Down-to-Earth Thoughts on Conserving Aquatic Genetic Diversity

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Box 1

'Threatened' freshwater fish species: Source, the IUCN red list of threatened animals, 1988, modified from Andrews, C. 1989. The size of the problem. "Fish". Newsletter of the IUCN Freshwater Fish Specialist Group. 1: p.1.

Region	Total no. of freshwater finfish species (approx.)	No. of threatened freshwater finfish species
North America[1] (USA, Canada)	700	157
South America	2,700	12
Africa	2,000 +	46(+250)[2]
Oriental Region	1,200	15
Sri Lanka	64	10

[1]According to Miller, R.R., J.D. Williams and J.E. Williams (1989), North America has also suffered the extinction of three genera, 27 species and 13 subspecies of fish (all freshwater or diadromous) over the last 100 years - see Fisheries 14(6):22-38.

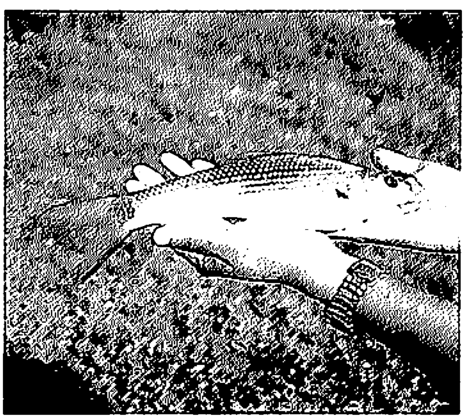
[2]The 250 species listed in brackets are the cichlids of Lake Victoria. The threat to them from the introduction of Nile perch *(Lates niloticus)* is still a matter of controversy.

Background

Environmental protection and nature conservation have a higher profile in the political arena, mass media and public awareness than ever before in modern times. Environmentalists must now consider how to ensure that this is sustained for immediate and long-term goals. Earth day affords a good opportunity for down-to-earth thoughts.

Conservation of aquatic genetic diversity faces special problems. Aquatic ecosystems are poorly understood, relatively unmanageable, shared by multiple users and highly vulnerable to human interventions and climatic change. The practical, aesthetic and moral grounds for conservation of genetic diversity are clear and generally accepted but have not prevented large-scale destruction of aquatic habitats and their biota through direct overexploitation (e.g., water abstraction and harvesting of aquatic fauna and flora at nonsustainable rates); habitat disruption (e.g., dam construction, conversion of mangroves into fishponds, coral reef destruction by dynamite fishing and siltation, drainage or salinization of wetlands): and displacement of or irreversible genetic changes in natural populations by transfers of exotic species, diseases and predators. In general, conservation of aquatic genetic diversity and development that has involved natural aquatic resources have been largely incompatible to date.

Sorting grass carp (*Ctenopharyngodon idella*) broodstock: wild carp genetic resources in Asia are now under threat. Photos by R.S.V. Pullin.



Native fish are important: *Labeo dussumieri* in Sri Lanka, a good species for fish production in seasonal reservoirs.

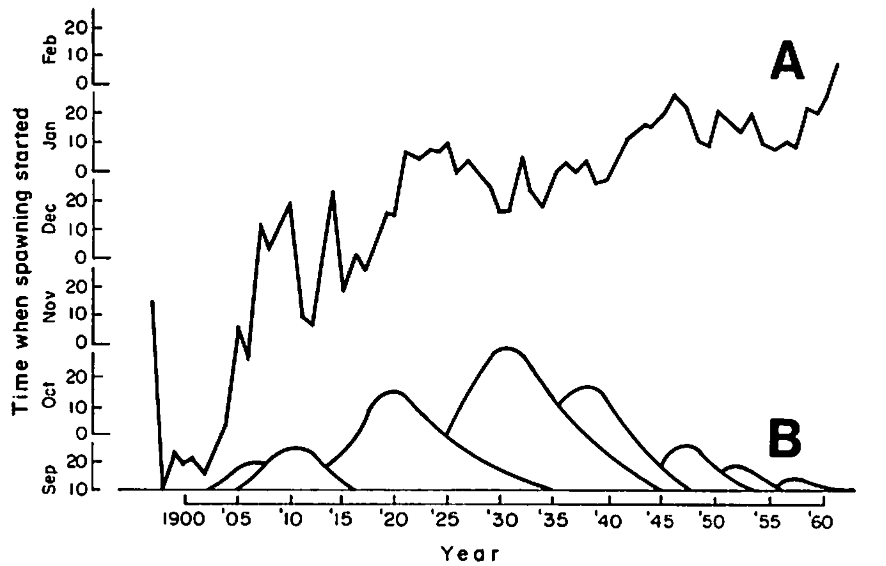
The remainder of the world's pristine aquatic ecosystems and their biota are as seriously threatened with irreversible damage or loss as are the more publicized terrestrial ecosystems and biota such as tropical rainforests and African game. Conservation of some aquatic organisms (whales, turtles) has benefitted from comparable publicity. Recognition of the problems affecting, for example, coral reef, mangrove and seagrass ecosystems is growing. The equally threatened status of many freshwater ecosystems (see box 1) is less appreciated. These often have less chance than marine ecosystems of recovery and recolonization by the previous species.

Why bother?

Even with the new wave of environmentalism, the growing pressure on freshwater and coastal ecosystems from population increase, food production, industrial development, tourism, etc., will probably mean that to answer the question "why bother?" with the answer "because it is the right thing to do" will not work. The answer "because, if we fail, it will *cost* in diminished quality of life (less food, livelihood, medicines, recreation, 'ecotourism' etc.)" seems more promising. WWF/IUCN are already using this approach successfully, emphasizing the medicinal value of plant genetic resources. However, estimating the value of "bothering" to conserve aquatic genetic diversity is not as easy as it has been for terrestrial species utilized in medicine or in agriculture.

For commercial and sport fisheries, the costs of bringing a stock to near extinction through overexploitation and/or habitat disruption are obvious. Genetic change caused by overfishing [though well-documented for example, in salmon *(Oncorhynchus tshawytscha)* and herring *(Clupea harengus)* and suspected for anchoveta *(Engraulis ringens)*[1] (see box 2)] is not widely appreciated. Unrestricted fishing removes the bulk of the fittest, most abundant individuals.

Box 2



Genetic change caused by overfishing: the example of herring *(Clupea harengus)*. The continued retardation of first appearance of herring on the spawning grounds of the west coast of Norway: A) first day catch of winter herring; B) splitting of the original run into a subset of independent groups.

According to Mathisen (1989, see below), "Another interpretation is that the original spawning group consisted of a number of units peaking successively in spawning time from November to March. Since an unrestricted fishing will hit the first segments hardest, they would be the first to go."

Perception of the genetic effects of fisheries and aquaculture and of the importance of conservation of aquatic genetic diversity remains limited and confused. There are strong lobbies against genetic "dilution" of populations by fish farm escapees (for example in Atlantic salmon - see the papers "Genetic Threats to Wild Atlantic Salmon Stocks", presented at the joint meeting of the Working Group on Introduction and Transfers of Marine Organisms, the Working Group of Genetics and NASCO representatives, 23 May, Dublin: International Council for the Exploration of the Sea, Addendum to C.M. 1989/F: 15, ICES, Copenhagen) but few perceive the importance of conserving wild stocks as future genetic resources for breeding programs in aquaculture. The application of genetics in aquaculture has only recently gained momentum. As it develops further, it is to be hoped that those working towards production of transgenic fish will not foster the dangerous and erroneous impression that this approach will make redundant the conservation of wild genetic resources.

The Bua River, Malaŵi, which drains into Lake Malaŵi and supports a strong run of 'lake salmon' *Opsaridium microlepis*. Lake Malaŵi and its associated watercourses are among the most important freshwater ecosystems in the world for conservation of aquatic genetic diversity.

[1] All these examples are discussed by Mathisen, O.A. 1989. Adaptation of the anchoveta *(Engraulis ringens)* to the Peruvian upwelling system, p. 220-234. *In* D. Pauly, P. Muck, J. Mendo and I. Tsukayama (eds.). The Peruvian upwelling ecosystem: dynamics and interactions. ICLARM Conference Proceedings 18, 438 p.

In recent years, there have been statements on a number of international meetings on the status of the wild genetic resources of some of the most promising groups of farmed aquatic organisms, for example, on tilapias, carps and giant clams (see box 3). These advances have yet to be developed into effective conservation strategies and action.

Box 3

Recent statements on threats and needs to document further the genetic diversity of farmable aquatic organisms:

a. Tilapias - Pullin, R.S.V., Editor. 1988. Tilapia genetic resources for aquaculture. ICLARM Conference Proceedings 16, 108 p. International Center for Living Aquatic Resources Management, Manila, Philippines. (French translation by Catherine Lhomme Binudin, available also).

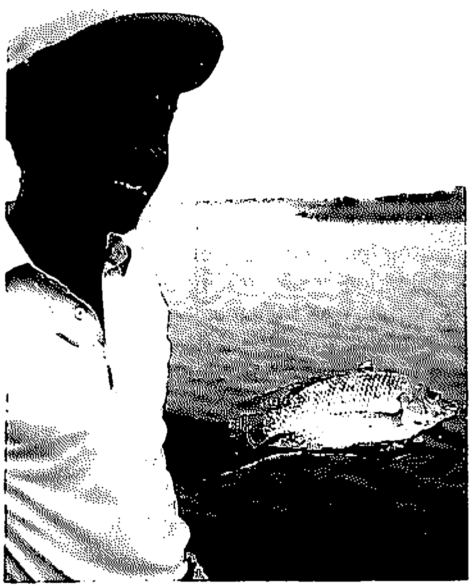
b. Carps - discussion following the paper. Differences in morphology and biochemical genetics among populations of silver carp, bighead and grass carp, presented by Dr. Li Si-Fa, Shanghai Fisheries University at the Third International Symposium on Genetics in Aquaculture, 20-24 June 1988, Trondheim, Norway.

c. Giant Clams - Copland, J.W. and Lucas, J.S. 1988. Giant clams in Asia and the Pacific. ACIAR Monograph 9. Australian Centre for International Agricultural Research, Canberra, 274 p.

Future Directions

For agriculture, Stephen Brush has summarized the well-developed and costly systems for *ex situ* crop gene banking and has recommended an expanded, complementary system of *in situ* conservation.[2] *In situ* conservation of genetic diversity in natural aquatic habitats also holds great promise -- even more so than for crops and livestock. *Ex situ* fish 'gene banks', though they will certainly have an important role in research and aquaculture breeding programs, are difficult and costly to establish and maintain. Moreover, only live fish and sperm banks are possible with current and foreseeable technology and these could not store all the species and strains required for future work.

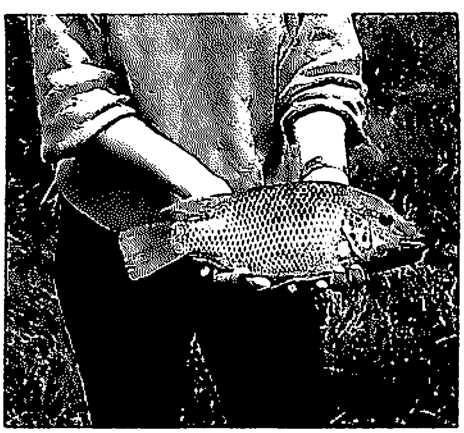
The first priority is better *documentation* of the status of the genetic diversity of aquatic organisms and greater awareness of its value. This means increased funding for training, field research, database development and awareness literature.[3] Documentation should emphasize species of commercial importance (food and ornamental fish) and the economic value of not disturbing their habitats. This will facilitate the conservation of *both* commercial and noncommercial species.



Nile tilapia (*Oreochromis niloticus*) has important populations for future breeding schemes in many parts of Africa. Here, Mr. Joseph Ofori of the Institute of Aquatic Biology, Ghana, holds a specimen of the 'Volta strain' at the Kpong headpond, near Akosombo.

A Practical Example: Tilapias in Africa

To illustrate possible action and obstacles, consider the tilapias, native to Africa. At the First International Symposium on Tilapia in Aquaculture (ISTA I) 1982, there were informal discussions towards increasing activities on the documentation, evaluation and utilization of wild tilapia genetic resources, with conservation as a common thread. Some felt, however, that past transfers of exotic species and 'strains' had been so widespread that hardly any undisturbed habitats and populations remained. Despite this, ICLARM staff and 30 like-minded collaborators from 16 countries, with support from the Federal Republic of Germany, organized a workshop on Tilapia Genetic Resources for Aquaculture, following ISTA II in Bangkok, 1987 (See box 3, a). In addition to identifying some undisturbed sites, the participants recommended "immediate conservation measures .... for the protection of important wild stocks and their natural habitats in Africa".



Oreochromis andersonii in Zambia: a promising candidate for aquaculture expansion. Its wild genetic resources merit conservation.

The documentation on the tilapias and their habitats in Africa has recently been greatly increased and a major new international database (FISHBASE) has been started by ICLARM and FAO, incorporating a tilapia strain registry and museum data, coordinated by ICLARM and the University of Hamburg. Much more documentation is needed, but the work so far on tilapias is already setting a useful pattern for work on other species groups. ICLARM hopes to convene in the near future a Genetic Resources Workshop on the Asiatic carps, in collaboration with IUCN and the Asian

[2] Brush, S.B. 1989. Rethinking crop genetic resource conservation. Conservation Biology 3(1):19-29.

[3] For the last of these, the Freshwater Fish Specialist Group of IUCN has just brought out the first issue of a newsletter, 'Fish': contact Chris Andrews, London Zoo, Regent's Park, London NW1 4RY, UK.

The author holding a bighead carp (*Aristichthys nobilis*), a species widely used in polyculture; wild genetic resources in Asia are threatened.

Lake Bosumtwi, Ghana, a site of special interest for conservation and Ghana's only natural freshwater lake: the home of *Tilapia discolor* and other cichlids.

Wetland Bureau. Evaluation of the culture potential of wild collected tilapia strains is also underway, principally by ICLARM in collaboration with groups from Norway and the Philippines. A global network on tilapia and carp genetic improvement for aquaculture is being considered.

The obstacles, however, are great. Aquaculture has as yet little economic importance in Africa. Many of the large waterbodies of Africa are shared between nations. Much disturbance of habitats and species assemblages has taken place and preventing more is difficult. Few nations have the necessary awareness, political will and enforceable legislation.

Malaŵi and Ghana are examples of nations with responsible attitudes and important fish populations. Their main waterbodies, Lake Malaŵi and the Volta system, fall under the downstream influence of neighboring nations. However, Malaŵi is making all possible efforts to conserve the Lake Malaŵi ecosystem and Ghana has established a nature reserve on an ecologically important sector of the Volta catchment.

In general, the best hope for conservation of tilapias and other African fish conservation probably lies in the protection of a realistic number of small streams and lakes that harbor important stocks, employing low profile but active measures, particularly education. Some of this could be done in existing game parks and nature reserves. Tilapias, other cichlids, cyprinids, catfishes and other species could thereby be conserved along with the more visible hippos, aquatic birds, etc. This must not be a costly exercise or it will not succeed. Most African countries having sites of special importance are unlikely to be able to invest much or any of their meagre funds directly on conservation of aquatic genetic diversity.

The key elements for success are documentation, education and linkages with other more bankable conservation efforts. The necessary funding will have to come from those who can afford it and who, though they may not realize it, will ultimately share in the benefits. The effort must be international so that all developing nations engaged in aquaculture will gain. This also means that assistance to Africa from nations more experienced in aquaculture must be increased. Global 'goodwill' is needed for success: a noble thought for Earth Day.

Tools for the Future

One final thought - as the debates continue on the pros and cons of the Convention on International Trade in Endangered Species (CITES) (for example, in relation to well-conserved *vs.* desperately poached elephant herds and other well-known, highly visible species) perhaps it is also time to reappraise the efficiency of such international 'tools' as applied to aquatic organisms. Such reappraisal should not be limited to the well-known species, such as crocodiles, turtles and giant clams: all of which can be farmed. Perhaps the best tools are those that bestow *linked* responsibilities for conserving aquatic species *and* examples of their habitats (as far as possible undisturbed) on a realistic scale. This is not a new idea: it is already being developed for wetlands conservation. Moreover, valuation of the "goods and services" provided by pristine habitats is becoming a more common tool; for example, see Dixon, J.A. (1989), Valuation of mangroves, Tropical Coastal Area Management 4(3):1 + 3 to 6 (available from ICLARM).

New wave environmentalists, longtime campaigners for nature conservation and developers and policymakers, being for the first time of one mind with respect to global responsibilities for the earth and its biota, surely now need to forge better linkages and tools for the long-term future conservation of aquatic genetic diversity.

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