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COMMITTEE ON FISHERIES

SUB-COMMITTEE ON AQUACULTURE

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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 species[1] 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 bard 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.

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

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 Commission[2] 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 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 ships 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.

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

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 Organisms[3] (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 species[4]. 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

[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.

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.

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 programmes[5]. 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 programmes[6]. In inland areas, FAO collaborated with the Department for International Development to summarize information on enhancements of freshwater systems[7]. 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.

[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.

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.

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.