with water management, but many ignore the fishery sector.⁸ Cross-sectoral and multi-disciplinary approaches to water management will be required and the Sub-Committee can help ensure that the fishery sector has a strong voice in future discussions.

Conclusion

22. With predictions of increased human pressure and the demand for food and recreation, many water bodies will need to be managed more intensively in order to provide adequate fish and fish products⁹; the use of hatchery fish to support culture-based fisheries is one form of this more intensive management of water bodies. The technology exists to produce large numbers of fish in hatcheries; marking technology is also improving to facilitate the quantification of hatcheries' contribution to a fishery. However, to date information on the contribution culture-based fisheries make to global fish production remains inadequate.

23. Whereas technical problems of raising and stocking large quantities of fish are being solved, some of the policy and political issues still need to be addressed: a common terminology and

⁴ Guidelines for the Ecolabelling of Fish and Fishery Products from Inland Capture Fisheries. Directives pour l'étiquetage écologique du poisson et des produits des pêches de capture continentales. Directrices para el ecoetiquetado de pescado y productos pesqueros de la pesca de captura continental. Rome/Roma, FAO. 2011. 106 pp

⁵ Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries. Revision 1. Directives pour l'étiquetage écologique du poisson et des produits des pêches de capture marines. Révision 1. Directrices para el ecoetiquetado de pescado y productos pesqueros de la pesca de captura marina. Revisión 1. Rome/Roma, FAO. 2009. 97p.

⁶ Technical guidelines on aquaculture certification. Directives techniques relatives à la certification en aquaculture. Directrices técnicas para la certificación en la acuicultura. Rome/Roma, FAO. 2011. 122 pp.

⁷ Comprehensive Assessment of Water Management in Agriculture. 2007. London, Earthscan and Colombo. International Water Management Institute.

⁸ State of World Fisheries and Aquaculture 2006. FAO, Rome.

⁹ Brummett, R.E. , Beveridge, M.C.M., Cowx, I.G. (in press). Functional aquatic ecosystems, inland fisheries and the Millennium Development Goals. Fish and Fisheries xx:xx-xx.

understanding of the concepts needs to be promoted; standard and consistent reporting needs to be adopted; securing fair and equitable access to fishery resources needs to be assured; and regional and transboundary management of culture-based fisheries in international, shared and transboundary water bodies need to be put in place. There may be a need in the future to modify the data format of fishery and aquaculture statistics to include a third category on production from culture-based fisheries.

24. A decade after the analysis presented in Annex 1 there are still issues that have not been adequately addressed as well as new opportunities that should be addressed. It may be time for an in-depth analysis of the role that culture-based fisheries can play given the new opportunities and challenges. The Sub-Committee on Aquaculture along with the Committee on Fisheries and the Sub-Committee on Fish Trade, as the only inter-governmental fora dedicated to responsible fisheries and aquaculture, could be instrumental in providing guidance on these and other relevant matters.

Annex 1: Towards responsible practices in culture-based fisheries

COMMITTEE ON FISHERIES
SUB-COMMITTEE ON AQUACULTURE
Second Session
Trondheim, Norway, 7-11 August 2003
TOWARDS RESPONSIBLE PRACTICES IN CULTURE-BASED FISHERIES

SUMMARY

Culture-based fisheries are examined in the light of stocking programmes. Stocking, the release into the environment of juvenile aquatic species that have been raised in aquaculture facilities, is considered one means to increase production and value from aquatic ecosystems. Furthermore, stocking has been used in efforts to re-establish populations of threatened and endangered species. Although the technology necessary to produce and release large numbers of juveniles is straightforward for many aquatic species, concerns have been raised regarding cost-effectiveness and social and ecological impacts of stocking programmes. The decision to undertake stocking programmes needs to be based on the status of the resource and the environment, potential impacts on biodiversity, potential impacts on local communities that may lose access to habitats and resources once aquaculture and stocking programmes have been initiated, and an assessment of possible alternatives to stocking. These are complicated and inter-related considerations that will need to be addressed responsibly and with regard for national objectives.

INTRODUCTION

1. The FAO Code of Conduct on Responsible Fisheries (CCRF) and the Technical Guidelines recognized the intimate link between aquaculture and culture-based fisheries and how both can significantly contribute to improved production and benefits from aquatic systems. Other development groups have also placed high expectations on the use of aquaculture and other fishery enhancements that constitute “culture based fisheries, as a means to increase or restore capture fisheries”. However, rehabilitating fisheries through technical interventions is controversial in regards to cost-effectiveness, efficacy, and environmental and social impacts.
2. Although the Technical Guidelines provide a working definition of culture-based fisheries that is extremely broad that included habitat modification, species eradication or introduction, and environmental engineering, this document restricts the topic to stocking of hatchery-raised fish into natural or modified ecosystems. The practice represents a concrete link between fishing and farming aquatic resources; responsible practices of both must be adopted in synchrony. Therefore several broad classes of issues must be addressed in order to evaluate correctly development strategies and decisions.
3. The decision to develop culture-based fisheries will be based on numerous factors discussed below. However, a primary responsibility of fishery managers is to establish clear objectives for

development. Management objectives may be to rebuild a fishery, to enhance a fishery above normal production levels, to improve the profitability of a fishery, to create new fisheries, to provide employment or recreation, or to re-establish or augment endangered species. These different objectives will require different strategies and resource management plans, and will impact on society and the environment in different ways.

DEFINITIONS AND CONCEPTS

4. This document focuses on the stocking aspects of culture-based fisheries. “Stocking” is a general term signifying several different, but related, intentional enhancement activities. Stocking may involve:

- a) release of hatchery-raised fish into natural or modified ecosystems where the fish are not expected to breed or produce self-sustaining populations;
- b) release of hatchery-raised fish into natural or modified ecosystems where fish are meant to breed amongst themselves;
- c) release of hatchery-raised fish into natural or modified ecosystems where fish are meant to breed amongst themselves and with con-specifics in nature;
- d) release of wild-caught fish from another area into natural or modified ecosystems, usually to establish self-sustaining populations.

5. The rationale for these types of stocking programmes is important to understand and may be for:

- a) Mitigation, where the stocking programme makes up for some disturbance, usually habitat destruction, to the environment. This is usually a release of hatchery-reared fish that mitigates for loss of spawning and early rearing habitat, as in the case of many Pacific salmon hatcheries in North America.
- b) Augmentation, where stocking is meant to increase the production of a system from what is expected under normal conditions, e.g., Japanese stocking of chum salmon, oysters and red seabream.
- c) Community change, where species are stocked into an area where they do not normally occur in order to increase the value of the fishery, Pacific salmon stocking into the Great Lakes of North America, and numerous stocking programmes of rainbow trout in New Zealand for recreational fishery development.

6. Although similar, these stocking types involve different assumptions and species (Table 1).

Table 1. The three major types of stocking activities

Type	Species stocked	Key assumptions
Mitigation	Native or close relative	Altered or alternate habitat acceptable and below carrying capacity; fishery is recruit limited
Augmentation	Native	Fishery is recruit limited, habitat is below carrying capacity, stocked and wild species compatible
Community change	Exotic	Species' performance in new environment similar to that in native environment, habitat below carrying capacity; resource base will not change substantially

ISSUES

7. Although the culture-technology necessary to produce and release large numbers of juveniles is straightforward for many aquatic species, concerns have been raised regarding cost-effectiveness and social and ecological impacts of stocking programmes.

Technical issues

8. Improvements in breeding and larval rearing have made the production of large numbers of juvenile fish straightforward for a large number of aquatic species. The FAO database on aquaculture production contains information on over 300 species of fish, crustaceans and molluscs, the majority of which are bred in captivity. However, other technical aspects such as genetic resource management and assessment of the contribution of stocked material to the fishery are more complicated.

9. Stocking programmes require the production of fish in an artificial environment, i.e. culture facility, for release into natural or semi-natural environment. This will require genetic resource management because the genes that allow a fish to grow well in a hatchery may be different from those that allow the fish to survive and grow in nature. Hatcheries may inadvertently provide selection pressure for genes that are not well adapted for nature. For example, by providing artificial food or protection from predators, hatchery fish may not recognize food or dangers once released from the confines of the hatchery.

10. Monitoring stocked material is a vital component of culture-based fisheries, but it is often omitted from management plans. This is in part due to the difficulty of marking large numbers of small individuals. However, technology for using physical tags is increasing and the use of genetic markers that do not require handling of young fish is becoming more common and inexpensive.

Ecological issues

11. Culture-based fisheries, and stocking in particular, are designed to have ecological impacts. Depending on the status of the resource (fishery) and the objectives of the stocking programme, the intended impacts may range from rehabilitation of a natural resource to the creation of a new fishery. Within this range there may be adverse impacts associated with:

- a) Predator/prey interactions – stocked material may consume local species or resources as in the case of Nile perch in Lake Victoria.
- b) Competition interactions – stocked material may compete for food, space, or breeding sites with closely related native species as in the case of introduced Pacific oysters crowding out local rock oysters in Australia.
- c) Habitat modification – stocked material may change a habitat as in the case of grass carp consuming large quantities of aquatic macrophytes in many areas.
- d) Disease transmission – stocked material may introduce pathogens as in the case of the crayfish plague brought from North America to Europe.
- e) Genetic pollution - stocked fishes may breed with local con-specifics or close relatives thus changing the genetic structure of local populations and possibly breaking down co-adapted gene complexes as in the case of tilapia in Africa and some salmon stocking programmes in Europe and North America.

12. Predicting the ecological impacts of stocking programmes is difficult, especially in the light of the facts that fishing pressure, land use, and water availability may change along with changes in the ecological community as a result of stocking. With many enhancement programmes, monitoring and evaluation were not performed so there is very scant information on which to base predictions. Furthermore, the impacts of stocking with the objective of establishing self-sustaining populations may

take many years to emerge. It was approximately 20 years after initial stocking of Nile perch into Lake Victoria before significant impacts on the fishery were seen.

13. The use of alien species¹ presents a special case where ecological interactions are extremely difficult to predict accurately. Often the new species will behave differently in its new environment, e.g. change prey preferences, growth characters, or activity patterns. Additionally, the new species may also bring along pathogens. Sometimes these pathogens are not problematic in the species home range, but may be devastating in the new environment. An abalone introduced from South Africa into aquaculture establishments in California also contained a sabellid worm that was not considered a pest in South Africa. The worm caused significant loss of production and the closure of the oldest abalone farm in California.

Social and economic issues

14. Culture-based fisheries may impact upon local society by providing new activities, e.g. fishing, processing, trading, etc. and increasing income. It is possible that new activities may be undertaken by women and children, income may also accrue to these groups as well. However, the benefits of increased fishery production may not always go to the sector of society that is most needy or that may have had traditional rights to the original waterbody. The stocking of high value carp species into ox-bow lakes in Bangladesh increased the value of the fishery, but then resulted in restriction of access to the waterbody by local fishers. The natives in the highlands of Papua New Guinea do not know how to process properly the Java barb stocked from Thailand and thus have associated health problems with this fish simply because of spoilage from improper processing. Clearly, the transfer of the barb should have also included the transfer of processing technology.

15. Stocking programmes may involve carnivorous species that may need inputs of fish protein sources during the culture-phase. In certain areas, use of this fish protein for aquaculture may deprive humans of a source of protein. It is often stated that “trash fish” may be fed to farmed fish, but in many rural areas and small communities there are no “trash fish”, all fish are important sources of protein for humans. Thus, it will be essential to ensure that required inputs for the aquaculture phase of stocking programmes are available and that the development of culture-based fisheries does not deprive fishing communities of resources.

16. Recreational fisheries may also be culture-based fisheries strongly dependent on stocking specific species of interest to anglers and tourists. Recreational fisheries have the potential to generate substantial income, and have done so in many developed areas. The European Inland Fisheries Advisory Commission² estimated that recreational fisheries in Germany and France are valued at US\$ 1 000 and US\$ 800 million, respectively, with millions of fishers in each country. There is increased interest in such development in inland and marine areas of developing countries. The actual value of the catch may be an order of magnitude lower than the above figures, which include license fees, bait, tackle, and tourism infrastructure. The Government of Norway has recently agreed to support a project on the development of culture-based fisheries in the Republic of Bosnia and Herzegovina to assist war invalids find employment.

Conservation issues

17. Hatcheries and stocking programmes have been developed to help in species recovery programmes. The genetic resource management programme of such “conservation hatcheries” is vital and must strive to re-create or preserve the natural genetic diversity of the species or stock under

¹ Alien species is the term adopted by the Convention on Biological Diversity and is also known as introduced species or exotic species.

² P. Hickley and H. Tompkins. 1998. Recreational Fisheries: social, economic and management aspects. FAO and Fishing News Books.

consideration. Although the Technical Guidelines on the Precautionary Approach to Fisheries Management and Species Introductions state that hatcheries should not be used for fishery enhancements, conservation hatcheries were specifically noted in the CCRF under 9.3.5. The ship sturgeon is threatened in the southern Caspian Sea and the Islamic Republic of Iran is actively maintaining broodstock and stocking programmes to ensure its continued survival. Endangered species of freshwater fish are maintained in the Dexter National Fish Hatchery in the USA until habitat is suitable for their reintroduction. Sub-populations of Chinook salmon listed under the USA Endangered Species Act are being raised in conservation hatcheries in California under a strict broodstock and genetic management programme.

18. Hatcheries alone are insufficient to conserve species and must be integrated into a programme of habitat rehabilitation and protection, and natural resource management. The Convention on Biological Diversity recommends *in situ* conservation as the preferred strategy and it should be noted that proper fishery management can be considered as *in situ* conservation.

Status of resource and environment

19. For all culture-based fisheries, accurate assessments of the environment, the status of the resource to be stocked, the native resources and the human resources involved in the fishery are essential. In areas of good fishery production and healthy native populations, attempts to increase production through stocking or other enhancements have generally not been successful. A key concern in evaluating effectiveness of stocking programmes is whether stocking increases production or merely displaces native individuals with hatchery individuals.

20. Stocking of coho salmon in California coastal rivers was successful because native populations had been reduced due to over-fishing and loss of spawning habitat. However, stocked coho in many inland lakes did not lead to self sustaining populations because of a lack of forage fish and suitable spawning habitat; Pacific salmon fisheries in the Great Lakes of North America are sustained by continuous input of fingerlings. Endangered species should not be re-stocked until the factors “endangering” them, e.g. pollution, over fishing, habitat loss, etc. have been rectified.

21. In some cases, appropriate fish may be stocked into modified or degraded environments where native fish are no longer viable and there are no plans for habitat improvement. Tilapia stocked into reservoirs in Cuba and municipal lakes in Venezuela provide fishery resources in areas where native fish will not thrive. However, stocking of such fish should not be used as an excuse to degrade habitats or forgo habitat rehabilitation where this is desirable.

22. There are significant differences between stocking marine and inland waters relating to the size and character of the waterbody that should be addressed. Inland stocking programmes may involve much smaller water bodies than marine and coastal stocking. These inland waterbodies, e.g. small reservoirs, irrigation canals, and floodplains, may be subject to extreme fluctuations in water volume and temperature. Marine stocking must consider in more detail seasonality of water temperature and current patterns. It will be necessary to choose species for these conditions with the correct life-history characters, and to stock appropriate sized individuals at appropriate times of the year.

Reporting and data issues

23. In the light of the fact that culture-based fisheries link capture fishing with aquaculture, the reporting of production from this sector is complicated and inconsistent. Are fish that are produced in a hatchery considered aquaculture, or since they are captured in nature do they represent capture fisheries? In the FAO data questionnaire, Members are asked to report on larval fish production by species and numbers of larvae produced. Further, Members are asked to report on numbers of these larvae stocked into contained environments, which would signify aquaculture, and numbers stocked into open environments, which would signify stocking to the wild. Thus, at the level of production of early life-

history stages, FAO collects some information on culture-based fisheries. However, this data-set is very incomplete and only sporadically reported by Members. Additionally, simple production of larvae from a hatchery is an extremely poor indicator of actual production from a culture-based fishery. Correlations between numbers of stocked fish and fishery production have provided evidence that the stocking of sturgeons in the Caspian Sea is contributing significantly to sturgeon fisheries. However, simple correlations do not always indicate causation and other factors such as climate change may also contribute to changes in fish abundance.

24. Once a species has been stocked into an area where it also occurs naturally, it will be difficult to determine what proportion of the catch is from stocked or native material. In sub-sequent generations, if the purpose of the stocked material is to breed with natives, contribution from hatchery fish or progeny of hatchery fish will be even more difficult without sophisticated molecular genetic tags. This demonstrates the need for accurate assessment of the status of the resources through monitoring the success and potential breeding of hatchery fish introduced into natural waters.

DECISION PROCESS

25. The issues above will need to be considered in order to evaluate risks and benefits from developing culture-based fisheries, i.e. stocking programmes. Furthermore, it will be important to identify which sectors of society suffer the risks and which accrue the benefits.

26. One means to facilitate decision-making in regard to introduced species is by the application of the International Council for the Exploration of the Sea (Ices) Codes of Practice on Introductions and Transfers of Marine Organisms³ (Box 1). These codes have been adopted by the European Inland Fisheries Advisory Commission and in principle by other regional fishery bodies. At the eighth Session of CIFA these codes of practice were judged to be useful as a set of guidelines to member countries as how to proceed with their own practices and regulations for introductions of fish species⁴. These codes provide a logical framework for deciding on whether to introduce an alien species. The framework (Box 1) could be made more general and expanded to cover stocking programmes as well.

27. The development of culture-based fisheries, i.e. stocking programmes, must be evaluated against other enhancement and management plans. The establishment of clear objectives is essential in this comparative evaluation of different enhancement strategies. Other strategies for improving production and employment from aquatic systems include:

- a) Aquaculture – traditional farming of aquatic species in ponds, tanks or raceways. Involves controlled breeding leading to increased domestication of the fishery resource. Aquaculture often also involves significant inputs and may not be appropriate for poor or marginalized areas.
- b) Habitat modification – may involve enclosing small water bodies, creating new waterbodies, e.g. reservoirs or ditches in rice fields, creating fish passage systems around dams, adding artificial substrates, e.g. artificial reefs or acadjas, fertilization.
- c) Habitat rehabilitation – pollution and siltation control, re-establishing hydrological regimes, e.g. re-connecting rivers to floodplains and dam deconstruction, re-establishing riparian forest communities, and re-establishing forage fauna and flora.
- d) Fishery management – may involve managing the resource and the people by limiting access, involving local community in management plans and enforcement, establishing season and gear restrictions.

³ International Council for the Exploration of the Sea. 1995. ICES Code of Practice on the Introductions and Transfers of Marine Organisms - 1994. ICES Co-operative Research Report No. 204.

⁴ Res. 8th Session CIFA, 21 – 25 October 1990, Cairo, Egypt, para 45.

28. In terms of providing additional employment opportunities for fishing/farming communities, the cost of stocking programmes should be compared to other training and welfare programmes that may need to be instituted in the case of a diminishing fishery. Newfoundland fishermen that were put out of work by the collapse of the cod fishery in the 1990s were provided with welfare funds in the order of CAN \$225- CAN \$460 at a cost in excess of CAN \$ 2 billion over a four-year period.

29. Culture-based fisheries are not a substitute for fishery management; they may require even more management in the form of hatchery and broodstock management, restricting access to stocked water bodies, and preventing fishing during stocking periods and periods where stocked fish are trying to establish populations. Stocking programmes need to be integrated within an overall fishery management plan that is based on community and national objectives.

FAO ACTIVITIES IN SUPPORT OF RESPONSIBLE STOCKING

30. FAO, in collaboration with partners that included the WorldFish Center (WFC - formerly ICLARM), national resource managers from Japan, Norway, the USA, and professional fishery societies such as the World Aquaculture Society, the American Fisheries Society, the International Council for the Exploration of the Sea, helped establish a responsible approach to stocking programmes⁵. The European Inland Fisheries Advisory Commission has produced technical papers on stocking of specific species. The Governments of Japan and Norway have been especially active in providing international fora for elaboration and dissemination of state of the art information on marine stocking programmes⁶. In inland areas, FAO collaborated with the Department for International Development to summarize information on enhancements of freshwater systems⁷. Much of this work addressed technical issues of fish production, survival of stocked fish in nature, genetics, fish health, and traditional economic analysis. Social aspects, benefit distribution, access to resources in the light of changes in fisheries, and analysis of the informal economy of stocking in rural areas have not been as well studied.

31. As human populations continue to grow, especially in developing countries and Low-Income Food Deficit Countries (LIFDC), pressure will continue to be placed on aquatic ecosystems, not only for fishery products, but for freshwater for drinking, irrigation, hydro-electric development, navigation, etc. Aquatic habitats are being modified to address these pressures by construction of dams and reservoirs, water diversions, and clearing of waterways. Natural populations of native fish may not be able to withstand many of these pressures, and carefully considered culture-based fisheries may provide the means to continue fishery production. In many areas development and environmental improvements are proceeding together and populations of native fish are being rehabilitated or conserved.

32. Guidelines that address the above concerns are required so that Members can decide amongst development options, and, in the case that culture-based fisheries is warranted, can know how best to go about developing the fishery. Technical Guidelines for Responsible Fisheries Number 5, Aquaculture Development, noted that technical guidelines for responsible culture-based fisheries were under preparation. It is time now to produce these guidelines addressing both inland, coastal and marine areas.

⁵ Blankenship, L.B. and K.M. Leber. 1995. A responsible approach to marine stock enhancement. American Fisheries Society Symposium 15: 167-175.

⁶ Sustainable Contribution of Fisheries to Food Security, Kyoto 1995 (Bartley, D.M. Thematic paper 5 – Marine Ranching); Global Symposium on Marine Ranching, Ishikawa Prefecture 1997 (FAO Fishery Circular 943); Stock Enhancement and Sea Ranching, 1999. B. Howell, E. Moksness, T. Svasand, editors, Fishing News Books. Second International Symposium on Marine Stock Enhancement and Sea Ranching, Kobe 2002.

⁷ Petr, T. (ed) 1998. Inland Fishery Enhancements. FAO Fish. Tech. Paper 374.

SUGGESTED ACTION BY THE SUB-COMMITTEE

33. The Sub-Committee is invited to review the issues and suggestions highlighted in the paper and to provide guidance to members and FAO, as well as other agencies and international organizations, on how to develop responsible culture-based fisheries. In particular, the Committee may wish to emphasize:

- a) How to improve reporting of production of hatchery raised fish.
- b) How to determine contribution of hatchery-raised fish to a mixed fishery.
- c) Establishment of “Best Practices” and Technical Guidelines on Responsible Culture Based Fisheries and Stocking Programmes.
- d) Desirability of collection of illustrative case studies on stocking programmes in the marine, coastal and inland environments.
- e) Identification of inter-sessional activities and partners in support of developing responsible culture-based fisheries, e.g. production of technical guidelines and best practices, collection and dissemination of case studies, consultations on means to improve data collection and reporting for culture-based fisheries.

Box 1. THE ICES CODES OF PRACTICE ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS	
Basic elements of the codes	Description
PROPOSAL	the entity moving an exotic species develop a proposal, that would include location of facility, planned use, passport information on the exotic species, and source of the exotic species;
REVIEW	an independent review would be conducted that evaluates the proposal, the impacts and risk/benefits of the proposed introduction, e.g. pathogens, ecological requirements/interactions, genetic concerns, socio-economic concerns, and local species most affected;
ADVICE	advice and comments are communicated among the proposers, evaluators and decision-makers, and the independent review panel advises to either accept, refine, or reject the proposal so that all parties understand the basis for any decision or action, thus proposals can be refined and review panel can request additional information on which to make their recommendation;
QUARANTINE, CONTAINMENT, MONITORING & REPORTING	if approval to introduce a species is granted, quarantine, containment, monitoring, and reporting programmes are implemented.

Annex 2: Suggested revisions to the FAO Glossary on Aquaculture and Fisheries

The FAO Glossaries of Aquaculture and Fisheries⁸ provide an authoritative source of information on key terms used in fisheries and aquaculture. In order to maintain the quality of the information provided in the glossaries, FAO reviewed the terms pertaining to culture-based fisheries. The review revealed that:

- the definition of some terms should be revised;
- one term should be added to the glossaries; and
- one term should be deleted from the glossaries.

This annex provides recommendations for improving the accuracy of the terms associated with culture-based fisheries and stocking.

I. Terms in the glossaries to be revised

The following definitions are taken from the FAO Glossaries of Aquaculture and Fisheries with a critique and suggested modifications included.

- **Culture based fishery:** Activities aimed at supplementing or sustaining the recruitment of one or more aquatic species and raising the total production or the production of selected elements of a fishery beyond a level, which is sustainable through natural processes. In this sense culture-based fisheries include enhancement measures, which may take the form of: introduction of new species; stocking natural and artificial waterbodies, including with material originating from aquaculture installations; fertilization; environmental engineering including habitat improvements and modification of waterbodies; altering species composition including elimination of undesirable species or constituting an artificial fauna of selected species; genetic modification of introduced species.
 - **critique and modified definition:** the FAO definition is not a description of a fishery but a general description of stock enhancement activities that includes activities that are clearly not ‘culture-based’ such as habitat improvement. **Suggested alternative:** *A fishery in which the use of aquaculture facilities is involved in the production of at least part of the life-cycle of a conventionally fished resource; aquaculture is usually the initial hatchery phase that produces larvae or juveniles for release into natural or modified habitats.*
- **Stocking:** The practice of putting artificially reared young fish into a sea, lake or river. These are subsequently caught, preferably at a larger size.
 - **critique and modified definition:** The FAO definition only refers to ‘artificially reared’ fish and needs to include transfers and species introductions that could originate from natural water bodies. The definition also omits stocking for conservation where the species would not be ‘caught’. **Suggested modification:** *The practice of placing aquatic organisms into natural or modified water bodies. Stocked material may originate from aquaculture facilities or translocations from the wild.*
- **Restocking:** The release of cultured or wild caught aquatic species (usually juveniles) into the wild to restore the spawning biomass of severely overfished stocks to levels at which they can once again provide sustainable yields.

⁸ <http://www.fao.org/fishery/glossary/en>

- **critique and modified definition:** - The definition neglects restocking for conservation. **Suggested addition:** *This may also involve reestablishing a commercial species where it is locally extinct due to overfishing, or release of juveniles reared in conservation hatcheries” to help restore endangered or threatened species⁹.*

- **Stock enhancement:** Process by which the numbers of wild stocks of a particular species in a particular body of water are boosted by releasing large numbers of hatchery raised organisms.
 - **critique and modified definition:** The above refers only to one aspect of stock enhancement – the use of cultured species, and not to the variety of other techniques that have been previously listed incorrectly under the term **Culture-based fisheries**. The original definition of Culture-based fisheries made reference to natural process, but any enhancements would also rely on natural processes to assist in increased production and therefore the phrase ‘existing natural processes’ i.e. before any enhancement, would need to be included. The original definition of stock enhancement refers to numbers of wild stocks, but not to individuals within stocks, which is the more conventional use of the term. **Suggested replacement with a modified definition of Culture-based fisheries:** *Activities aimed at supplementing or sustaining the recruitment of one or more aquatic species and raising the total production or the production of selected elements of a fishery beyond a level, which is sustainable through existing natural processes (see Enhanced Fishery). In this sense stock enhancement includes enhancement measures, which may take the form of: introduction of new species; stocking natural and artificial water bodies, including with material originating from aquaculture installations; fertilization; environmental engineering including habitat improvements and modification of water bodies; altering species composition including elimination of undesirable species or constituting an artificial fauna of selected species; genetic modification and introduction of non-native species or genotypes.*

- **Sea ranching (or Ranching):** Commercial raising of animals, mainly for human consumption, under extensive production systems, within controlled boundaries and paddocks (e.g. in agriculture), or in open space (oceans, lakes) where they grow using natural food supplies. In fisheries: stocking usually of juvenile finfish, crustaceans or mollusks from culture facilities for growth to market size or to maturity in the natural environment. Species usually used are migratory and return close to the point of release (e.g. salmon) or non-migratory and remain for at least a substantial portion of the life-cycle in restricted areas where they enter the local fishery (e.g. red sea bream, *Penaeus japonicus*, etc.).
 - **critique and modified definition:** Ranching is often done by the public sector and therefore ‘commercial’ is too limiting, and the reference to controlled boundaries and agriculture and paddocks is unclear and inappropriate. **Suggested modification:** *The release of cultured juveniles into unenclosed marine and estuarine environments (sea ranching) or inland waters (ranching) where they grow using natural food supplies for harvest at a larger size in “put, grow, and take” operations. Note that the released animals are not expected to contribute to spawning biomass, although this can occur when the size at harvest exceeds the size at first maturity, or when not all the released animals are harvested. Release is usually of juvenile finfish, crustaceans or molluscs from culture facilities for growth until harvest (which may also be by recreational fishers) in the natural environment. Species usually used are migratory and return close to the point of release (e.g. salmon) or non-migratory and remain for at least a substantial portion of the life-cycle in restricted areas where they enter the local fishery (e.g. mollusks, red sea bream and Penaeus japonicus).*

⁹ Bell, J.D. et al., 2008. A New Era for Restocking, Stock Enhancement and Sea Ranching of Coastal Fisheries Resources. *Reviews in Fisheries Science*, 16(1–3):1–9.

II. Term to be added to the glossaries

The following term is in common usage, but is not currently described in the glossaries.

Enhanced fishery – FAO¹⁰: - To be added to FAO Glossary *Fisheries that are supported by activities aimed at supplementing or sustaining the recruitment of one or more aquatic species and raising the total production or the production of selected elements of a fishery beyond a level, which is sustainable through existing natural processes (see stock enhancement).*

III. Term to be deleted from the glossaries

The following term should be deleted from the glossaries.

- **Culture enhanced fishery - FAO Glossary:** Fishery in which the use of aquaculture is involved in at least part of the life-cycle of a conventionally fished resource, usually the initial hatchery phase.
 - **critique and justification for deletion:** this is a description of a culture-based fishery and is incorporated in the definition of culture-based fishery. A search of this term in Scopus returned 0 results indicating it is not being used in the scientific literature on the subject.

¹⁰ FAO, 2011. Guidelines on Ecolabelling of fish and fish products from inland capture fisheries. FAO, Rome. 106p.