9 CONSERVATION OF WILD FISH GENETIC RESOURCES AND AQUACULTURE[105]

9.1 Introduction

In unanimously adopting the Code, States recognized that conservation is a necessary element of responsible use. This chapter addresses the responsible use of wild fish genetic resources (FiGR) for aquaculture, emphasizing their conservation**.** Wild FiGR are a very valuable subset of all of the FiGR that are available for current and future use in aquaculture and related research. Wild FiGR are free-living FiGR in nature and minimally changed by human activities, though it is becoming difficult to find any completely unchanged wild populations (see section 9.2). Wild is therefore a relative term, meaning as wild as possible in changing circumstances.

Like all FiGR for aquaculture, wild FiGR comprise DNA, genes, gametes, individual organisms and populations (Chapter 1). Although not mentioning wild FiGR explicitly, the Code includes them implicitly in all of its references to biodiversity, cultured stocks, living aquatic resources, genetic diversity, wild stocks, cultured stocks and genetically altered stocks and, thereby, calls for their management (i.e., conservation and sustainable use) and for care for their habitats. The purpose of this chapter is to provide guidance to aquaculture policy- and decision makers so that they can promote responsible aquaculture, protect valuable wild FiGR and, where necessary, contribute to their recovery.

9.2 Wild fish genetic resources

Wildness in fish is a special quality, widely recognized by naturalists and conservationists, as well as by commercial and sport fishers and fish consumers. However, true aquatic wilderness is shrinking and the wildness of free-living fish populations is easily compromised. Capture fisheries, loss of habitat and degradation of the aquatic environment reduce the genetic diversities of aquatic populations and other biodiversity. Aquatic protected areas become less natural the more intensively they are managed and the more they are influenced by non-protected areas around them.

Many self-sustaining fish populations in nature have been derived from purposeful stocking, from fish escaped from aquaculture and from fish discarded from aquaria. Such populations include alien and native species.

[105] Contributed by Roger S.V. Pullin.

Those descended from fish that were wild types or genetically close to wild types still represent wild FiGR. Those descended from fish that were at various stages of domestication, including distinct strains, hybrids and other genetically altered forms, are feral fish; analogous to the feral livestock that are descended from by animals that escaped from farms and ranches. Feral forms are naturally selected back from domestication to fitness in the wild. Feral fish represent valuable FiGR for capture fisheries and for aquaculture and related research. They are not wild FiGR *per se* but should be included with wild FiGR for management purposes.

The following types of fish all contribute to the diversity of wild FiGR: wild type native species; free-living alien species, descended from introductions and releases of wild fish; and free-living populations of species that extended their former natural ranges when barriers were removed, e.g. introductions into the Mediterranean via the Suez Canal. Many of the world's wild fish populations are distinguishable from their farmed relatives by their location, appearance, behavior and, above all, by biochemical genetic characterization. Although some farmed fish populations are wild types because they were collected as wild seed - for example, mollusc spat - most are genetically different from their free-living relatives in wild populations, with markedly different frequencies for many alleles.[106] Even where no purposeful selection or other genetic alteration is applied, successive generations of captive reproduction yield fish that differ increasingly from wild types (Chapters 3 and 4).

In the broadest sense, wild FiGR for aquaculture comprise not only those of farmed fish species but also those of other species in all of the ecosystems that support aquaculture production; for example, wild fish populations that are harvested for making aquaculture feeds and the plankton and microorganisms on fish farms that provide feeds, oxygen and waste processing. Therefore, the genetic resources of these organisms, upon which aquaculture production depends, must also be documented and conserved through appropriate measures applied to capture fisheries and to the health of the ecosystems in which aquaculture is practiced.

9.3 Importance for aquaculture

Domestication and genetic improvement of most farmed fish are far behind those for cultivated plants and livestock. Captive reproduction and breeding

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[106] Elliot, N. and Evans, B. 2007. Genetic change in farm stocks: should there be concern? World Aquaculture, 36 (1): 6-8.

programmes have been established for many species of farmed fish but not for all. Therefore, some fish are still farmed as wild types or as undomesticated populations that are close to wild types. Seaweed farming also relies heavily on the propagation of wild types. If domestication of fish is defined as continuous controlled reproduction for more than 3 generations, only 30 species of farmed fish, out of 103 for which 2004 production exceeded 1 000 mt, can be termed domesticated[107] (Chapter 3). Capture-based aquaculture (CBA),[108] aqualture-based fisheries (CBF – Chapter 8) that involve wild-collected fish seed or hatchery seed from wild-collected broodstock, and capture fisheries that provide feeds and feed ingredients for aquaculture all harvest wild fish. As new technologies for captive reproduction become available, the farming of wild and undomesticated fish will diminish but wild FiGR will remain important for aquaculture, for use in fish breeding programmes and related research**.** This is analogous to the continuing importance of the wild relatives of cultivated plants as sources of genetic diversity to be tapped by plant breeders, despite huge progress in plant genomics. The same will apply to farmed fish, even as fish genomics advance and modern genetic technologies are increasingly used in aquaculture. Aquaculture will face inevitable challenges from, for example, new and more virulent diseases, climate change and the need to cut production costs and raise productivity by improvement in a wide range of performance traits. Most of the FiGR that can contribute to meeting these challenges are wild FiGR. They are extremely valuable public goods that are vulnerable and, in may cases, vanishing. Therefore, it is important first to recognize that wild FiGR are vital for the future sustainability and profitability of aquaculture and, second, to invest adequately in their characterization and conservation, so as to ensure their continued availability.

9.4 Approaches to management

9.4.1 Categorization and prioritization

Wild fish populations can become genetically differentiated when there is a reduction in the exchange of genes (gene flow) among them and when there are different selective pressures from the environment (Chapter 3). They are found as small populations with high rates of gene flow; partially

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107 Bilio, M. Controlled reproduction and domestication in aquaculture. The current state of the art. Part II. Aquaculture Europe, 32 (3): 5-23.

108 Ottolenghi, F.; Silvestri, C.; Giordano, P.; Lovatelli, A. and New, M. 2004. Capture-based aquaculture. The fattening of eels, groupers, tunas and yellowtails. Food and Agriculture Organization of the United Nations, Rome, Italy. 308p.

isolated subpopulations sometimes having local adaptations; more isolated local populations often having local adaptations; isolated, distinct closed populations; and metapopulations connected through migrations. For any species used in aquaculture, the overall goal should be to maximize the continued availability of as much wild genetic diversity as possible.

The genetic diversity of a species is usually represented by variations across its geographical range, with the more isolated and undisturbed populations often being the most distinct. The key is to gather sufficient genetic data to characterize as much as possible of the genetic diversity of the species, and in so doing to identify the wild populations that represent the most significant contributions to that diversity. In the conservation literature, these may be called conservation units or evolutionarily significant units. They represent important components of the total genetic diversity within a species. Moreover, some local fish populations, though superficially similar to others, are distinct, cryptic species and as such have unique and valuable genes.[109]

Prioritizing among a wide diversity of wild FiGR for conservation and arriving at consensus on management measures are difficult, especially where genetic data are limited. A highly precautionary approach is recommended, assigning high priority to conservation of FiGR that are clearly distinct and which represent significant contributions to the overall wild genetic diversity of the species, as far as that is known, but also assuming that all other FiGR are potentially important. Advice from professional geneticists should be sought to make the most of all information to hand and to remedy information gaps.[110]

High priority wild FiGR for conservation include populations in separate waterbodies and watercourses, on and around different islands, and in different bays and estuaries. Geographical isolation usually indicates distinctiveness and potential value of wild FiGR. For highly migratory species, this criterion of isolation applies particularly to breeding populations and early life history stages. Potentially distinct and valuable wild FiGR are also indicated by different migration patterns, spawning seasons, and other behaviour. Populations close to the natural centres of genetic diversity of species are usually important as wild FiGR and should be given high priority for conservation, but it is also important to conserve representative populations

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109 Thorpe, J.P.; Solé-Cava, A.M. and Watts, P. 2000. Exploited marine invertebrates: genetics and fisheries. Hydrobiologia, 420: 165-184.

110 Pullin, R.S.V. 2000. Management of aquatic biodiversity and genetic resources. Reviews in Fisheries Science, 8 (4): 379-393.

across the entire natural range of a species, particularly those close to its limits and in extreme habitats: for example, the most northerly and southerly populations and those in hot springs or high salinities. Expert advice from conservation geneticists should be sought to prioritize among wild FiGR for conservation. Where such advice is not easily obtainable, it can be sought from international organizations, including FAO, the World Conservation Union (IUCN),[111] the secretariats of international conventions – for example, the Convention on Biological Diversity,[112] the Convention on International Trade in Endangered Species,[113] and the Convention on the Conservation of Migratory Species of Wild Animals.[114]

9.4.2 Intersectorial perspectives

Article 9.1.3 provides for the sharing of resources among aquaculture and other sectors: "*States should produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities.*" This requires intersectorial perspectives. Conservation of wild FiGR is part of nature conservation, which is a sector in its own right. The habitats of wild FiGR and their waters are used by humans to varying extents for agriculture, aquaculture, conservation of wildlife, forestry, industry, mining, nature conservation, navigation, power generation, recreation and tourism, water supplies to human settlements and industry, and waste treatment and disposal. Conservation of wild FiGR must contend with the needs of all these other sectors, as they must all contend with each other's needs.

Reconciling aquaculture with conservation of free-living wild FiGR is particularly difficult. Some waters that present opportunities for aquaculture also contain wild FiGR of high national and sometimes international importance. Fish farmers need and should be permitted to farm the most productive and profitable fish species and strains, as in agriculture, subject to their compliance with biosafety, biosecurity, other environmental safeguards and legal access and ownership. However, fish that have escaped from farms and pathogens from fish farms can have adverse impacts on wild FiGR and on other wild biodiversity and habitats.

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[111] www.iucn.org
[112] www.biodiv.org
[113] www.cites.org
[114] www.cms.int

As aquaculture expands in watersheds, coastal areas and the open sea, policy-makers and regulators must increasingly consider which fish they will allow to be farmed in which locations, and the conservation of wild FiGR is a factor here. The four options, in order of increasing restrictiveness and precaution in pursuit of conservation goals, are: 1. permit the farming of any fish; 2. permit only the farming of a native fish species; 3. permit only the farming the strain of a native species that is typical of that locality – note here, however, that the farmed fish strain(s) will soon become genetically different from the local wild strain(s); and 4. prohibit all aquaculture. Choosing among these options is difficult. Aquaculture development gains must be balanced against losses of and changes to wild FiGR, other biodiversity and habitats. The approach recommended here is to follow the general provisions of the Code to allow only development of responsible aquaculture, which implies the setting and pursuit of nature conservation goals, including conservation of wild FiGR, and the safeguarding of interests of other sectors. Taking an intersectorial perspective is the key to achieving a balance between development and conservation. Even when limited to a few sectors – for example, to aquaculture, nature conservation and water resources management – an intersectorial perspective here benefits those and other sectors that depend upon aquatic ecosystem health and services.

Stakeholders in these and other sectors should meet, discuss and arrive at a balanced consensus, based upon mutually agreed compromises, sacrifices and sharing of benefits. This will often be difficult because, historically, many of the institutions for aquaculture and for conservation have been separate, with aquaculture development and oversight proceeding independently of the setting and pursuit of conservation goals. Intersectorial institutions are not yet well developed, though their establishment is implied in the Code for the furtherance of responsibility in aquaculture. Therefore, development of intersectorial institutions, to work for harmony among aquaculture, conservation and other sectors, should be pursued urgently. The intersectorial perspective must be maintained not only prior to and during the development of aquaculture but also through ongoing and indefinite oversight of aquaculture and its intersectorial relationships. This is also recognized in Article 7.6.8 which requires that "*conservation and management measures and their possible interactions should be kept under continuous review.*"

9.4.3 Twinning aquaculture and conservation

Twinning the development and oversight of aquaculture with measures for and monitoring of the conservation of wild FiGR, is recommend as a logical means to ensure both the sustainable use and long-term conservation of wild FiGR.[115] Twinning requires the zoning of areas that are designated for aquaculture and areas for conservation that are completely off-limits to and isolated from aquaculture and fish farm waters, as well as from the impacts of other potentially disruptive sectors. In well chosen aquaculture areas, a wide choice of fish can be farmed, provided that conservation of wild FiGR is fully assured in twinned conservation areas, such as nature reserves and sacred sites. But twinning is more than just separate zoning of aquaculture and conservation of wild FiGR. It must involve co-policy-making, integrated action, co-monitoring and especially co-financing, with both sectors advancing interdependently. Use and conservation then become *twinned* management objectives and are co-funded continuously thereafter.

Conservation areas that fit the strict criteria defined here for twinning will not always be available. Many nature reserves and aquatic protected areas, though lacking isolation from impacts of aquaculture, fishing and other sectors and sometimes allowing rational use of their living aquatic resources, including fishing, play vital roles in conservation of FiGR.[116] Where, despite best efforts, it proves impossible to identify and to establish one or more conservation areas in a given ecosystem, such as a watershed or coastal zone, because of historical or present ecological and social circumstances, the concept of twinning can be widened, nationally and internationally. The main requirement is aquaculture development anywhere that could compromise the integrity of wild FiGR is linked to *in situ* and complementary *ex situ* conservation of those wild FiGR somewhere.

9.4.4 **In situ *conservation***

By convention, the distinct varieties, strains and breeds of cultivated plants, farmed fish and livestock are called *in situ* genetic resources when located in the farms that are their natural surroundings. Their free-living wild relatives in nature are also called *in situ* genetic resources. Well-managed aquatic protected areas are *in situ* genebanks for wild FiGR (Chapter 10), though this role is not often recognized and their management often lacks adequate

[115] Pullin, R.S.V. *in press.* Aquaculture and conservation of fish genetic resources: twinning objectives and opportunities, p. 00-00. *In* Pioneering Fish Genetic Resource Management and Seed Dissemination Programmes for Africa: Adapting Principles of Selective Breeding to the Improvement of Aquaculture in the Volta Basin and Surrounding Areas. CIFA Occasional Paper No. 29. FAO: Accra, Ghana.

[116] Ramsar Convention on Wetlands (www.ramsar.org), Parties to which consider the presence of important fish populations as a criterion for designation of Ramsar sites.

gathering and use of genetics data. *In situ* wild FiGR are found only in natural or relatively undisturbed habitats. The two main requirements for *in situ* conservation of any population of wildlife in any protected area are: i) to maintain a genetically effective population size; i.e., an number of effective breeders (N_e), so as to avoid the inbreeding depression and loss of genetic variation to which small, isolated populations are always at risk (see also Chapter 3);[117] and ii) to pay equal attention to the management of their habitats, so as to prevent their degradation or loss. Unless the latter is successful, the FiGR targeted for conservation will be changed or lost. The continued presence and integrity of the waters and biological communities that host particular wild FiGR must be assured, in the face of challenges by *inter alia* climate change, dam construction, droughts, floods, introductions of alien species and diseases, overfishing pollution, siltation and water abstraction. In this respect, *in situ* conservation of wild FiGR faces the same constraints as all nature conservation, but the threats to wild fish, especially freshwater and highly migratory fish, are greater then those for all other vertebrate groups used as food by humans.

In situ conservation of threatened and important wild FiGR should not be abandoned because the populations that remain for conservation purposes have low N_e s. Small populations of wild FiGR conserved *in situ* contribute to the overall conservation effort for a given species and are particularly important where they represent rare or sole remaining examples of a genetically distinct local population, such as a riverine or lacustrine race. *In situ* conservation of wild FiGR has operational and opportunity costs and these must be recognized and shared by public and private beneficiaries.

One of the key issues with respect to all *in situ* wild genetic resources, including FiGR, is how to ensure their responsible collection from nature, avoiding in particular over-collection and unauthorized collection, and their exchange and fair use thereafter. In 1993, the Member Nations of FAO negotiated an International Code of Conduct for Plant Germplasm Collecting and Transfer,[118] the objectives of which can all be applied to wild FiGR. The Convention on Biological Diversity[119] – particularly its Articles: 8, on *in situ* conservation, and especially 8j, on equitable sharing of benefits; 15, on access to genetic resources; 17, on exchange of information; and 18 on technical and scientific cooperation - and many other international and national instruments

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[117] Frankham, R. 1995. Conservation genetics. Annual Review of Genetics, 29: 305-327.

[118] FAO. 1994. International Code of Conduct for Plant Germplasm Collecting and Transfer. Food and Agriculture Organization of the United Nations: Rome, Italy. 20p.

[119] www.biodiv.org

provide for the management of all biodiversity, including implicitly *in situ* wild FIGR, but have so far been applied much more extensively to other wild genetic resources, especially to the wild relatives of cultivated plants.

9.4.5 **Ex situ *conservation***

Conservation of FiGR as live fish is called *in vivo* conservation. All *in situ* conservation of wild FiGR is *in vivo*, as fish populations of various sizes. The *ex situ* conservation of wild FiGR can be either *in vivo* as individuals or populations held in research establishments and aquaria, or *in vitro* as cryopreserved sperm, and more rarely as embryos and as any tissues containing DNA. *Ex situ/in vitro* conservation of wild FiGR as cryopreserved sperm is by far the most important technology available (Chapter 10). The absence of comparable technology for cryopreservation of the eggs and embryos of all farmed finfish and of most farmed aquatic invertebrates means that cryopreserved sperm can only be used to fertilize eggs from live females. However, cryopreservation of sperm is still a very important means of conserving wild FiGR, especially threatened wild FiGR, and for providing wild FiGR in breeding programmes and related research.

Ex situ/in vivo conservation of wild FiGR, in research collections and aquaria, faces the same constraints as all captive breeding for conservation purposes in zoos and other establishments: chiefly, that captive-bred populations become genetically different from their wild relatives, that the facilities available often constrain effective population size (N_e) and that security of funding is often limited. Public-private partnerships can help to mobilize more resources for *ex situ* conservation of wild FiGR, sharing the costs and benefits, though public funding will usually have to take the lead. *Ex situ/in vivo* collections of wild FiGR are kept for research purposes by many public funded organizations, especially universities, as well as by the private aquaculture sector. Public and private aquaria are also *in vivo* fish gene banks and some of their fish can be FiGR for aquaculture. *Ex situ/in vivo* collections of wild FiGR should be managed to keep them as genetically close to wild type as possible, minimizing loss of genetic variation (Chapters 3, 4 and 10).

Ex situ conservation of wild FiGR should be considered first as complementary to their *in situ* conservation, with high emphasis on the latter. However, where no or few undisturbed and accessible free-living populations of important FiGR remain, *ex situ* conservation becomes the main or only approach to ensure their long-term conservation and availability. As recommended above for *in situ* conservation, all efforts to conserve threatened and important wild

FiGR *ex situ* are valuable and contribute to the overall conservation of genetic diversity for a given species. As with the conservation of rare animals in zoos and rare breed trusts, this applies even where cryopreserved genetic material is representative of only a few individuals or populations and where *in vivo* populations have low N_e s.

Wherever aquaculture development and conservation of wild FiGR for aquaculture are undertaken, concurrent provisions should be made for all necessary current and foreseen *in situ* and *ex situ* conservation of wild FiGR. The twinning approach is again recommended here, with appropriate institutional development and capacity building for both *in situ* and *ex situ* FIGR conservation methods.

9.5 Information

Accurate and up to date information is of paramount importance for the effective management of wild FiGR. For effective zoning of aquaculture and *in situ* wild FiGR conservation areas, wild FiGR must be fully documented, including as far as possible genetic characterization. Only with such information can they be prioritized for conservation. Thereafter, information must still be collected to monitor the status of *in situ* populations and, where applicable, complementary efforts in *ex situ* conservation. This information should be shared and disseminated in a variety of formats such as genetic databases, scientific journals, and on-line open access sources. FishBase[120] is a good example of an information system that can be used for recording and disseminating such information, from its own contents that relate to wild FiGR and from linkages to other relevant databases. The FAO Species Identification Programme[121] and Aquaculture Fact Sheets[122] contain taxonomic descriptions, based on morphology, with only limited genetic data. However, information systems for wild and other FiGR are likely to change as the scope and demand for this information grow. Guidance on new developments in FiGR information sources can be sought from the FAO Commission on Genetic Resources for Food and Agriculture. Moreover, with conservation genetics increasingly applied to a wide range of taxa, information on wild FiGR is increasingly available from national, regional and international nature conservation organizations.

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[120] www.fishbase.org

[121] http://www.fao.org/fi/website/FIRetrieveAction.do?dom=org&xml=sidp.xml

[122] http://www.fao.org/fi/website/FISearch.do?dom=culturespecies

National and local inventories, i.e. computerized lists and databases, of wild FiGR should be established from an inclusive perspective, to comprise all free-living fish populations - wild, feral and others - and their accessible individuals, gametes, DNA and genes. This approach recognizes that wildness is a relative attribute. Inventories should include for each population and for other forms of wild FiGR: accurate and authoritative specific (and where applicable intraspecific) identification and scientific nomenclature, references to sources of local and indigenous knowledge and nomenclature, distinguishing characteristics, genetic characterization data, conservation status, history of use in aquaculture and main threats.

Site-specific, management of *in situ* wild FiGR requires broader information sources and planning instruments because it comprises both the management of the FiGR *per se* and the management of their habitats. Information must, therefore, be sourced from all the sectors that could have adverse impacts on the latter, including all likely changes to the surrounding watershed or coastal zone and especially any foreseeable changes in water quality and quantity, Some of the methods to be applied here, such as Geographical Information Systems are long-established, though their application in conservation genetics is relatively new. Managing natural habitats specifically for FiGR conservation is also relatively new and published information about experiences and guidelines are limited. Medical practice faces a similar situation in striving to synthesize and disseminate recent information in order to maximize effective actions, and it has been suggested that conservation could learn from some its approaches to information processing.[123]

Information sources about different types of fish habitats are generally less well developed than those for fish biology, and every individual situation of a fish habitat and its wild FiGR will have some unique features. The need to understand fish habitat ecology is a key requirement for conservation[124] and advice from aquatic ecologists that can be applied to management of *in situ* wild FiGR is increasing. A good example is the list of sites for which Ecopath analyses have been completed as information for ecosystem-based management.[125] Expert advice on information for managing habitats in conservation of wild FiGR should be sought from professional aquatic

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123 Fazey, J., Salisbury, J.G., LindenMayer, D.B., Maindonald, J. and R. Douglas, 2004. Can methods applied in medicine be used to summarize and disseminate conservation research? Environmental Conservation, 31 (3): 190-198.

124 Rice, J.C. 2005. Understanding fish habitat ecology to achieve conservation. Journal of Fish Biology, 67 (Supplement B): 1-22.

125 www.ecopath.org.

ecologists and geographers. Where such advice is not easily obtainable, it can be sought in the first instance from IUCN.

9.6 Conservation aquaculture for endangered fish

The term endangered is used here in a broad sense, comprising species listed by the Convention in International Trade in Endangered Species, [126] all species categorized in the Red List of IUCN as threatened (where three subcategories - vulnerable, endangered, and critically endangered – are defined),[127] and all species and other taxa termed endangered in national legislation. International lists are important; however, lists should also be made at a national or local level of endangered species that are locally important and that may be endangered. Aquaculture decision makers could request such lists from national fisheries or environment officers. The main strategies for conservation of all endangered species are to protect and to rehabilitate their natural habitats from degradation and to protect their populations from adverse impacts.

Captive breeding can be also used to augment remaining wild populations and, where there have been local extinctions, for reintroductions.[128] When applied to endangered fish, this can be termed conservation aquaculture, but its interventions must be integrated into an overall resource management strategy involving *inter alia* conservation areas, fishery management and well managed access to natural resources. Captive breeding and the production of hatchery seed have been used to assist with the conservation and use of a wide range of endangered fish, including: the Mekong giant catfish; mahseers; giant clams; ornamental species such as arowana; paddlefish and sturgeons; and several species, subspecies and runs of salmon and trout.

Many public aquaria have some endangered fish among their collections, but the large captive breeding efforts of zoos to assist conservation of endangered animals, particularly birds and mammals, have not yet been matched by similar efforts for fish. Guidelines have been published for captive breeding as an aid to conservation of endangered fish species.[129] As with all *ex situ* breeding of wild fish, the main principle for captive breeding to assist in the conservation of endangered fish is to keep captive broodstock and their

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[126] www.cites.org

[127] IUCN. 1994. IUCN Red`List Categories. IUCN, Gland, Switzerland. 21p.

[128] IUCN. 1998. IUCN Guidelines for Re-introductions. IUCN, Gland, Switzerland and Cambridge, U.K. 10p.

[129] Huntley, R.V.; Langton, R.W. 1994. Captive Breeding Guidelines. Aquatic Conservation Network, Inc., Ottawa, Ontario, Canada. 62p.

progeny as genetically close as possible to the wild type populations that are being augmented or re-established (Chapter 3). However, for endangered fish that are close to extinction, the situation can be so serious that any captive breeding, even if compromising these genetic goals and reliant on very low N_e s, is better than none.

9.7 Summary

Wild fish genetic resources (FiGR) represent the majority of the genetic diversity that is available for the further domestication and genetic improvement of farmed fish.

Many wild FiGR are threatened with genetic change or extinction. These wild relatives of farmed and potentially farmable aquatic species must be valued and protected in order to ensure their future availability for use in aquaculture.

With adequate recognition of the value of wild FiGR and sharing of the costs and benefits of their conservation, there is still time and opportunity for aquaculture to avoid losses of wild genetic resources to the extents that have been experienced in the livestock and crop sectors.

In situ conservation of wild FiGR should be recognized as part of the nature conservation sector, and should be pursued through intersectorial action and cooperation.

Ex situ conservation of wild FiGR to complement *in situ* efforts for aquaculture is an important option and captive breeding can assist conservation of some endangered fish.

For all aspects of the management of wild FiGR, accurate and up to date information is of paramount importance.

Conservation of wild FiGR should be accorded adequate importance in funding allocations and in the sharing of natural resources with other sectors.

10 BANKING AQUATIC GENETIC RESOURCES[130]

10.1 Introduction

A gene bank is a managed collection of genetic resources. Gene banks are necessary whenever the genetic resources fundamental to farming and harvesting animals and plants are threatened. While modern genetic techniques make it possible to bank any plant or animal tissue that contains DNA, most gene banks are collections either of whole organisms, their reproductive cells or early life stages. A good indication that a collection is actually a bank is if one can make a withdrawal from it. The technologies used for aquatic gene banking are as applicable to industry (broodstock collections, prospecting for new genetic material) as they are for traditional conservation.

10.2 *In situ* and *ex situ* gene banks

A gene bank can be *in situ* or *ex situ*, a distinction based largely on its physical location. *Ex situ* banks, which can be collections of DNA, genes, single cells, seeds or whole organisms, are remote from the organism's natural or farmed habitat; they are the commonest kind of gene bank, and the one most familiar to the public. *In situ* banks are populations of organisms protected along with their natural or farmed habitat; they are less common than *ex situ* banks, but may be more palatable to agencies and the public (see Chapter 12). While the Convention on Biological Diversity (CBD) regards *ex situ* banks as "complementary" to *in situ* ones, both explicitly address Articles 7.2.2 and 9.3.1 (*in situ* and *ex situ* banks) and 9.3.5 (*ex situ* banks) of the CCRF. They are equally important for aquatic genetic resources.

Gene banks for aquatic organisms are much more recent than the seed banks and livestock insemination centres familiar to many people. The biggest difference is that, unlike domesticated plants and animals, aquatic organisms are still captured from wild ecosystems or from farmed stocks, so their preservation in gene banks should involve preservation of natural habitats (aquaculture systems are not yet threatened). Loss of habitat means that the option of an *in situ* gene bank of wild species no longer exists for many wild plants and animals, but remains very much available for finfish, shellfish and aquatic plants. Managers of aquatic gene banks must thus be clear about the breadth of options for conserving genetic resources of farmed aquatic species, for which an *in situ* bank can include not only a live, "on farm"

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130 Contributed by Brian Harvey.

collection of a particular breed, but also a portion of the habitat of its wild relatives (Chapter 9). In this chapter, only the first *in situ* option, namely on-farm conservation, is considered.

10.3 History

The first gene banks for aquatic organisms were small collections of cryopreserved sperm gathered by researchers interested in wild populations of finfish. Their most obvious utility, however, was for safeguarding the results of aquaculture breeding programs. Many of the collections that followed were short-lived due to poor investment planning, poor technology and lack of government buy-in. A number of "living gene banks" (again, mostly finfish) also arose in the form of captive broodstock collections in state or private hatcheries.

Today, managed *ex situ* collections of aquatic animal germplasm and whole organisms are maintained by national, state and indigenous governments, private companies, academics and NGOs. Some are part of a concerted national effort at aquatic germplasm conservation. While these *ex situ* banks are widespread, their terminology and technologies need to be standardized and lines of communication set up. Partnerships between groups enormously strengthen any program, and should be sought.

10.4 Guidance on banks of cryopreserved gametes and embryos

A gene bank represents an unusually long commitment to maintaining infrastructure. Athough relatively easy to set up, gene banks are hard to maintain over decades, which is their natural time frame. They *can* be successfully used on a small scale (for example, on a single farm) but the livestock model, which uses a central (and centrally funded) storage and records centre is probably the best long-term bet. This multi-user model is the one contemplated in the following discussion.

The sperm of many species of freshwater finfish has been successfully cryopreserved (frozen indefinitely in liquid nitrogen). Fish spermatozoa present few serious technical problems, although progress has been hampered by a low quality scientific literature on the topic, reflecting many empirical attempts uninformed by cryobiological theory. Researchers and those establishing gene banks should consult recent reviews[131] for more in-

[131] A recent example is Tiersch, T., and Mazik, P. (eds). 2000. Cryopreservation in aquatic species. World Aquaculture Society, Baton Rouge. 439 pp.

depth technical guidance and are encouraged to disseminate their experiences widely, including in the peer-reviewed literature.

Fish sperm is generally frozen and stored in plastic straws. The actual freezing can now be done in the field using portable, low cost equipment. It is not yet possible to freeze finfish eggs. Sperm and ova of some shellfish have, however, been successfully frozen, and the larvae of bivalves (oyster, clam, scallop, mussel) are well suited to cryopreservation; several national research programs currently target bivalve gene banking. Gene banks should currently target fish spermatozoa or bivalve ova and larvae.

Cryopreserved sperm, ova and larvae are stored in liquid nitrogen. Secure storage should be sought in a livestock breeding centre amenable to contracting out space and manpower. Duplication in another site is an extra safeguard but is practical only for small collections. If the species being conserved has not been cryopreserved before, the main cost for this kind of *ex situ* bank is in developing or acquiring the technology; sources include academic and government researchers, although some private fish farms have also invested in refinement of existing techniques.

10.5 Guidance on living gene banks (broodstock collections)

Isolated collections of "pure" brood lines of live fish have long been part of large-scale hatchery programs that produce fish for sale to other farms, for conservation and for release to the wild. The main requirements of this or any other kind of living gene bank are that the conserved stocks remain secure and that their genetic diversity is maintained. They must, however, be bred, which imposes selective forces and inevitably distances them from their original wild state (see Chapters 3 & 9). Captive breeding of endangered fish populations has become a familiar part of the gene banking scene. Broodstock collections can also be maintained in academic research laboratories and public aquaria.

10.6 Data management

While much effort has been spent to develop software for managing plant and livestock gene bank accessions, and the existing international agreements on gene banking have stimulated a fair degree of standardization, the majority of fish gene banks still rely on crude in-house record-keeping systems based on widely available spreadsheet software. Most of these home-grown systems fail when asked to provide good records of withdrawals, exchanges and replacements;

none of them can account for the broad range of data that plant and livestock gene banks normally maintain. While the requirements for fish gene banking will differ somewhat depending on location and the kind of bank, data that must be accounted for will usually include provenance (what was collected, where and by whom, and under what legal arrangement); identification (species and, where possible, population genetics); and subsequent use (removal and re-deposit of samples, by whom and for what purpose).[132]

10.7 Policy implications

Given the appropriate containers, cryopreserved genetic resources are far easier to transport, over any distance, than living ones. Those doing so must be aware of national and international legislation on introductions, transfers and disease control.

Few governments, even those which are parties to the CBD have policies on aquatic gene banking. Yet the CBD enshrines precisely those principles that demand such policy – namely access to genetic resources and sharing the benefits derived from them. These principles affect every group possibly interested in gene banking: communities, the aquaculture industry, indigenous groups, NGOs and fisheries and environment ministries. Access to genetic resources, especially those removed from their natural habitat and stored for later use, can rapidly become politically or legally difficult. Each group must therefore understand the policies of other involved group before embarking on a gene banking program, and reach prior agreement on access, storage and use of those resources. There is so far no standard format or general principles for such agreements specific to aquatic genetic resources.

Resource management and development agencies, especially international agencies, should work toward standardization of terminology, policies, technologies and record keeping; additional policies may need to be developed as the field of genetic resource characterization advances.

10.8 Establishing an aquatic gene bank

For any group wishing to establish an *ex situ* aquatic gene bank, the following steps should be followed:

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[132] SpermSaver – Gene Bank Management Software. 2005. World Fisheries Trust, Victoria BC, Canada. This is a beta version of fish gene banking software that addresses all these areas available from World Fisheries Trust (www.worldfish.org).

- find a long term institutional home for the programme (e.g. a fisheries or agriculture agency) and a long term physical home for secure storage (e.g. a state or private livestock insemination station);
- secure short-term funding (e.g. granting agencies) for research and long-term funding (primarily government) for secure storage;
- acquire the technology from academia or in-house research funded as above;
- train field staff regularly on technology, data management, permitting and legislation;
- survey and incorporate into a gene bank management plan all relevant environmental and fisheries legislation and regulations, including those on disease control, transfer of live animals and their gametes, and endangered species;
- develop policies on acquisition and release of material and in particular with regard to access to genetic resources and the sharing of benefits arising from its use;
- make the links to providers of associated data on accessions (for example, modern DNA analysis allows for fine-level characterization of genetic structure; a standardized aquatic gene banking system would incorporate the results of such analyses); and
- develop a mission statement and hire a communications specialist to promote the objectives, terms of use and policies of the gene bank with all partners.

11 A PRECAUTIONARY APPROACH[133]

To ensure that aquaculture development proceeds in a responsible manner, the international community through, for example, the Convention on Biological Diversity (CBD) and the FAO Code of Conduct for Responsible Fisheries, many national governments, NGOs and others are calling for the adoption of a precautionary approach.

All development has impact. Society wishes to benefit from the development of new technologies and genetically improved species for culture, while at the same time society expects government to protect it from any harmful effects of that development. Balancing developmental progress and the adverse impacts from progress is the essence of a precautionary approach to the use of genetically altered species (Chapter 2) in aquaculture.

There is still a high level of uncertainty and debate on the probability and magnitude of many of the adverse impacts of genetically altered species on the environment and on aquatic biodiversity. Current understanding of many species, aquatic ecosystems and the forces that structure them is often not adequate to predict accurately how a biological community or ecosystem will respond to the introduction of genetically altered species.

11.1 An approach

The precautionary approach advocated by FAO and CBD states that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. Elements of the precautionary approach developed for capture fisheries and introduced species[134] follow.

- Reference points should be established to help determine desirable situations and undesirable impacts, e.g. target and limit reference points. For example Maximum Sustainable Yield could be considered a target reference point, whereas occurrence of not more than a given number of escaped farmed fish in the wild would be a limit reference point. Some potential reference points are listed in Table 11.1. Resource managers should develop quantitative values for the reference points listed in Table 11.1.

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133 Contributed by Devin M. Bartley.

134 FAO. 1996. Precautionary Approach to Capture Fisheries and Species Introductions. FAO Technical Guidelines for Responsible Fisheries No. 2. FAO, Rome.

Table 11.1 Possible reference points for the application of a precautionary approach to genetic resources management in aquaculture. T and L are Target and Limit reference points, respectively.

Purpose of establishing a reference point	What to measure for reference point
Genetic	
To establish acceptable level of inbreeding (L)	- Inbreeding coefficient (F) (Chapter 3)
To establish acceptable level of gene flow/introgression between farmed and wild stocks (L)	- Number of wild and farmed fish exchanging genes - Change in gene frequency in wild stocks
To establish acceptable number of fish to be used as broodstock (T)	- Effective population size (N_e) (Chapter 3) of broodstock
To ensure sterile aquaculture product	- Number of triploid fish in hatchery product
To conserve rare genes in culture (T)	- Effective population size (N_e) (Chapter 3) - Gene frequency in hatchery stocks
Native stock abundance	
To assess impact of escapes	- Number of escaped fish from aquaculture - Percent decline in native fishes
To establish level of endangerment (L)	- Reduction in population size over a given period of time (e.g. 10 years or 3 generations)
To establish acceptable fishery impacts (T and L)	- Fishing mortality; - Maximum Sustainable Yield.
To establish risk of extinction (L)	- Effective population size - Probability of extinction within a given time (e.g. 5 yrs) - Decrease in population size (e.g. order of magnitude decrease over a period of time)
Pathogens	
To prevent spread of disease (L)	- Levels of specific pathogens in farmed and wild populations (often 0 is set as a target and limit reference point for pathogens)

- Undesirable outcomes, as well as corrective or preventative measures, should be identified, including the prohibition or enforced cessation of activities that carry unacceptable risks or have already had unacceptable adverse impacts. Pre-agreed actions or contingency plans should be implemented in a timely manner when limit reference points are approached, or when adverse impacts are apparent. Thus monitoring of aquaculture facilities, local species and the environment is necessary to know when reference points are reached. Such actions could include switching to sterile fish if breeding with local species is a problem or changing containment or location of facilities. Conversely, if good culture practices are used and no adverse impacts are monitored, additional development following the same approach could be planned.

- Priority should be given to maintaining the productive capacity of the resource where there is uncertainty as to the impact of development. In capture fisheries, this means that priority is given to conservation of stocks over harvesting the stocks when there is uncertainty. This can be extended to aquaculture where the productivity of local stocks should be maintained when there is uncertainty as to the risk of genetically altered species adversely affecting them. This may require locating fish farms in areas away from valuable local resources (Chapter 9).
- The impacts of development should be reversible within the time frame of 2 - 3 decades. This element renders as non-precautionary the use of reproductively viable, genetically altered species in many situations, none the less a precautionary approach can be followed. Species introduced for aquaculture have naturalized and established self-sustaining populations in many instances; the eradication of such populations (i.e. the reversibility of the impact) is difficult or impossible, especially in marine areas, large inland water bodies and wetlands, and extensive river systems.
- The burden of proof should be placed according to the above requirements and the standard of proof should be commensurate with risks and benefits (i.e. a higher standard of proof would be required when risks relative to benefits are high). The precautionary approach has often been taken to mean that the burden of proof rests with those proposing the use or development of a resource (i.e. the aquaculture facility must prove that a genetically altered species will have no adverse impact). This is the "guilty until proven otherwise" approach. The application of this, in real situations, is very complicated. All cases for allowing or prohibiting aquaculture activities should be based, to the greatest extents possible, on sound scientific information and opinion.

11.2 Conclusions

A precautionary approach acknowledges uncertainty and establishes mechanisms to deal with potential problems. Such mechanisms may involve *inter alia* policies, management programmes, risk management, monitoring systems and changes in management or development based on experience. Thus, this approach has much in common with adaptive management. The requirement to perform environmental impact assessment or to follow codes of practice, such as the those developed by the European Union[135], the International Council for the Exploration of the Sea and the European Inland Fisheries Advisory Commission (ICES/EIFAC) (Chapter 5) are excellent precautionary devices that help determine whether the use of genetically altered species should be undertaken.

The precautionary approach is action in the face of uncertainty, and in advance of and during development. The approach does not call for a lessening of research or less effort to reduce uncertainty. Action must be taken with the best scientific information available and to improve the scientific information available.

The application of a precautionary approach should weigh benefits and risks (Chapter 7). Thus, in areas with needs for increased protein or economic opportunities, aquaculture and the use of genetically altered species may provide benefits that other types of agriculture or development would not provide. Thus, a higher level of risk may be justified when benefits to a needy area are expected to be substantial. However, the needs of future generations must also be considered, especially if short-term interventions pose risks to maintaining their breadth of options for availability and use of wild genetic resources and aquatic ecosystems.

A precautionary approach to the use of genetically altered species in aquaculture requires the mobilization of significant effort in regards to management, monitoring and research. Reference points will be critical and, for the present, they are not well agreed for acceptable levels of genetic diversity or for numbers of escaped farmed animals necessary to cause adverse impacts. Countries should strive to apply the approach and provide information to national policy-makers and to FAO so that uncertainty is reduced, lessons can be learned and information can be disseminated to a wider audience.

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[135] EU Directive 90/220, on the release of genetically modified organisms in to the environment.

12 PUBLIC RELATIONS AND CONSUMER AWARENESS[136]

12.1 Introduction

Consumer acceptance of genetically altered organisms from aquaculture is critical to the success of a breeding programme. Not only will people decide whether or not to purchase the farmed product, they can also put pressure on policy-makers that can influence legislation governing the import and use of genetically altered organisms.

Public awareness is not considered in the original CCRF, except in a very general manner. Article 6.16 on General Principles recommends that, *States should … promote awareness of responsible fisheries* (including aquaculture) *through education and training…"*. Yet public acceptance of genetically altered products is increasingly important in aquaculture, its role in livelihoods and its potential impact on the environment. The Convention on Biological Diversity and Agenda 21 both cite public awareness as crucial to sustainable development and for effective public participation in decision-making.[137]

This chapter alerts decision makers to some of the issues around public relations. Problems result from a *lack of information* or *different points of view*. Both kinds of problem can be averted if the users and managers of genetic technologies establish lines of communication with stakeholders – and with each other. The goals of this chapter are to make decision makers and advocates of the application of genetic technologies aware of some non-technical issues that can influence the success of genetic resource management programmes, and to propose elements of a general communication or public relations strategy to help disseminate accurate information.

12.2 Communication strategy

A communication strategy is needed to help promote the responsible use of genetic technologies because consumers and the general public in most of the world do not understand how their food is produced. Confusing terms, inconsistently used terms, exaggerated claims of success or disaster, complicated subject matter, deliberate attempts to hide information or influence public opinion add to consumer confusion, even mistrust, of genetic

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136 Contributed by Devin M. Bartley

137 Raymond, R.D. 1999. Agricultural research and the art of public awareness. Pages 217-224 *in* Pullin, R.S.V., D.M. Bartley and J. Kooiman (eds) Towards Policies for Conservation and Sustainable Use of Aquatic Genetic Resources. ICLARM Conf. Proc. 59. 277p.

technologies. This is extremely unfortunate because the responsible use of appropriate genetic technologies can greatly benefit the consumer and the environment.

The communication strategy should have defined objectives and a defined target audience. A successful approach to communication is "framing"[138] a subject area. Framing deliberately focuses on certain parts of an issue (inside the frame), while omitting other aspects (outside the frame), in order to meet the objective and elicit support from an audience (e.g. consumer or policy-maker). For example, in a strategy to promote acceptance of genetically improved fish, the frame could include the cost savings from growing or buying fish that can be produced more efficiently, and not focus on the technical details of how that fish was produced.

A communication strategy may have to "reframe" an issue by changing the current focus. For example some groups have "framed" aquaculture as using too much land and natural fish in the production of aquaculture feeds. By stressing reduced land and feed requirements associated with producing genetically improved fish it is possible to "reframe" the discussion in a more positive light (Table 12.1).

None of the above is to suggest that promoters of genetic resource management should conceal, withhold or distort information. They should be pro-active by disseminating positive and accurate information on the advantages of genetic resource management.

Other elements that can help create the "frame" are presented below.

12.2.1 Know your audience

Know your audience is the most basic rule of public awareness. The "public" is composed of numerous diverse groups with different interests. These different interests will dictate their information needs. Current sociological research has demonstrated that people often make decisions not on the basis of science or logic, but on deeply held preconceptions or on very simple principles. Consumers want to feel good about what they are buying, either because it is good for their health, good for the environment or good value for

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[138] Annex 2: Sink or Swim: mobilizing key audiences through strategic communication. Suzanne Hawkes and Liz Scanlon IMPACS, September 2006. (worldfish.org/images-pdfs/Projects/sinkorswim.pdf)

Table 12.1 "Framing" genetic management in aquaculture helps stress positive aspects to promote acceptance of genetic improvement programmes.

Current "Frame" concerning genetic technologies	Suggested focus of a new frame
Genetic technologies are costly	Genetic technologies are cost-effective by producing an organism that grows well and uses less inputs. Genetic technologies can be used to produce a specific color or shape of fish that consumers would pay a premium for.
Genetic technologies are complicated	Genetic technologies are often based on traditional animal breeding practices. The reproductive biology of fishes makes application of genetic technologies easy.
Genetic technologies are bad for native biodiversity and environment	Genetic technologies in aquaculture can reduce adverse environmental impacts. They can be used to produced organisms that have reduced ability to interact with wild ones; by growing more efficiently there will be less waste going into the environment; by having increased disease resistance there will be less chance of disease transmission and less pharmaceuticals used. Genetic resource managers in aquaculture should demonstrate that they place a high value on wild genetic diversity – it is the raw material for all genetic improvement programmes.
Genetic technologies benefit large companies	Benefits of decreased production costs will be passed on to the consumer.
Genetic technologies produce a product that consumers are afraid of, e.g. unhealthy, bad tasting, strange	Genetic technologies can be used to produce a healthy fish that has no ingredients not found in wild relatives.
Genetic technologies are harmful to farmed organisms	Improved domestication and production efficiencies from farming genetically improved fish will mean fish are less stressed in the culture environment, they feed better, have lower levels of aggressive interactions and will be less susceptible to diseases.

money, aquaculturists want access to lucrative markets, policy-makers want to do what is best for the majority of their constituents.

Consumers will be more strongly influenced by reduced prices for high quality genetically improved fish that are grown more efficiently and with less environmental impact. Policy-makers will be influenced by growing consumer and business demand for these traits. The growth of "organic" agriculture products and eco-certified capture fisheries is an indication that consumers want to buy a product that has reduced environmental impacts, as well as a product that is economical.

Because consumers may have strong feelings that are difficult to change, and existing laws are difficult to change, surveys should be conducted to ensure that any genetic technology used in production is accepted by consumers and will not have any associated legal or trade restrictions. For example, hybridization between different species is prohibited or requires special permits in some areas. Although at present there are no aquatic genetically modified organisms (GMO's) (i.e. transgenics) available to consumers, some are likely to be developed and approved in the future. Thus, consumer and trade partner acceptance of this technology should be examined before using it.

12.2.2 Establish partners to help promote genetic management programmes

Proponents of genetic technologies in aquaculture will need to partner with numerous stakeholders to ensure that the technologies are given a chance, used responsibly, and accepted by consumers and policy-makers (see also Chapter 9 on multi-sectoral approaches). Aquaculture is being criticized for causing adverse environmental impacts because of over-use of certain inputs and high discharge of contaminants. Genetic programmes that reduce these impacts through more efficient production should find wide acceptance in the aquaculture industry and conservation sectors.

Partnerships will promote confidence in the product produced and credibility in the information disseminated by genetic improvement programmes. The "Shrimp Consortium"[139] composed of international development and conservation groups and donor institutions would serve as an excellent example of how such partnerships could work in the promotion of genetic improvement programmes.

While much has recently been made of the role of aquaculture in "filling the supply gap" arising from limited production from capture fisheries, aquaculture is only one solution to this problem and genetic improvement programmes can help. Conflicts between aquaculture and capture fisheries based on competition and access to resources have developed and could pose a threat to both sectors. Efforts should be made to conserve and protect wild fishery resources (Chapter 9), to help in promoting partnerships and to avoid conflicts.

It should be recognized that there are areas where aquaculture is not appropriate, regardless of whether or not genetic technologies are used. It is best not to spend time fighting these battles that may alienate partners and

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[139] http://www.worldwildlife.org/cci/dialogues/shrimp.cfm

result in failed aquaculture operations. The twinning strategies of Chapter 9 and the designation of areas where aquaculture is limited or excluded should be loudly embraced by the aquaculture sector so that other areas more appropriate for aquaculture can be developed fully, using the best species and strains available.

12.2.3 Learn from other sectors

The terrestrial farming sectors are more advanced than aquaculture in the use of genetic technologies and there are good lessons to be learned from them. Some lessons include the following:

First, it should be stressed that the benefits of genetically improved fish will be passed onto the consumer. The plant biotechnology sector is experiencing strong consumer resistance to the use of genetically modified organisms, whereas the pharmaceutical sector routinely uses modern genetic engineering with little public resistance. One reason for this is that the public perceives the benefits of genetic engineering in plants to benefit only the industry, whereas the use of genetic biotechnologies by the pharmaceutical company is perceived to benefit sick people.

Second, ethical issues matter. Cconsumer concerns have been expressed for the welfare of genetically engineered livestock and for general growing conditions of farmed animals. Similar concerns have arisen to a limited extent for farmed and genetically altered fish. Genetic alterations that may cause deformities should be avoided and it should be emphasized how genetically improved fish will have improved welfare in culture because of increased domestication. Food security issues and intellectual property protection that could deprive farmers of adequate food have arisen in the crop sector. Seeds for crops essential for rural communities were genetically sterilized so that farmers could not replant them. Advocates of genetic improvement programmes should be aware of how genetic improvements may impact food security of rural communities.

Finally, labelling is a controversial issue with which all sectors are dealing. Guidelines on eco-labelling fishery have been produced by FAO and partners and guidelines on aquaculture products are under development; the Marine Stewardship Council and the Forest Stewardship Council have developed private industry guidelines. These existing guidelines do not address genetic criteria yet. Some inter governmental fora have mandated labelling of certain terrestrial products from modern biotechnology (e.g. GMOs) and some organic labeling schemes do not allow certain genetic technologies. In light of the sensitive and complicated nature of this field, discussions on how to use genetic information in these guidelines is not yet at a sufficiently advanced level where guidance can be given at this time. It is recommended that genetic resource managers and proponents of genetic technologies in aquaculture follow this rapidly advancing field and engage partners as recommended above to help develop an informed way forward.

12.2.4 Use accurate terminology consistent with national and international legislation

The field of genetics is complicated and often controversial. Accurate terminology and correct use of terms and principles will help in communicating useful and accurate information and in avoiding problems associated with misunderstanding (see Box "some terminology" in Chapter 2). Glossaries exist to help understand this complicated arena.[140]

12.3 Conclusion

The benefits of genetic management programmes in aquaculture are substantial, but often poorly understood by the general public and policy- makers. Communicators (see footnote 138) state that new ideas are first embraced by a small number of "innovators"; then slowly by others. When 15 percent of a group adopt the idea, it can successfully spread. Promoters of genetic technologies and breeding programmes need to communicate the positive aspects of these programmes to a wide audience and seek partnerships with other users of aquatic resources and civil society to help reach this 15 percent level of acceptance. The responsible use of genetic technologies can help aquaculture produce more food more efficiently and with less environmental impact. Once this is realized by a large audience it will help aquaculture integrate into multisectoral local community development plans. These facts should be part of an overall communication strategy that helps build public relations and consumer confidence in genetically improved fish.

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[140] FAO glossaries exist on biotechnology (www.fao.org/biotech/index_glossary.asp); fisheries (www.fao.org/fi/glossary/default.asp); and aquaculture (www.fao.org/fi/glossary/default.asp).

ANNEX 1

NAIROBI DECLARATION [1]

CONSERVATION OF AQUATIC BIODIVERSITY
AND USE OF GENETICALLY IMPROVED AND ALIEN SPECIES FOR AQUACULTURE IN AFRICA

BACKGROUND

Fish are a critical source of animal protein to the people of Africa, and aquatic resources play a central role in sustaining rural and urban livelihoods across much of the region. Yet, for the continent as a whole, per capita supply of fish is declining and current projections of supply and demand indicate that this gap will continue to grow in the coming decades. If this gap is to be bridged, capture fisheries need to be sustained and the potential of aquaculture realised. In doing so attention needs to be given to protecting the rich aquatic biodiversity of Africa, especially the rich diversity of freshwater fish and its role in sustaining capture fisheries and providing species for aquaculture.

At present, fish production from aquaculture in Africa is low. However as population increases, together with demand for fish, the aquaculture sector is projected to grow. For this to happen, a wide range of constraints need to be addressed and a greater range of management practices considered. Pond and broodstock management will need to be improved, a wider range of feeds developed, and market access improved.

In addition, there is considerable potential for improving performance of the fish species and strains used. At present many of the fish used in aquaculture in Africa are derived from undomesticated stocks. This contrasts with crops, livestock and poultry where large increases in production have been achieved through application of breeding programs and other genetic improvement procedures. However, while improved strains and introduced species have potential to increase production there is clear risk of escape into the wild, and possible negative impacts on biodiversity. If the full potential for sustainable aquaculture in Africa is to be realised these concerns need to be addressed.

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1 Gupta, M.V., Bartley, D.M., Acosta, B.O. (eds) 2004. Use of Genetically Improved and Alien Species for Aquaculture and Conservation of Aquatic Biodiversity in Africa. The WorldFish Conference Proceedings No. 68. Declaration available at www.cta.int/pubs/nairobi/declaration.pdf

RECOMMENDATIONS

1. Quality seed

Given that aquaculture from small-scale, low-input systems to large-scale intensive systems can achieve potential benefits from genetic enhancement, quality seed should be made available and used in conjunction with proper broodstock and farm management.

2. Genetics in broodstock management

Since genetic resources in cultured populations can be degraded as a result of captive breeding, genetic aspects of broodstock management need to be a basic element within all aquaculture and stock enhancement programmes.

3. Responsible introductions

Introductions of fish, including genetically improved strains and alien species, may have a role in the development of aquaculture. Any movement of fish between natural ecological boundaries (e.g. watersheds) may involve risk to biodiversity and there is need for refinement and wider application of protocols, risk assessment methods, and monitoring programs for introductions of fish, including genetically improved strains and alien species. States have an important responsibility in the development and implementation of such protocols and associated regulations, the establishment of clear roles and responsibilities, and capacity building. Such efforts should be linked to obligations pursuant to the Code of Conduct for Responsible Fisheries, the Convention on Biological Diversity and other relevant international agreements.

4. Conserving wild stocks

Unique wild stocks of important tilapia species still exist in many parts of Africa. Priority areas should be identified and managed as conservation areas in which introductions of alien species and genetically improved strains should be prevented.

5. Transboundary problems in fish transfer

The majority of issues and problems associated with movement of fish and the use of genetically improved strains are common to most African countries. Countries are encouraged to: (a) look beyond borders for examples of workable policies and legislation, adopt them where appropriate to fill national policy gaps and harmonize them where necessary; and (b) use existing regional bodies or form new bodies to assist in coordinating management activities taking into account ecological realities, in particular transboundary watersheds.

6. Strengthening access to information
Baseline information on fish genetic diversity, environmental integrity and aquaculture practices exists, but it is neither comprehensive nor easily accessible. The existing mechanisms for collection and dissemination of information need to be strengthened.

7. Controlling pathogen movement
Internationally accepted codes and protocols for reducing the risk of transboundary movement of pathogens (the term pathogen used here includes parasites) through movement of fish including alien species do exist, but they do not address any specific needs regarding genetically improved species. States and other relevant bodies should evaluate the existing codes and protocols for reducing the risk of transboundary movement of pathogens through movement of fish including alien species and genetically improved strains, and adapt them for African conditions.

8. Raising awareness of risks of fish introductions
Policy-makers, enforcement agencies, stakeholders and the general public need to be made aware of issues related to, and the need for, policy on the movement of alien species and genetically altered species, and this should be high on national agenda.

9. Engaging stakeholders
Some policies relevant to movement of fish seem difficult to implement, are unknown to users, create conflicts of interest, or are viewed as restrictive, in part because they have been developed with limited consultation and participation. Formulation of policy and legislation concerning fish movement should seek to engage all stakeholders in a participatory process. In addition, governments should establish advisory groups with links to independent and scientifically competent expert bodies such as FAO, IUCN and ICLARM (now the WorldFish Center).

10. Liability for adverse environmental impacts
Although economic benefits can be derived through the use of alien and/or genetically improved species in aquaculture, in many cases, those to whom benefits accrue do not bear the costs associated with adverse environmental impacts. In view of this, there should be provision for liability, compliance (e.g. incentives) and restoration within policies and legislation concerning the movement and use of alien and genetically improved fish species in aquaculture.

These technical guidelines have been developed to support sections of FAO's Code of Conduct for Responsible Fisheries on aspects of genetic resource management in aquaculture. Guidance is provided on broodstock management and domestication, genetic improvement programmes, dissemination programmes for genetically improved fish, economic considerations in genetic improvement programmes, risk assessment and monitoring, culture-based fisheries, conservation of fish genetic resources, gene banks, a precautionary approach and public relations. The effective management of genetic resources, risk assessment and monitoring can help promote responsible aquaculture by increasing production output and efficiency, and help minimize adverse impacts on the environment. The benefits of the responsible application of genetic principles to aquaculture should be communicated to consumers, policy-makers, scientists and others interested in responsible fisheries and aquaculture.

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