Consultation on Fish Genetic Resources

Edited by

Roger S.V. Pullin
Christine Marie V. Casal

ICLARM
International Center for Living Aquatic Resources Management

SGRP
CGIAR System-wide Genetic Resources Programme (SGRP)

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Summary proceedings of a workshop convened
by the International Center for Living Aquatic Resources Management (ICLARM)
as part of the CGIAR System-wide Genetic Resources Programme (SGRP)
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member of the food web of high-biodiversity coastal ecosystems throughout
the tropical Indo-Pacific and an important food fish caught by artisanal fishers
with traditional methods such as hook-and-line. Photo by Mark Prein.

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Foreword

Fish farmers and fishers, like farmers and those who depend on the forests, face a future in which the diversity of their basic resources is under threat and the genetic composition of these resources will be increasingly reliant on human protection and manipulation. Food supply, livelihoods and income are among the stakes.

Genetic resource issues, therefore, are given the highest priority among most centers of the Consultative Group on International Agricultural Research (CGIAR). In 1994, the CGIAR established a Systemwide Genetic Resources Program (SGRP) which links 15 of the 16 centers to provide a forum for collaboration on germplasm conservation, agrobiodiversity, natural resources and ecosystem management research. Historically, most of the CGIAR work has been concerned with the genetic resources for agricultural crop and livestock production but, since incorporating aquatic and forest resources into the system in 1992, much more attention is now being given to these.

In December 1995, ICLARM, in collaboration with the SGRP convening center, the International Plant Genetic Resources Institute (IPGRI) convened a Consultation on Fish Genetic Resources as part of the greater focus on aquatic resources. ICLARM takes great pleasure in publishing the summary proceedings of that Consultation.

The purposes of the Consultation were to discuss fish genetic resources research, information, and training in the context of existing and future activities of the SGRP; to make recommendations for future fish genetic resources (FiGR) activities within the SGRP and for institutional and funding arrangements for their implementation; and to assist ICLARM and its partners in clarifying FiGR policy and intellectual property rights (IPR) issues.

It is hoped that these summary proceedings will be of use to scientists and policymakers involved in research on and management of fish genetic resources. The overviews presented by representatives of international and national institutions; assessment of ICLARM activities and linkages; perspectives on important topic such as biosafety and *in situ* and *ex situ* conservation of fish genetic resources; discussions on strategic research, training, information and policy issues pertaining to fish genetic resources; and rights and access issues are documented here. Conclusions and general recommendations were made by the Consultation.

This Consultation will strengthen ICLARM's collaboration with the institutions that participated and will lead to wider linkages and cooperation in this expanding field.

MERYL J. WILLIAMS
Director General, ICLARM

Preface

Naturally occurring fish genetic resources are of great importance for fisheries and aquaculture because they are themselves usually the sources of seed, harvested products, or both. The diversity of exploited aquatic organisms is high: of the 24 600 finfish species described, over 5 000 are used by humans. Other exploited aquatic animals total several hundred more species and many, perhaps thousands more, have potential uses. About 2 600 finfish species are exploited in capture fisheries.

Fisheries depend not only upon the genetic resources of the harvested species but also upon the many diverse aquatic organisms that comprise aquatic foodwebs and that contribute to maintaining environmental quality. Yet little is known about the genetic impacts of fisheries and enhanced fisheries, stocked with hatchery-reared juveniles (once, irregularly or regularly), are often managed without consideration of their genetic legacies for the stocked populations or for the wild populations with which these interact.

Much of the world's aquatic fauna has yet to be evaluated for aquaculture potential. Most farmed fish have not yet been domesticated and are genetically close to wildtypes. With few exceptions (for example, the common carp and some catfish and salmonids), their breeding histories are not comparable to those of crops and livestock. Captive breeding of the Asian carps, that provide most of the world's farmed freshwater finfish production, dates only from the 1960s. Some aquaculture operations, like mullet and milkfish farming, rely mainly upon catching wild fry. Hence, there is not yet a wide diversity of farmer-developed (domesticated) fish breeds, as exists for crops and livestock.

At this early stage in the domestication of fish and the exploration of fisheries genetics, fish genetic resources are being lost rapidly. Over 700 finfish species (mostly freshwater species) have become threatened by human activities during this century. Marine species, such as those associated with coral reefs and mangroves are less threatened with species extinction, but many of their local populations that are Evolutionarily Significant Units (ESUs) of biological species (i.e., stable and distinct populations that are substantially reproductively isolated from conspecific population units and that represent important components of the species' evolutionary legacy) have probably been lost and this is probably accelerating.

Conservation of fish genetic resources can be assisted by their sustainable use, recognizing the vulnerability of aquatic populations and habitats to overexploitation and to environmental damage. Fisheries and aquaculture can themselves have adverse impacts upon fish genetic resources. Fisheries usually overexploit stocks and some damage habitats through destructive fishing methods. Aquaculture can have large impacts on adjacent habitats: through water abstraction, effluents, spreading diseases, and clearance or fragmentation of habitats (e.g., mangroves). In addition to the purposeful releases of fish to enhance fisheries, farmed fish often escape from aquaculture installations. When they mix with wild stocks and disperse through natural habitats, the possible environmental consequences include: depletion or loss of wild fish stocks (e.g., by predation, competition for food or territory or diseases); changes in natural aquatic habitats (e.g., clearance of vegetation or increased turbidity); and genetic change by interbreeding. Risks of such adverse impacts are generally higher with exotic than with indigenous species. At present, particularly in the developing countries where most aquaculture is practiced, introductions and transfers of aquatic organisms, especially by the private sector, are not effectively controlled and quarantine measures are inadequate. Genetic manipulation in aquaculture is also growing fast but without adequate safeguards.

ICLARM is the only center within the Consultative Group on International Agricultural Research (CGIAR) that works on living aquatic resources. ICLARM concentrates on systems research for natural resources management and regards fish genetic resources as vital for the sustainability of systems supplying human needs for food fish. ICLARM's current fish genetic resources research, training and information activities contribute to the CGIAR's System-wide Genetic Resources Programme (SGRP).

The consultation, reported here, was ICLARM's main contribution to the SGRP in 1995, in terms of exploring common problems and approaches with the CGIAR's crop livestock and forestry centers and with others active in this field; notably FAO, IUCN, and national institutions.

This consultation was organized by ICLARM in partnership with the International Plant Genetic Resources Institute (IPGRI) and supported by funding from the SGRP. IPGRI provided wonderful support prior to and during the workshop. We thank the IPGRI Director General, Dr. Geoffrey Hawtin, and the IPGRI staff particularly Ms. Layla Daoud, for their hard work and support.

Roger S.V. Pullin **Christine Marie V. Casal**

SESSION I
OVERVIEWS OF INTERNATIONAL PROGRAMS AND LINKAGES

Chairperson: Dr. Geoffrey Hawtin

Origin, Structure, Management and Aims of the System-wide Genetic Resources Programme (SGRP)

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Abstract

A System-wide Genetic Resources Programme (SGRP) was established by the Consultative Group on International Agricultural Research (CGIAR) in 1994. This followed a Stripe Study of Genetic Resources in the CGIAR which recommended that all activities related to genetic resources be integrated, and the decision by the CGIAR to establish and fund programs at a System-wide level. The SGRP was among the first of the CGIAR's System-wide programs to be established.

The SGRP comprises individual center genetic resources programs and related activities, coordination by a secretariat and an InterCenter Working Group on Genetic Resources (ICWG-GR), and specific collaborative activities. The International Plant Genetic Resources Institute (IPGRI) is the Convening Center. Currently 15 of the 16 CGIAR centers participate and the SGRP covers agroforestry, aquatic, crop, forest, and livestock genetic resources. Coordination of SGRP activities among centers is facilitated through the ICWG-GR.

The SGRP's guiding principle is collaboration, with the aim of consolidating centers' genetic resources efforts and harnessing collective strengths for a System-wide effort greater than the sum of its parts. The overarching goal of the SGRP is to move the CGIAR forward to meet the challenges posed by the Convention on Biological Diversity (CBD) and Agenda 21. In line with the CGIAR's goals for System-wide programs, the SGRP aims to optimize efforts and the use of expertise and resources among centers to create greater effectiveness and cost-efficiency, to ensure consistency in policies and strategies, and to enhance partnerships.

Within the framework of the SGRP, the species-focused approach of germplasm conservation is incorporated into a broader framework encompassing agrobiodiversity, natural resources and ecosystem management. Activities on the conservation and use of aquatic, livestock and plant genetic resources can be pursued at an ecosystem level. The involvement of the International Food Policy Research Institute (IFPRI) and International Service for National Agricultural Research (ISNAR) provides an opportunity to address policy, economic and institutional issues relevant to genetic resources within the context of broader national and international development policies, strategies and priorities. This broad approach is critical to an effective response to Agenda 21. Development and coordination of the CGIAR centers' genetic resources documentation and information systems, and providing access to these, are pivotal to meeting the Program's aims.

The SGRP mission statement

Through coordination among the centers of the CGIAR and collaboration with partner organizations, the SGRP contributes to the global effort to conserve agricultural, forestry and aquatic genetic resources, and promotes their use in ways that are consistent with the CBD. The SGRP seeks to advance research on policies, strategies and technologies for genetic resources, and to provide information, advice and training to its partners.

The SGRP's objectives are to contribute to the global effort to conserve genetic resources and promote their use in agriculture, forestry and fisheries for the current and future benefit of humankind by:

- generating new knowledge, technologies, methods and products through research partnerships;
- strengthening institutional capacity through training and information exchange, particularly in developing countries;
- assisting in the development and implementation of policies and strategies;
- promoting institutional linkages, complementarity and synergy.

IPGRI has overall responsibility for the facilitation, coordination and representation of the SGRP. A small coordinating Secretariat, led by the SGRP Coordinator and hosted by IPGRI, assists the SGRP Program Leader (the IPGRI Director General) and supports the ICWG-GR in the representation, development and implementation of the Program. The ICWG-GR, as the Program's Steering Committee, has the responsibility of overseeing program planning and implementation, and facilitating and giving advise on the Program's development.

The independently managed and funded center programs and activities, which comprise the primary elements of the Program, together amount to an annual operation in excess of US$30 million.

The System-wide Information Network for Genetic Resources (SINGER) and Fish Genetic Resources

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Abstract

Genetic resources, the SGRP and the SINGER

Genetic resources are the most basic components of biodiversity. They are vital to ensure the continued evolution of species in response to changing environments and to both human-derived and natural stresses. The importance of genetic resources has generated significant responses through the establishment of conservation and use programs, to ensure that they will be available in the years ahead. Over time, large collections of genetic resources have been assembled by scientists and others interested in their conservation. The CGIAR centers have been very productive in amassing collections for plant agricultural species, to a limited extent, and for a few species of finfish, crustaceans, molluscs and other invertebrates.

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Currently efforts are underway to work with FAO on the conservation of livestock genetic resources. Both the conservation and use of genetic resources collections require access to data that describe important characteristics that promote accessibility and use of the genetic resources. The databases used to manage these types of data have been developed independently by countries and by international organizations over the last 20 years. The ability to search through more than one of these databases at once provides a very efficient means for locating potentially useful germplasm, especially for related organizations. It also helps to ensure accountability and transparency of the organizations that manage them. The CGIAR is currently involved in a project to develop a mechanism of this type among its centers that hold genetic resources. This paper will describe this effort and its intended results and provide some specific thoughts on the incorporation of aquatic genetic resources.

In 1994, the CGIAR instituted a System-wide Genetic Resources Programme (SGRP) with the intention of enhancing the cohesiveness of certain genetic resources activities across the CGIAR centers. The goal is to strengthen those activities that span across one or more centers by enhancing collaboration amongst Centers for those activities. IPGRI was made the convening institute for the SGRP and has appointed a coordinator to steer this effort. Centers that are participating actively with the SGRP and the SINGER project are: Centro Internacional de Agricultura Tropical (CIAT), Center for International Forestry Research (CIFOR), Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), Centro Internacional de la Papa (CIP), International Center for Agricultural Research in Dry Areas (ICARDA), International Center for Living Aquatic Resources Management (ICLARM), International Centre for Research in Agroforestry (ICRAF), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Food Policy Research Institute (IFPRI), International Institute for Tropical Agriculture (IITA), International Livestock Research Institute (ILRI), International Plant Genetic Resources Institute (IPGRI), International Rice Research Institute (IRRI), International Service for National Agricultural Research (ISNAR) and West Africa Rice Development Association (WARDA). The System-wide Information Network for Genetic Resources (SINGER) began as the first SGRP activity in mid-1994. As a component of the SGRP, the SINGER acts as the CGIAR's principal solution for access to and management of genetic resources data on a System-wide basis. It will allow concurrent access to the genetic resources data held by all CGIAR centers.

The SINGER project was made possible through funding from the Swiss government for a period of two years (through 28 February 1997). Extensive communication with all participating centers about the SINGER has taken place since March 1995. Subsequently a System-wide SINGER Planning meeting was held. It discussed issues and made decisions on the objectives for the SINGER, its data model and data delivery mechanisms.

The SINGER project includes the establishment of the network that will effectively act as the CGIAR System-wide information network after the project has been completed. The components of this network are:

1. Genetic resources and their data. The genetic resources held by the CGIAR centers are a rich source of diversity for immediate and future crop development, both for the developing and developed world. The story behind and the description of them assists in their use and accessibility.
2. Data access and/or delivery mechanism(s). This component is composed of tools and methods that allow access to data and eventually the genetic resources that these data are describing.
3. Provider components. These can be envisioned as those that cooperatively manage the data made available through the SINGER. They are also essentially the management component of the network and should direct its development over the next few years.
4. User components. This component is the focus of the effort behind the SINGER. It includes both CGIAR users and users that are collaborators with the CGIAR.

These components should all work together to provide the information needed to both run the SGRP and to provide data effectively to all those that want access to them.

What can the SINGER do for the CGIAR and its collaborators?

The Convention on Biological Diversity (CBD) is the legal instrument that provides for the fair and equitable sharing of benefits to the parties from which germplasm was acquired. This is particularly important for accessions to the CGIAR centers' germplasm collections acquired since the coming into force of the CBD on 29 December 1993. In 1994, the CGIAR centers individually signed agreements with FAO that put genetic resources collections held by them "in trust" under the auspices of FAO. These "in-trust" collections include a great deal of material that entered the collections prior to December 1993. The "in-trust" designation has effectively pushed back the date of coming into force of the Convention on Biological Diversity by making it necessary for all data pertaining to the germplasm to be shared, as well as the germplasm itself. Access to and tracking of origin and distribution data, as well as other information, are particularly important.

The CGIAR centers offered, in 1994, to the Conference of the Parties to the CBD (COP-CBD), to participate in the CBD's Clearinghouse Mechanism (CHM). This aims to promote scientific and technological cooperation, at the international level, by making available to the parties all the centers' information and data on germplasm, scientific and technological methodologies, etc. The centers are working in close collaboration with the Secretariat of the CBD to implement this through the linkage of the SINGER to the proposed CHM network of relevant international, regional and national institutions. In addition, the first session of the CBD's Subsidiary Body on Scientific and Technical and Technological Advice (SBSTTA) (September 1995) and the Second Conference of the Parties (November 1995), referred to the SINGER as an information network on genetic resources which will be useful to the international community.

There is an expanding need to be able to address information inquiries at the CGIAR System level. These inquiries originate from all categories of CGIAR collaborators; including NGOs, research scientists, policymakers, etc. Typical questions asked are: how many accessions in the CGIAR System are landraces or farmer varieties?; what proportion of CGIAR-maintained accessions originated in a specific country or region?; how many CGIAR accessions were sent to a specified country or region during a particular time period? Demands for such information are increasing, but are extremely difficult to process correctly due to lack of standardized data. In order to improve the situation, the centers have agreed to allow access to certain data fields and to provide translation of data in cases where the center's data definition does not correspond with that used for the SINGER.

The usefulness of a System-wide information network has not been experienced before in the CGIAR. The SINGER is showing that there are many potential benefits. These include: the management of safety duplication activities, joint planning of germplasm collection activities and identification of within and between Center accession duplication. It is also possible to track and to manage where and to whom germplasm has been distributed, and what and where material should be regenerated. In addition, the need to know the current status of germplasm held within the CGIAR (where it is located, how much exists) is helpful for resource allocation by System-level management. However, the System-wide effort must ensure that the SINGER and its partners are maintained after the project is finished and that it evolves with the changing and demanding needs of the CGIAR.

Genetic resources data and the SINGER

The CGIAR collectively maintains data on over 590 000 samples of genetic resources for many crop species and biological and resource system data on some aquatic animals. These data are maintained in databases that exist in 12 centers located in 11 countries around the world. All these databases have been developed and managed autonomously since their beginning. The SINGER project has determined that certain of these data should be made accessible on a System-wide basis. This would mean that particular data items and/or data for a crop that are held in more than one CGIAR center would be accessible at the same time from all centers, in the same format, and using the same basic data standards. This project has provided financial and participatory incentives for individual centers to examine the current state of their data, to improve its accuracy and try to fill gaps. Data that describe the identification of genetic resources, their transfer to collaborators and some of their morphological and agronomic characteristics will be available through the SINGER.

In many of the CGIAR centers, the management of genetic resources data may need to be rethought to allow compliance with decisions agreed upon for the SINGER. This is particularly true for those centers that do not have a single genetic resources unit or program under which all data management activities are included. In these cases, the logistical aspects of data management may not be particularly clear and there is no basis upon which such centers can quickly and efficiently build a picture of their total genetic resources situation, without considerable effort.

ICLARM is the only CGIAR center that works with and maintains aquatic genetic resources. The SINGER project has included ICLARM from the beginning, with the intention of providing access to genetic resources data throughout the CGIAR, regardless of their categorization as plants or animals. ICLARM maintains data on cryopreserved spermatozoa and captive breeding data on live fish, giant clams and sea cucumbers. The breeding data are possibly more research- rather than genetic resources-oriented. ICLARM will need to decide to what extent access to these data is appropriate through the SINGER and whether the data fit into the SINGER data model. At this time, ICLARM maintains genetic resources data in separate databases depending on the organism. ICLARM has approached the SINGER project to fund their consolidation into a single system.

ICLARM's biological databases, FishBase and ReefBase, will provide access to valuable information regarding the finfish species of the world and the coral reefs of the world, respectively. However, they are principally species- and resource systems-orientated and provide no data on genetic resources collections. The integration of such biological data into the SINGER has not yet been discussed. However, the hardware and software infrastructure that is set up for the SINGER data delivery mechanism was planned so that it could potentially be used also as an access mechanism for these and similar databases. It would, in essence, allow access to many types of data through the Internet, but not accessible through the SINGER interface. This would expand the usefulness of the SINGER project and assist with the unification of data access methods used throughout the CGIAR.

The SINGER data access methods have been designed to utilize currently available and affordable technology, to provide access to data without interfering with current center data management procedures. There are wide geographical distances between centers and all have developed and maintained their genetic resources databases autonomously. It is therefore necessary to develop data access methods that will (1) preserve existing center's autonomy; (2) provide a certain level of data standardization for System-wide access; (3) ensure that other data, such as exist in centers' databases, can be presented; and (4) provide a method whereby updates can be reflected in the centrally accessed database with the minimum of disruption of ongoing data work at the centers.

An Internet-based (World Wide Web Interface) data access method has been planned and is currently being implemented. It takes the form of a wide-area distributed database for the SINGER with data replication built into it. This option requires software and hardware at each center and will use the communication lines that are now being installed as the CGIAR's Integrated Voice and Data Network (IVDN). Structured query language (SQL) servers and software will essentially communicate with the center's database management system software. This will create a "view" of the center's data that would be composed of only those data items that would be available through the SINGER interface. This computer server will periodically talk to a computer with high speed access by Internet. The required data will be "moved" to the "central" server for access by Internet users. This is "replication" which is necessary to allow a "complete" System-wide query to take place, even if the communication link between one or more centers is down. To allow access to System-wide data for those without Internet access, a CD-ROM that will allow searching and reporting in essentially the same format, will be produced. It is expected that both of these delivery mechanisms will be available by late 1996 to early 1997. For collaborators that require paper listings or diskettes, it will also be possible to download parts of the database and send these to the interested collaborators. This will be possible for anyone with Internet or CD-ROM access.

Goals and Activities of FAO in Relation to Fish Genetic Resources

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Abstract

The importance of genetic diversity in general, and of aquatic diversity specifically, have been highlighted by recent international events. The entry into force of the Convention on Biological Diversity (CBD), the acceptance of the FAO Code of Conduct for Responsible Fisheries, and the expansion of the FAO Commission on Plant Genetic Resources to include all genetic resources for food and agriculture demonstrate that the world is becoming aware of the critical role of genetic resources in providing food and other products, recreation, functioning ecosystems and a pleasing environment today and in the future. The goals of the FAO Fisheries Department reflect the principles of the United Nations Conference on Environment and Development (UNCED) and the Convention on Biological Diversity (CBD); namely, the sustainable use and conservation of the components of biological diversity and the fair and equitable sharing of the benefits derived from such use. The primary focus for FAO activities is the world's poor and the low income, food deficit countries.

In order to fulfill the mandate with regard to fishery genetic resources, four main areas of activity have been undertaken: i) documentation and characterization of genetic diversity, ii) identification of threats and opportunities, iii) identification and evaluation of new technologies, and iv) identification of trends, e.g., in resource status, development, demography, etc.

Documentation and characterization are the vital first steps in the conservation and sustainable use of genetic diversity. Knowledge of the genetic resource base available to fish farmers in the form of genetically diverse populations or genetically improved breeds will help to optimize production, to manage broodstock more effectively, and to evaluate selection programs. Fishery managers will need to know the genetic stock structure of wild populations to set stock-specific harvest quotas, to minimize risk of species transfers, to choose appropriate stocks for fishery enhancement, and to identify and to manage species or Evolutionarily Significant Units that may be at risk.

However, the numbers of and products from many of the fish species that are utilized in capture fisheries and aquaculture are very imperfectly known. The genetic stock structure of most of the world's

fisheries is also poorly known. Of the top five categories of aquatic production statistics for 1993, the single largest category is for 'marine fishes not reported by species'; the fourth largest category is for unidentified freshwater species (Fig. 1). Many species used for aquaculture are also not reported by species, and in some cases even the farmers do not know what species or strain they are growing.

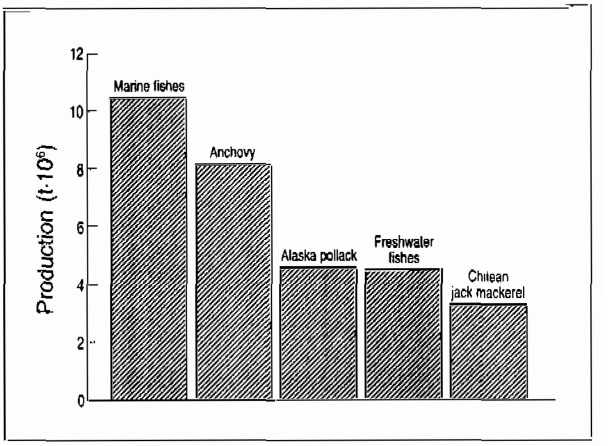

Fig. 1. Fishery (capture + aquaculture) production for 1993 of the top five categories of aquatic organisms. "Marine fishes" and "Freshwater fishes" represent categories where production is not reported by species. (Source: FAO FishStat PC 1995).

Once a resource base has been described, the threats to and opportunities for the use of the resource can be better identified. The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) established under the CBD has identified four main areas of threat to marine biodiversity that can be extended to aquatic diversity in general. These comprise the threats from: i) alien species, ii) aquaculture, iii) improper area management, including pollution from land-based and other sources, and iv) overexploitation. These areas also present opportunities to utilize genetic diversity in that the activities are part of established development practices and the use of genetic principles will make them more sustainable in the long term.

New technologies both to utilize and to document genetic resources have developed quickly over the last ten years. Genetic resources can now be described by a variety of extremely sensitive methods including nuclear and mitochondrial DNA analysis through sequencing, mini- and microsatellites, DNA fingerprinting, and restriction fragment length polymorphisms, and isozyme analysis which is comparatively easy and inexpensive and has a wealth of comparable data for many aquatic species.

Breeding programs have demonstrated that substantial long-term improvement in commercially important characters is possible through conventional selective breeding, whereas immediate improvement is possible through chromosome manipulation and hybridization. The production of transgenic organisms becomes possible as characters controlled by single genes are discovered and the genes and their regulators identified. However, transgenic production is currently a medium-term activity that must involve additional research and adequate safeguards. It will probably be integrated with other genetic improvement strategies. The use of genetic technologies must be consistent with the biological, development or scientific problem that is being addressed.

Trends relating to genetic resources reflect the acute need to increase production from the aquatic environment. Overexploitation has been a trend that is hopefully being curbed as stocks are depleted. There appears to be a marked intensification in the use of aquatic systems, both natural and artificial. Stocking and enhancement of waterbodies may utilize improved breeds or organisms genetically altered to minimize genetic impacts on natural populations. The movement of aquatic species will increasingly involve strains and genetically altered organisms, as these become commercially viable. There also appears to be a trend away from strict regulation of products of conventional breeding, whereas gene transfer technologies are heavily regulated in many areas.

The above activities and concerns in the area of fish genetic resources are being incorporated into FAO's program through the normative section of the regular program in Rome, field activities in Member Countries, the development of international policy such as the Code of Conduct for Responsible Fisheries, participation in international fora, publications, and through the assistance of regional fisheries bodies. It is apparent that, in today's world, no single organization can cope with the multitude of problems facing the conservation and sustainable use of fishery genetic resources. Therefore, the Fisheries Department of FAO is improving and establishing important linkages with relevant international bodies such as other UN agencies, ICLARM, the CBD and its subsidiary bodies, international organizations and NGOs. These linkages are essential to provide consistent advice, to form synergies and to avoid unnecessary duplication of effort.

IUCN and Fish Genetic Resources

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Conservation and sustainable use of biodiversity are at the core of the IUCN mission. IUCN - the World Conservation Union - contributes to the conservation and sustainable use of marine biodiversity through three components, which are:

1. Its Members - over 900 non-government organizations, government agencies and governments, including the International Plant Genetic Resources Institute (IPGRI) and the International Center for Living Aquatic Resources Management (ICLARM).
2. Its Secretariat, which has global, regional and country program offices. The global Secretariat includes the Marine and Coastal Programme as well as other programs addressing aspects of marine biodiversity (e.g., biodiversity policy and economics, protected areas, species conservation and sustainable use, wetlands conservation and sustainable use). IUCN's efforts are increasingly focused at the regional and country levels.
3. Its Commissions, which include global networks of specialists. Several of the commissions contribute to the conservation and sustainable use of marine biodiversity. These include: the Commission on National Parks and Protected Areas (CNPPA) which has a theme area on Marine Protected Areas; and the Species Survival Commission which has several Species Survival Groups focused on marine species (e.g., sharks, marine turtles, coral reef fish).

The IUCN Marine and Coastal Programme facilitates and coordinates efforts in the conservation and sustainable use of marine biodiversity with IUCN Members, the Secretariat and the Commissions. The overall themes of the Programme are: conservation of marine biological diversity, sustainable use of living marine resources, integrated coastal and marine management, and marine protected areas. The Programme works in collaborative partnerships with key international marine and coastal programs, e.g., the World Bank, UNEP (especially the Regional Seas programs), IOC (including the Global Coral Reef Monitoring Network), UNESCO, and the World Conservation Monitoring Centre.

The IUCN Marine and Coastal Programme works to ensure that marine biodiversity conservation and sustainable use is addressed in international conventions and programs, e.g., the Convention on Biological Diversity, the International Agreement on Land-Based Activities, and the International Year of the Reef (IYOR).

Animal Genetic Resources Activities at the International Livestock Research Institute: Commonalities and Differences with Fish Genetic Resources

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Abstract

Over 40 livestock species are presently used for food and agriculture. These animals have adaptive attributes and provide unique genetic material for numerous smallholders in developing countries. The International Livestock Research Institute (ILRI), through its research on animal genetic resources as part of the System-wide Genetic Resources Programme, aims to ensure that the diversity of important domesticated animal germplasm in developing countries is safely maintained and remains a functioning part of the farm production system. Specific objectives toward achieving this goal include: the development of baseline information on indigenous livestock populations; the characterization of these populations in terms of their physical, physiological and adaptive attributes and their performance under traditional and alternative development of strategies to halt or reverse the process; the estimation of genetic diversity among and within populations; the development of strategies to incorporate adaptive traits into breeding programs; and the identification of national and regional constraints that prevent the use and improvement of indigenous animal genetic resources and of solutions to alleviate these constraints.

Through the years, ILRI has concentrated its efforts on the three major species found in sub-Saharan Africa - cattle, sheep and goats. A comprehensive review of conventional and non-conventional literature on cattle has been completed. The review on sheep and goats has started. ILRI has developed a database, the Domestic Animal Genetic Resources Information Database (DAGRID) which covers the geographical distribution, the physical characteristics, the performance and population data and the unique genetic and adaptive characteristics of African indigenous breeds. Plans have been made to expand the database and to incorporate a menu-driven module and full color pictures of the breeds and to publish breed catalogs for cattle, sheep and goats. Pilot projects in four African countries are being used to test methodologies for rapid field surveys aimed at obtaining population statistics of individual breeds/strains and data on physical characteristics. Results from these projects will be used to standardize the survey methodology, which will be implemented by the national agriculture research systems.

Research, both on-farm and on-station, has been and is being conducted to study the genetics of trypanotolerance of cattle and genetic resistance of small ruminants to endoparasites. Studies are also being conducted to quantify the between and within breed variation in deposition and mobilization of body reserve and to characterize the Sanga cattle for heat tolerance, selective grazing and tick resistance.

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Studies to quantify genetic diversity and estimate genetic distances within and among the African cattle populations using microsatellite markers are being carried out. This effort is to be expanded to cover sheep and goats.

Although livestock and aquatic species have usually been considered separately in various fora, livestock and fish have always played important roles as sources of animal protein. Some issues related to their genetic resources, in terms of similarities and differences, are presented in Table 1.

Table 1. Commonalities and differences between livestock/animal genetic resources (AnGR) and fish genetic resources (FiGR).

	AnGR	FiGR
Rationale for conservation		
Diversity	medium	high
Asset to rural smallholders	high	high
Adaptation to various environments	high	high
Genetic erosion	high	high
Knowledge about the genetic resource	little	little
Characterization		
Baseline information	moderate	limited
Performance recording	moderate	limited
Molecular characterization	recent	beginning
Conservation/utilization		
In situ	implemented	implemented
Ex situ	expensive/limited	very limited
Germplasm movement/health	some guidelines	in early stage
Ownership/management		
Individual	common	rare
Communal	limited	common
Regional	none	common
Policy		
Property rights	inadequate	inadequate
National legislation/control		
- Existence	yes	yes
- Enforcement	poor	poor

Forestry, Fish and Crop Genetic Resources: Commonalities and Differences for Effective Conservation, Sustainable Management and Use

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Abstract

Crop genetic resources conservation and use have been characterized by an extractive approach; hence, the development of large *ex situ* genebanks. This has not been done so far for forestry and fish genetic resources. For forestry and fish genetic resources conservation, an ecosystem approach is needed. The following table summarizes some of the characteristics of forestry, fish and crop genetic resources. Such comparisons have limitations. The important decisions to be made with respect to fish genetic

resources are the scale and scope of conservation efforts; the connections among the various actors that design and implement them; and the policies that are devised to support them. Fish genetic resources have some properties that make their conservation and use different from forestry and crop genetic resources; in particular their mobility, and the financial and technical constraints to *ex situ* genebanking. Knowledge about agricultural systems and watersheds is important for freshwater fish genetic resources conservation.

Table 1. Fish (FiGR), forest (FoGR) and crop (CGR) genetic resources: commonalities and implications for effective conservation, sustainable management and use.

Characteristics	FoGR	FiGR	CGR
Ecosystem/habitat	Natural/seminatural	Natural/seminatural	Managed/seminatural
Species diversity	High	High	Low; efforts on few species and varieties
Population intraspecific diversity	High outcrossing rates; widespread populations	High	Variable
Individual	Long-lived; most seeds recalcitrant	Long- and short-lived, according to species	Annual; short-lived
Selection and breeding techniques	Broad genetic base; multiple breeding populations	Under development	Annual or shorter breeding breeding cycles; daptedness
Conservation methods	Dynamic programs *in situ* most appropriate/*ex situ* to complement	Dynamic programs; *in situ* priority/*ex situ* to complement	*Ex situ* important; *in situ* for landraces and wild relatives
Harvesting techniques	Extensive over large areas; low intensity extraction, controlled by site	Extensive over large areas; low intensity extraction, controlled by site	Intensive

Regulatory Frameworks: A Summary of Issues

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Abstract

Recent work has highlighted the important influence of regulatory frameworks on the development of the agricultural seed sector worldwide. Protocols covering plant breeding procedures and methods, variety release regulations, seed certification procedures and standards, plant variety protection and quarantine regulations all shape the organization and output of the seed sector - whether these things are formally covered by national seed legislation, or are simply a set of agreed practices.

It is often assumed that regulatory frameworks tend to work towards reduced crop genetic diversity over time, and that there is a real danger of overbureaucratization: regulation beyond the point where some control is helpful.

There may be parallels between the experience with regulatory frameworks for crop genetic resources and those for fish genetic resources. Consider two examples relating to the sustainability of systems supplying fish for human needs:

Breeding and release of varieties

Can and should the crossing of any combination of wildtypes and/or bred varieties, and the distribution of the results be allowed? Are there already variety release mechanisms that place limits on this? Should there be such mechanisms? Do they and/or should they evaluate material according to the distinctness, uniformity and stability criteria used in the plant breeding world? This has implications for the sustainability of the genetic base in fisheries relying on captive-bred populations.

Quality and control

- *Genetic:* when producing fish or fish seed for distribution commercially or otherwise, is there any statutory verification of the genetic quality of the fish seed sold? How can buyers be sure that they are being sold the fish type that they requested?
- *Quarantine and disease control*: there are clearly major environmental and economic dangers from the spread of disease in fish stocks, not only for individual fisherfolk but also for, for example, countries reliant on fish exports for foreign exchange.

The information in this abstract is derived from ODI's current research work on seed regulatory frameworks and resource-poor farmers in Asia, Africa and Latin America.

Session I - Discussion

Pullin: Most fish used by humans, in fisheries and aquaculture are wildlife but are not usually considered as wildlife by the Ministries that have responsibility for these sectors. Fish are often only considered 'wildlife' when they are in nature reserves or managed protected areas - when they may in fact be less wild.

Welcomme: Another problem is that institutional responsibilities for fisheries and aquaculture may be split between different Ministries: fisheries, aquaculture, parks and wildlife, etc.

Harvey: What is the meaning of 'in trust' as the term is applied to plant germplasm and what might this imply for *ex situ* fish germplasm?

Hawtin: The plant genetic resources that the CGIAR centers hold 'in trust' for global access represent a large proportion of the total genetic diversity for some of the world's major crops. Designated 'in trust' germplasm is held under the auspices of agreements between FAO and the centers concerned. The CGIAR has nearly 600 000 accessions in plant genebanks.

Pullin: Fish genetic resources held *ex situ* represent, by comparison, only a minute proportion of the total genetic diversity of exploited fish species. However, FAO is broadening the mandate of its Commission on Plant Genetic Resources to become the Commission on Genetic Resources for Food and Agriculture, including livestock and fish. So, the question of whether *ex situ* fish genetic resources should be designated as 'in trust', in the same sense as plant genetic resources, will have to be resolved.

Bartley: Can Keith Hammond please outline some of relevant breeding work with livestock to illustrate commonalities and differences with fish?

Hammond: Livestock breeders have tended towards developing and distributing single breeds, hoping that these would then adapt to different situations. We realize that we don't know enough about that process. The idea is to use adaptation, rather than a genetic improvement program as such. However, there are some terminology problems here. We need to standardize on common terms.

Welcomme: Yes, and FAO will need to consider, for its enlarged Commission on Genetic Resources for Food and Agriculture, to what extent it can deal with all genetic resources on a common basis or on an individual sectoral basis. A matrix approach can work but note the added complication for fish: capture fisheries that deal with wild stocks and aquaculture that deals with farmed fish. The livestock equivalent of the former would be 'bush meat' which is extensively used in Africa.

Harvey: Standard terminology is definitely needed. On what basis does Keith Hammond feel that fish genetic resources are less threatened than animal genetic resources?

Hammond: As with agriculture, we are dealing here with food production from populations, which are also genepools - whether you think of thesc at the species or variety levels or at other taxonomic levels is not so important. However, most of the fish literature seems to have the species as the primary lower limit for considering resources, whereas for livestock, the primary lower limit is the breed. At the breed level for livestock, there is a lot of documentation on breeds at risk, certainly more than I have seen for species of fish. However, these comparisons are not important compared to addressing the imperatives for food and agricultural production.

Froese: There are about 600 fish species on the IUCN Red List, for which at least one population is at risk. Freshwater fish species are more threatened than marine species.

Hammond: For livestock, there are 800 breeds that have less than 20 breeding males left, or less than 1 000 breeding females. There seems to be a communication problem here because the information on fish genetic resources at risk is not easily available.

Hodgkin: For crop plants, the 'conservation unit' would be considered by most to be the gene or allele, not the breed as for livestock.

Hammond: So there are large differences here between conservation perspectives for crop plants (alleles) and livestock (breeds, combinations of complex traits) and fish (species).

Beardmore: But we are not comparing like with like. The important question is how genetic variability is distributed among farm populations and among wild populations. For example, compare the feral camel populations of Australia with the domesticated camels of the Middle East.

Hammond: Yes, and under the Convention on Biological Diversity, for livestock, countries are concerned to exercise their sovereignty over their populations of livestock, i.e., their breeds.

Hawtin: In conclusion, this raises many questions such as who is doing the breeding? how easy is it to transfer genes? how important are breeds and gene complexes? what are the problems and the challenges for fish breeders and conservation of fish genetic resources? The experience of crop and livestock breeders could be useful - but rather than look for commonalities from the outset, let's explore the fish genetic resources issues first.

SESSION II
ICLARM'S ACTIVITIES AND LINKAGES

Chairperson: Dr. John L. Munro

ICLARM's Fish Genetic Resources Activities*

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Abstract

ICLARM's current fish genetic resources activities comprise the following:

- Development of research methods and approaches to the characterization, documentation and conservation of fish genetic resources.
  This includes multiple interactions with members of the International Network on Genetics in Aquaculture (INGA) (see p. 18) as they develop their biodiversity and genetic resources research agendas; and a collaborative research project on biochemical methods for tilapia characterization, with the Institute of Aquatic Biology, Ghana and the University of Hamburg.
- Research for the development of coastal aquaculture and enhanced fisheries, principally in coral reef environments, through sustainable use of fish genetic resources (finfish, giant clams, pearl oysters, sea cucumbers), including research on marine protected areas.
  This is undertaken mainly at ICLARM's Coastal Aquaculture Centre (CAC), near Honiara, and the Nusa Tupe Field Station, near Gizo, Solomon Islands, with institutional linkages around the tropics.
- Further development of the global database, FishBase, on the biology of exploited finfish, in collaboration with FAO and numerous developed- and developing-country partners (mainly museums and universities).
  This is undertaken mainly at ICLARM's Manila Headquarters and is distributed on CD-ROM.
- Contributions to the meetings and the still evolving mechanisms of the Convention on Biological Diversity (CBD), including its Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), and to Global Biodiversity Assessment (GBA) efforts.

From 1996, ICLARM will execute these and other fish genetic resources activities by means of a new Biodiversity and Genetic Resources Program, which has the following objectives.

Overall Objective: To contribute, through multiple partnerships, to the characterization, evaluation and conservation of aquatic biodiversity and genetic resources, for their use in providing food, employment and a healthy environment. The beneficiaries will be those who depend upon living aquatic resources; especially the resource-poor fishers, farmers and consumers of aquatic produce in the developing regions.

Specific Objectives:

- To generate, through strategic research partnerships, new knowledge, methods and tools for characterizing, evaluating and sustainably using aquatic biodiversity and genetic resources.
- To provide training courses and materials that will increase the capacity of those concerned with the conservation and use of aquatic biodiversity and genetic resources (researchers, developers, teachers, policymakers, and the private sector, including farmers and fishers) to manage these assets widely, for the needs of the present and future generations.

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*ICLARM Contribution No. 1342.

- To assemble, through global partnerships and networking, comprehensive databases on aquatic biodiversity and genetic resources; accessible to all who require such information for research, development, policymaking and education.
- To participate in international, regional, national and local fora in which research, training and information on aquatic biodiversity and genetic resources are discussed and advice is sought for their conservation and sustainable use.

Fish Genetic Resources Databases, Present and Future*

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Recent developments in information technology have practically removed the limits for data storage and data processing capacity. The CD-ROM disk is a cheap (~$2 per disk) medium to store up to 650 megabytes of data. A new standard with 5 gigabytes storage will be available in 1997. Current notebook computers have the processing power of 10-year old mainframes. Prices for powerful desktop computers are clearly below $2,000. Because of the limited lifespan of computers (max. 5 years), this hardware is regularly replaced and thus upgraded. Most research institutes in developing countries now have fast desktops with CD-ROM drives.

Relational databases have emerged as a software capable of dealing with millions of records in a rigorous and reliable form. Because of their ability to link independent datasets, relational databases are the only software where one can get more out than has been put in. To give a very simple example, by linking a global list of species used in aquaculture with a list of species occurring in a given country, one can generate a list of all fish with potential for culture that are present in the country.

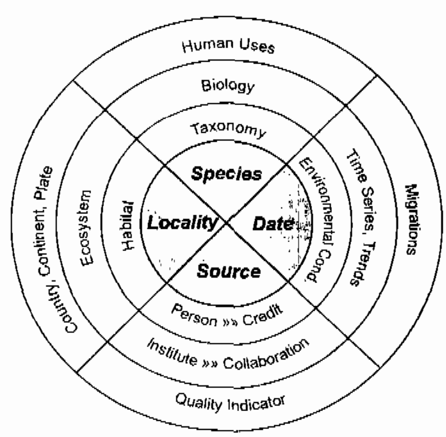

Fig. 1. Relational links between occurrence data and other data sets. (Source: Froese, R. and D. Pauly. Bioquads: four bits of information are suggested as necessary, and often sufficient for biodiversity studies. Paper submitted to BioScience).

Storage capacity and processing power allow new approaches to data analysis. For fish genetic resources, one could think of combining in a single database the estimated 10 million existing records on the occurrence of fish in space and time. Combined with other existing datasets on, e.g., biology, status of threat, genetics, climate, oceanography and human uses, it will be possible to document the current status of fish resources, predict trends and identify species of special interest for culture, medicine, aquarium trade, restocking, etc. (see Fig. 1, which indicates relational links between occurrence data and other data sets). The FishBase Project which maintains a global biological database on finfish, intends to show the feasibility of this approach.

*ICLARM Contribution No. 1343.

Fish Genetic Resources and the Coastal Aquaculture Centre*

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Abstract

ICLARM's principal activities concerned with fish genetic resources in the marine environment are undertaken at its Coastal Aquaculture Centre (CAC) in the Solomon Islands. The organisms involved are giant clams, pearl oysters and sea cucumbers, characteristic of the coral reef flats, slopes, shelves and lagoons which comprise coral reef resource systems. The principal objectives of the CAC are the development of sustainable, small-scale, farming systems and fisheries enhancement systems for coastal villagers living adjacent to coral reefs.

The CAC does not currently undertake any *ex situ* genetic resources conservation work, although cryopreservation techniques for sperm and larvae are fairly well established for some bivalve molluscs and might be contemplated in the future in connection with specific medium-term projects. Live broodstock of sea cucumbers are held in tanks on a transient basis, used for spawning and then replaced on the reefs. This cannot be considered as *ex situ* conservation.

In the case of giant clams and pearl oysters, the CAC maintains *in situ* conservation systems by keeping broodstock in fully controlled marine protected areas (MPAs). The species involved are the giant clams *Tridacna crocea, T. derasa, T. gigas, T. maxima* and *T. squamosa* and *Hippopus hippopus;* and the pearl oysters, *Pinctada margaritifera* and *P. maxima.* The larger species of the clams, *T. derasa* and *T. gigas* and *H. hippopus* are threatened species, having been extinguished in many parts of their ranges, whereas all of the other species have been seriously reduced in abundance by overexploitation in many areas of the tropical IndoPacific.

The marine protected areas include a 100 m wide strip of fringing reef adjacent to the CAC's Nusa Tupe field station in the western Solomon Islands, about 300 km from the CAC. Both of these MPAs are protected by exclusive 50-year leaseholds extending to 2038.

All bivalve broodstock are individually numbered. They have all been collected within the Solomon Islands, normally by purchase from individual villagers. Those at the CAC are brought ashore for spawning induction as required and then restored to holding areas on the reef. Those kept at Nusa Tupe constitute a reserve of broodstock. A total of about 500 broodstock are currently on hand. Currently, sea cucumbers cannot be tagged and are thus not identifiable on an individual basis.

Batches of selected specimens from successive cohorts are maintained at the Nusa Tupe MPA for future selective breeding. These have been the best-growing individuals of a cohort, but specimens of the

*ICLARM Contribution No. 1344.

more decorative species (*T. crocea* and *T. maxima*), chosen for their color, are also now being maintained in these *in situ* collections.

COHORTS, a relational database, has recently been completed. This is to be used for tracking the origins and dispersal of successive cohorts of bivalves as they are dispersed from spawning tanks, through hatchery and nursery tanks and to various ocean nurseries.

Four shipments of post-larval *T. gigas* have been sent from the Solomon Islands to the Philippines in the past six years to assist in the reestablishment of this species. The oldest of these cohorts are now nearing maturity and will be crossed with material from the Great Barrier Reef with a few specimens in the Philippines and the progeny reared in MPAs.

ICLARM is also undertaking work on natural recruitment of selected invertebrates to an MPA in the Solomon Islands and will shortly embark on two projects in the Caribbean (Discovery Bay, Jamaica, and in the British Virgin Islands) covering fish and invertebrates. The reestablishment of viable breeding stocks in MPAs and consequent conservation of genetic resources is an important component of this work.

Fish Genetic Resources, the International Network on Genetics in Aquaculture (INGA) and Breeding Programs*

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Abstract

Domestication of aquatic animals (mainly crustaceans, molluscs and finfish - here collectively termed 'fish') and aquatic plants has a short history compared to that of crops and livestock: less than a century for many farmed aquatic species. Many aquatic species have still to be evaluated for aquaculture potential. Hence, the world's aquatic genetic resources are mainly to be found *in situ*: as wild populations in seas, rivers, lakes, reservoirs and associated wetlands. Large *ex situ* genebanks, such as are maintained for crops, are less feasible for fish because of the high costs of keeping live collections and because, for most fish, only spermatozoa (not eggs and embryos) are amenable to cryopreservation. However, limited *ex situ* collections of fish germplasm are held by public-funded institutions and by the private sector. Moreover, as aquaculture and fisheries stocked from hatcheries contribute increasingly to the world's supply of fish, *ex situ* fish genebanks will become increasingly important, complementing *in situ* fish genetic resources conservation and fish broodstock maintained on fish farms.

Fish genetic resources conservation and sustainable use are complex objectives that require international collaboration. Hence, at the suggestion of the United Nations Development Program (UNDP), ICLARM and thirteen developing-country members have formed an International Network on Genetics in Aquaculture (INGA). ICLARM is the Member Coordinator and the current developing-country members are: Bangladesh, China, Côte d'Ivoire, Egypt, Fiji, Ghana, India, Indonesia, Malaci, Malaysia, the Philippines, Thailand and Vietnam. The INGA is a joint program of all participating countries and ICLARM, and hence, is jointly owned and jointly managed. Participating member countries and ICLARM carry out

*ICLARM Contribution No. 1345.

cooperative research and trials, and make the results available to each other for information and follow-up strategies. Likewise, the products of research (improved fish breeds) are among the interested member countries. INGA's program planning is guided by a Steering Committee composed of selected aquaculture geneticists from different member countries.

The objectives of the INGA are as follows:

Near-term

- To evaluate, through linkages among national scientists and institutions, using standardized protocols, the culture performance of promising lines of tilapias and carps in selected countries (representing a range of agroclimatic and developmental scenarios) wherein these species are important or potentially important for poor farmers and consumers.
- To assess the needs and opportunities for the application of genetics to increase the productivity of cultured fish.
- To link together established and potential aquaculture geneticists from different countries so as to ensure mutual awareness of each other's activities, in the application of genetics to inland aquaculture, and to foster regional and interregional cooperation.
- To assist in the development of strategies for national fish breeding programs.

Long-term

- To contribute, through collaborative research, to the domestication and sustainable performance of tropical finfish species farmed in developing countries.
- To demonstrate that the application of genetics, especially selective breeding, can greatly increase the productivity, profitability and sustainability of low-cost input agriculture in developing countries and can thereby generate support for self-sustaining national fish breeding programs.
- To strengthen the long-term national capabilities for continued genetic enhancement of farmed fish through exchange of germplasm and methodologies, and through training and interactive fora.
- To strive for the conservation of biodiversity in farmed and wild populations of tilapias, carps and other fish species prominent in inland aquaculture in developing countries.

Where transfer of fish is involved, appropriate precautions, including quarantine, are taken in strict compliance with existing International Codes of Practice and emerging protocols that help to prevent harmful impacts on environment. Members of the INGA have also evolved their own voluntary protocols on biosafety (see p. 34). The research in each country focuses on the respective preferred species, with initial emphasis on the tilapias and the carps, whereas the activities in which the individual member countries participate depend upon their needs and resources. Exchange of improved breeds either for evaluation followed by direct use in aquaculture, or for utilization in breeding programs for incorporating specific useful traits is guided by the policies of the individual member countries.

ICLARM, its INGA partners and others collate and disseminate information on fish genetic resources, through global databases and CD-ROMs, including documentation for the conservation of local knowledge pertaining to fish genetic resources. The main outputs of these partnerships are methods, approaches and information for fish genetic resources conservation, germplasm enhancement and breeding. The aim is to assist the development of national programs for genetic resources conservation and for germplasm enhancement and breeding.

More information about the INGA can be obtained from its Coordinator, Dr. Modadugu V. Gupta, at ICLARM.

An Example of a NARS (IAB)-ASI (ZIM)-IARC (ICLARM) Partnership for Research, Training and Information

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Abstract

Productive research partnerships or collaborations for research, training and information involve National Aquatic Research Systems (NARS), Advanced Scientific Institutions (ASIs), International Agricultural Research Centers (IARCs) and international funding agencies. An example is the collaboration among the Institute of Aquatic Biology (IAB), the Zoologisches Institut und Zoologisches Museum (ZIM) and the International Center for Living Aquatic Resources Management (ICLARM) funded by the Deutsche Gesellchaft für Technische Zusammenarbeit (GTZ). The collaborative research in which IAB, ZIM and ICLARM have been involved has been primarily on species characterization of tilapias as a basis for their sustainable use in fisheries and aquaculture.

Partnerships are formed for different purposes. A research partnership or collaboration is a way by which groups with different research capacities combine their strengths and come up with a project or product which could not have been possible without their combined efforts. The NARS brings in scientists and technicians, scientific information and the local knowledge that only they can provide. The collaboration also enables them to develop highly trained scientific personnel and to broaden the scientific information that they can utilize to improve their agriculture/aquaculture production.

The ASI, on the other hand, contributes to the partnership by bringing in its scientists, advanced technical expertise, modern laboratories to develop new laboratory methods and to train the scientific personnel of the NARS. It contributes to increasing the scientific know-how and knowledge available to the NARS.

The contribution of the IARC to the partnership is to share its expertise on broadening the application of a methodology developed to benefit not only the country where the NARS is situated but to other countries that might be able to use it, to facilitate the development of the technique and to disseminate information to other probable users.

The funding agency supports the partnership by providing funds to assist in the human resource capacity building of the developing country or the NARS and in so doing ultimately helps in increasing food production in a country, region or worldwide.

A successful collaboration may also have minor problems and dissatisfaction among the partners. These usually stem from the different interpretations of the partners as to what questions the research should be able to answer; e.g., developing countries usually expect research to produce a better product in a very short time. Funding agencies on the other hand expect sustainability and evidence of impacts of the results. However, collaborative research brings a wide array of techniques and expertise to the collaborating group.

Session II - Discussion

Pullin: Ultimately, for the conservation and sustainable use of living resources, the world will need to have a complete inventory of these, in terms of their genetic diversity, abundance and distribution. This would help, along the way, to set some research agendas. It has already been done for some charismatic wildlife species, like the tiger. Obviously it is more difficult for fish, invertebrates and microorganisms but I believe that this goal is attainable. In fact, fisheries biologists might take a lead here because fisheries science has tools for estimating population size, etc. ICLARM has a proposal for a project on the genetic diversity, conservation and use of a fresh- and brackishwater tilapia *(Sarotherodon melanotheron)* the various subspecies of which range from Sénégal to Zaïre. This will be a case study, a very small step towards the larger goal. I'm not sure what others think of this ambitious goal. Could it ever be attained for all aquatic species?

Harvey: I think it's attainable for economically important species, but for others how would the necessary support be obtained, with no economic arguments? The economic evaluation of aquatic biodiversity and genetic resources is needed to help such studies.

Abdou-Salam: This goal is possible, in two stages: the first dealing with highly valuable species - say, the fish species of the major shelf fisheries; the second with species that are threatened.

Bartley: For databases, especially biodiversity databases, maintenance and regular updating are critical because threats to populations and their status are subject to change. This is expensive and difficult.

Toll: Are there academics, hobbyists, museums, etc. that have the kind of information needed for this? Or is some of it available in grey literature? In the plant world, the botanical gardens have a lot of information for efforts like this.

Pullin: Bird conservationists certainly take this approach (diversity, abundance and distribution) whether the bird species are of economic importance or not.

Munro: What you are suggesting is demanding and technically very difficult; for example, studies along the entire range of a tilapia species from Sénégal to Zaïre.

Pullin: Yes.

Munro: In multispecies fisheries, this would be so horrendously difficult as to be almost inconceivable.

Pullin: For stock assessments plus diversity assessments?

Munro: Well, if you want to know the status of stocks of your case study species in every estuary and river along the coastline, this would be enormously expensive and probably not worth doing because their status could change from year to year quite rapidly.

Froese: There are already large amounts of the data, much of it computerized, that are needed for the long-term goal mentioned here. It can certainly be done given the necessary cooperation. The four attributes that we have proposed for encounters between biodiversity and humans (species name, data, locality, source) are our current approach to this. There are millions of such records for fish, the largest and oldest vertebrate group. More are collected everyday.

Pullin: A question to Paul Holthus - the case study species that I mentioned has five subspecies. For IUCN to decide that a species should go on the Red List, how are decisions made? Usually, I would guess in the absence of genetic data.

Holthus: For aquatic organisms the process has not yet been developed very well. As desirable as your overall goal is, is it really a priority when we look at what's happening in the meantime? For example, a Shark Specialist Group has been started up in the Species Survival Commission because of the threats to that group of fishes. This will attempt to do for sharks essentially what you are suggesting. Similar needs and opportunities may go by while the world is trying to count and to catalog all other species, as you suggest. In some recent rapid ecological appraisals in Papua New Guinea, we came up with three new fish species in one two-week study and probably two species in another. So, we need to strike a balance between working on the species that we know about and those that we do not know about.

Pullin: For these 'inventory-type' exercises is it IUCN that is actually doing the counting, or is it the national programs, for their national biodiversity strategies?

Holthus: The work is done by a lot of people all over the place. IUCN itself does not have any particular mandate or authority for this. The CBD requires parties to know what they've got in terms of biodiversity and this should be happening. A very focused institution like ICLARM can help and IUCN could certainly contribute to making that happen.

Munro: Putting species on to the Red List is a rather political process, undertaken at successive IUCN Congresses. Lobbyists put forward cases for species that are said to be threatened. Sometimes the cases made are not supportable (for example, Atlantic herring and bluefin tuna were recently suggested). Queen conch in the Caribbean was also suggested and was indeed listed. This is a heavily exploited species but it is not threatened as a species.
Regarding the tilapia species in West Africa, by doing electrophoretic or DNA work you can get an idea of genetic variation and you can get an idea of relative abundance by asking the people who fish for them by diverse methods. But even this rather superficial sampling approach is costly.

Pullin: Well, for West Africa, we do know how many lagoons there are. The maps are good. Moreover, we do have fisheries statistics - albeit probably less reliable for some countries than for others. There is also a huge wealth of secondary data that could be gathered and sifted for the purposes of assessing diversity, abundance and distribution. Is it worth doing this as a research exercise? I feel that it is.

Welcomme: Why has ICLARM chosen *Sarotherodon melanotheron* for this West African case study? This species uses acadja systems well but otherwise is an unattractive species for aquaculture. Why not work on say *Clarias gariepinis* or some other widespread species with higher potential?

Abban: You are not entirely right concerning *S. melanotheron*. For the last five years or so, *Oreochromis niloticus* has been the species of focus for tilapia culture. However, when it comes to salinity tolerance, work in Côte d'Ivoire and Ghana suggests that it is far cheaper to improve *S. melanotheron* for coastal aquaculture than to improve breeds of *O. niloticus*, which has very limited salinity tolerance. During this work, it has become apparent that *S. melanotheron* has good growth in slightly saline waters. It seems that the range of conditions, under which *S. melanotheron* could be used for viable aquaculture, may be even better than that for *O. niloticus*. We have been trying to persuade those along the West African coast, who want to do coastal aquaculture in basins where *S. melanotheron* is available (but in which *O. niloticus* does not exist because it is not native) not to introduce *O. niloticus*. The other native coastal species is *Tilapia guineensis* but this does not have such a wide range of environmental tolerance as *S. melanotheron*. *S. melanotheron* does well in a range of salinities down to almost freshwater. There is quite a body of information on *S. melanotheron*, from Sénégal to the Congo, for example, the studies of J.-F. Agnèse and colleagues. Your negative impression of *S. melanotheron* for aquaculture probably comes from the fact that, as you have said, it supports traditional fisheries, like acadja systems, so well. It is prolific and is fished for 24 hours a day in most lagoons. This fishing pressure means that you only see small fish in the markets, etc. We feel that the value of *S. melanotheron* as a resource for both fisheries and aquaculture can easily be shown. Therefore, a broad look at this species, its stocks and its use by people will provide a good baseline survey. Of the thousands of publications on tilapias, probably more than half are on *O. niloticus*, and even for this species the gaps in genetic information are huge. Different laboratories have used very different methods and pursued different objectives. For *S. melanotheron* we plan to look at the genetics of a representative range of populations, using simple methods. We can then describe the stock structure and advise those who seek to develop breeding programs for aquaculture. The same approach could be applied to other fishes.

Pullin: This is why we chose *S. melanotheron* as a case study species. *Clarias gariepinus*, which is very widely distributed in Africa would be, as Robin Welcomme suggests, an excellent choice for a catfish species to study along the same lines.

Abdou-Salam: But we also need to understand the effects of selective pressure on and continuous use of key ecosystems, not just focus on a single species. This needs an inventory as a first step.

Froese: Well, we (ICLARM) are also about to embark upon another collaboration with IUCN's Freshwater Fish Specialist Group to document the status of threat to all of the world's freshwater fish species: 10 000 species. This can be done using IUCN's new categories of threat and entering the results into a database. We will be using existing information and tools to do this. The data will be point data. My impression is that it is possible to do this for a whole group, in this case the freshwater fishes, rather than be limited to one or a few species of special significance. In the Philippines, there may be as many as 500 fish species, in the fish markets on any one day and perhaps 3 000 or more species swimming in Philippine waters. Is it better to approach whole assemblages like this with an ambitious, but achievable, agenda or to neglect most of them and take a much narrower focus?

Welcomme: I agree with the absolute necessity to make the most of existing data, but this will not answer all the questions. It will in fact pose many questions.

Froese: Agreed.

Holthus: Where populations or species are clearly threatened there is often a need to *act*, before all the relevant information is gathered. Actions are often based on local, anecdotal information.

Toll: An inventory is a good thing to aim for, but at what level? And who are going to be the focal points for assembling the data - ministries? hobbyists? And even for an interactive system of databases with limited data points, such as the four attributes mentioned by Dr. Froese, the quality of the data must be assured.

Welcomme: Discussions and protocols on fish transfers and introductions so far have concerned species, not breeds. As genetic manipulation proceeds, for example to produce cold tolerant tilapias, shouldn't there be mechanisms to control their potential impacts?

Pullin: Absolutely yes. Some INGA members wish to breed fish for specific environments; e.g., cold- and saline-tolerant tilapias. Their potential environmental impacts have yet not been well evaluated. The CBD could consider this in its biosafety protocols, rather than restricting these to organisms modified by genetic manipulation.

Beardmore: Some groups have already given thought to this, including further manipulations that would ensure that such fish would not reproduce.

Abban: Should not ICLARM attempt to influence national programs that may be attempting genetic modifications which ICLARM can see may well have adverse environmental effects?

Pullin: ICLARM can certainly help to inform and give opinions, but the national programs of the INGA members and of other countries are of course theirs to decide.

Hodgkin: It seems that world aquaculture is likely to become dominated by a few species - as have agriculture and forestry - but the movements of aquatic species around the world to achieve this have not yet been as extensive.

Villwock: New Codes of Practice on fish transfers are surely needed and ICLARM can add its voice to encourage their use.

Munro: We have had this problem in the South Pacific, where some organizations had been shipping giant clam species across international boundaries. ICLARM was in the position to advise that this was probably not a good idea. But the recipient countries (9 out of 10) did it anyway, in the hope that there might be some financial benefits.

Welcomme: Advisory codes of practice are not often heeded. Until there are binding protocols on fish movements under the CBD or an equivalent, then there is little chance that controls will be respected. For example, the ICES-EIFAC codes were signed by ICES member countries, but at least one member country later introduced an exotic oyster and seaweed species in contravention of the codes. This is but one example of many.

Pullin: I agree completely on the need for legally binding protocols, but it has been encouraging that the INGA members have evolved their own voluntary biosafety protocols on fish movements and are applying these (see p. 34).

Villwock: The lack of information on what different agencies and institutions are doing is a serious constraint to cooperation.

Pullin: Yes, there is a lot of activity on biodiversity research, for example in Europe, of which ICLARM needs to become more aware.

Beardmore: It would be useful to learn about ICLARM's proposed restructuring of its programs with respect to biodiversity and genetic resources.

Munro: This is one of ICLARM's new programs (see Appendix V).

Harvey: What is the emphasis in ICLARM's work on conservation of genetic resources as opposed to breeding research? What is ICLARM's policy on genebanking?

Pullin: ICLARM is still developing its policy on genebanking. The genetic resources that ICLARM keeps are used for collaborative research. ICLARM does not have a large program of breeding and genetic enhancement. The GIFT project, for genetic improvement of tilapias, is an attempt to develop and to demonstrate selective breeding methods, not an attempt to develop and to provide the world with so-called 'super tilapia': a name that was, incidentally, not our choice but a journalist's. The main results of ICLARM's strategic research are proven methods.

Munro: The CGIAR places genetic improvement and breeding research in a different category - 'Improving Productivity' - than genetic resources research, characterization and conservation.

Harvey: Since the coming into force of the Convention on Biological Diversity, many of the groups whose lands and waters in which genetic resources are found have developed high expectations as to their potential value. This may be wishful thinking.

Munro: Some of these expectations are also expressed by a number of NGOs and they are often unrealistic.

Hodgkin: A large European project is also aimed at the development methods for genetic characterization, rather than their application in genebanks etc. However, a 'platform' has now been set up for application of these methods and for sharing data. IPGRI and FAO are members of this and presumably ICLARM could be.

Bartley: One danger of developing new methods is that they can become attractive just because they are new; for example, the new techniques in molecular genetics. The methods themselves can then become the 'science' rather than the scientific questions and hypotheses to test. For example, there is now a project to produce sterile triploid fish for stock enhancement of the Caspian Sea. The entire fishery is based on stock enhancement. But where will the breeders come from after a few generations? The proponents got hooked on the prospects for polyploid production and the assumption that these fish would grow better.

Pullin: Agreed, but note that the GIFT project adapted simple, selective breeding methods, not transgenic technology etc.

Beardmore: Methods must indeed be chosen and developed for addressing specific problems. The resolving power of methods is extremely important in genetics. What is needed is a portfolio of methods from which choices can be made.

Toll: The CGIAR is not trying to repeat for fish, livestock and trees what it has done with respect to crop genetic resources. Conservation efforts for fish will depend upon partnerships with NARS and with regional and international institutions. The SGRP can help by assessing which methods might be transferable to fish genetics research, and by comparing policy and institutional aspects. Intersectoral perspectives are needed for crop and other genetic resources research (cultivated varieties and wild relatives) not just for fish. The CGIAR does not set policies but can help to provide scientific information for policy-setting and can help to increase public awareness on the importance of genetic resources. As ICLARM will not have itself a major genebanking role, what about the role of the International Network on Genetics in Aquaculture (INGA) or other possible mechanisms for genetic resources conservation? Could regional and international organizations be linked to the INGA?

Pullin: Aquatic genetic resources conservation cannot be centralized, by way of *ex situ* genebanking, to the same extent that has been possible for crops. It has to be more decentralized and is really the mandate of national programs. It is their governments who are the signatories to the Convention on Biological Diversity, with consequent rights and obligations. The latter include the development of national strategies for biodiversity documentation and conservation. NARS will therefore need genetic characterization laboratories (including capacity for molecular genetics) for working on fish and other organisms. ICLARM and regional organizations should strive to complement these national roles. The bulk of the work will always be done by the NARS who will need adequate resources for this. ICLARM is looking for a complementary, strategic role. We have made a start on the database front (FishBase and ReefBase). We have also made some contributions on fish breeding and *in situ* genetic resources conservation (such as aquatic protected areas) but we don't yet have a clear view of our future roles vis-à-vis the activities of NARS and the CBD. ICLARM is the member-Coordinator of the INGA, which has 13 NARS members.

Welcomme: ICLARM's role can best be synthetic, seeking more general insights from the information generated by the NARS and others. I am uneasy at the hiving off of genetic resources and biodiversity research from ecology and ecosystem research. Our discussions have focused so far on biodiversity and genetic resources as components of aquaculture. However, those concerned with the management of wild fish stocks also need to grasp the importance of these components. They are mentioned in the FAO Code of Conduct for Responsible Fisheries but the enormous changes that can be caused by overexploitation are not yet appreciated. How can we get relevant information on this so as to inform and influence public opinion and policymakers?

Froese: Perhaps FAO could expand its species coverage in the statistics that it compiles, in the light of biodiversity concerns. Farmers usually know the species or the strain that they are farming, even if they don't know its Latin name. More species are used than statistics suggest. There is also a need for an effective internationally agreed system for naming strains. Who could take the lead on this? I am also a bit concerned at the suggestion that living specimens (germplasm), with their short lifetimes, should be included in genetic resources information systems. For example, ICLARM's research collections currently include about 700 cryopreserved sperm accessions and above 3 500 live fish. The lifespan of the latter is about 2-10 years. By comparison, the plant genebanks keep material more or less indefinitely. This can also apply to cryopreserved fish sperm accessions, and these will definitely increase in number. But should the live fish collections also increase and be cataloged? This is not like keeping a wild population in a marine protected area when you can go and sample it, like a forest, from time to time.

Welcomme: FAO statistics collection depend upon the goodwill of countries. We do not even have a separate system for reporting inland capture fisheries. Moreover, the reporting of aquaculture production by species is different from that of capture fisheries by species and sometimes the production of different sectors has to be deduced by subtraction.

With regard to a naming system for fish strains, this need applies to other organisms, not just fish. Definitions and nomenclature require much more standardization. We need to convene consultations to sort this out, for statistical and other purposes. Definitions (of strains, for example) will have to conform to various legal systems.

Bartley: At recent consultations, there has been lack of consensus among aquaculture geneticists on standardized nomenclature and definitions for strains and genetically modified organisms (GMOs). Codes of Practice (like the ICES Code), the CBD, and countries (like the UK) have very different definitions of GMOs. Ongoing practices and consumer attitudes could be seriously affected if, for example, a broader GMO definition suddenly required the labeling of a farmed product as genetically modified whereas perhaps it was just derived for selective breeding - and therefore not a GMO under a narrower definition. For a 'strain' definition, the key is probably to link this to ownership and to legal requirements.

Pullin: All captive breeding has genetic consequences from natural selection. These can be large, even over a very few generations because of the high fecundity of many fish and the (sometimes heavy) mortalities that can occur, especially in early life history stages. However, it *is* still worth keeping breeding records and having protocols for broodstock replacement - as is done in the GIFT project. This is similar to the rare breeds trusts established for livestock.

Froese: But does this just need a metadatabase of who has which broodstock, or does it really need records of each individual fish; for example on the SINGER?

Pullin: Individual records are very valuable, to estimate parameters like accumulated inbreeding. I think that they are needed.

Perry: Yes, the collection and presentation of historical data, sometimes for long-dead material can sometimes be important. If you have individual data on live fish, best maintain it.

Pullin: In fact, if we also took scales and otoliths from the fish used in breeding programs we could get growth data from these (and from museum specimens) for comparison. These data could also be stored and made available.

Harvey: There are some US 'living genebanks' on, for example, endangered winter Chinook salmon runs. Live fish are kept just for say a couple of years (one cross) rather than say for 10 years, when domestication selection could set in. New collections are then made. Frozen sperm can also be used in such operations.

Hodgkin: The naming of crop strains/cultivars is well-developed but much of the useful information that was formerly present in names has been eliminated. Names that are identifiers and indicators of origin and performance are not allowed for the naming of plant cultivars.

Munro: Surely if a variety has a known genetic marker, this can be named?

Hodgkin: Well, a variety is registered only when its genetic characteristics prove its distinctness.

Beardmore: It's easier in the plant world where there are a lot of in-breeders and a lot of vegetative propagation.
Now, I have to take issue with criticism of the narrow UK definition of GMOs because the other broader definitions are biologically incorrect. They require that any organism produced by normal Mendelian recombination be considered as a GMO and this does not make sense. Real GMOs are easy to define and to regulate.

Pullin: Concerning strain nomenclature, there are a few examples of fish strains - for example, the various strains of common carp developed in Indonesia - Koi carp, and the goldfish varieties (which appear as diverse as dog breeds) - that are easily recognized and easy to name. The problem with a situation like Nile tilapia 'strains' is that they look very similar. In the GIFT project (4 founder stocks collected from Africa and named according to their country of origin and 4 farmed strains from Asian countries, again named after their countries of introduction and principal use) we made lots of hybrid crosses and now we have a wide range of material. We could call a strain anything we like, as could any farmer or breeder. The default option is probably to assume that the strains from different farms are indeed different. Genetic characterization to check them would be costly. Hence, the position that is likely to prevail for tilapias in the near future is that if a farmer, breeder or researcher says that this fish is the 'ABC' strain, users of the fish will probably accept this and form their opinions based upon subsequent performance trials. International agreement on naming fish strains will be very difficult to achieve because breeders like to name their fish after their countries, home towns, family names, performance claims, etc. Has the plant world achieved this?

Abban: In tackling the basic requirements for fish genetic resources documentation and characterization, for conservation purposes, will anyone ever finish naming strains?

Munro: There must be an infinite variety of strains, especially when users begin to make crosses.

Froese: But if you want to be able to report on the existence and use of strains in a database, you have to be able to distinguish among them and name them.

Abban: Well, according to your database there are different strains from this or that river, but they may be more or less the same. It will take a lot of money to resolve this.

Pullin: Nevertheless, we can see in some existing examples, such as common carp and salmonid strains, clear morphological differences. As fish breeding programs for aquaculture, and fish domestication progress, surely recognizable domesticated breeds will emerge, as they have for common carp.

Villwock: It is important to recognize that strains will perform and behave differently in different environments.

Hodgkin: The question of whether genebanking is aimed at conserving primarily genotypes or alleles is relevant here. Duplication represents unnecessary expenditure where funds are scarce and genotypes similar.

Pullin: This is important - the question of whether to aim for conserving genotypes or just genes. Consider, for example the development of Norwegian red cattle - which now comprise the national herd. The view there seems to be that ancestral breeds of cattle, as kept by rare breeds trusts, are interesting exhibits to show the history of agriculture but of no practical utility for any further breeding purposes. I'm not convinced of this. I can't imagine that livestock and fish breeders will not have to go back to ancestral breeds or wild relatives for some of the genes that will be required in future breeding programs, as the crop breeders do. So whether conservation is targeted at conserving just alleles, say in synthetic strains, or conserving as well a wide range of genotypes is a fundamental decision.

Hodgkin: It depends where you stand along the spectrum of possibilities. There are such things as adaptive gene complexes, the conservation of which may not require keeping every genotype. However, the recognition that certain landraces, breeds etc. have particular adaptive complexes is important. These have been built up over many thousands of years and it would not be sensible to attempt to rebuild them from scratch. Plant breeders have had swings of opinion on this over the last thirty years. Some of the plant geneticists take the view that they can put together whatever is needed any time. Others say that it is better to start with material that is adopted to a particular environment and not to try to work *de novo* with a lot of alleles from a genebank.

Beardmore: Plant breeders are generally more flexible than animal breeders on this question. I agree with Roger Pullin that we should feel worried about applying to fish the perspective that he mentioned.

Munro: This has been a wide-ranging discussion. We are still a long way from charting the course for ICLARM's future programs but it does seem that we will have to keep track of breeds and strains and develop and document appropriate methods.

Harvey: This has been a problem in salmon genebanking. We assume the fish that look different or are from a different river system are genetically different, but in the absence of DNA fingerprinting, we don't know.

Pullin: If you know the breeding history for different captive broodstocks, then that is surely enough to say they are different. For example, the 'GIFT strain' contains genes from Nile tilapia stocks found in Egypt, Ghana, Kenya and Sénégal and from farmed stocks found in the Philippines, Singapore, Taiwan and Thailand. No one else in the world has a fish with this history.

Harvey: I agree for farmed stocks, but for most wild stocks the evidence is anecdotal or mere assumptions are made about what is worth saving.

Toll: The same problem is found in assessing landraces of plants. Collectors use their knowledge of the species and collect across the geographical range of a species and from different farmers' fields, assuming that these accessions are different. They are identified just by their passport data and from local knowledge. Moreover, the characteristics of these landraces change very much over time.

Perry: Yes, and the genebanks lack detailed descriptions of much of their contents. There could be extensive duplication of crop varieties, even within some of the smaller genebanks. This could be reduced by cultivation trials and by DNA fingerprinting.

SESSION III
SPECIAL TOPICS

Chairperson: Dr. John A. Beardmore

Ex situ Genetic Conservation and Policy Development at the International Fisheries Gene Bank

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Abstract

The International Fisheries Gene Bank (IFGB) is a program of the World Fisheries Trust, a Canadian NGO dedicated to the preservation of wild fish stocks. The IFGB operates by providing training programs in the theory and practice of genetic conservation, including cryopreservation techniques that are field-oriented, inexpensive and require little equipment, and by assisting governments and agencies to develop policies for the collection and exchange of fish genetic material. The IFGB was formed in 1992, and presently holds over 3 000 accessions of salmonid germplasm from six species and 29 stocks, representing both wild populations and privately held broodstocks.

IFGB receives funding from corporate donors, including resource-based industries, foundations and government agencies, and currently has training and research programs in Canada, Colombia, Venezuela and Brazil. Work in Canada focuses on collection of wild salmon genetic material and training of aboriginal fisheries workers. In South America the emphasis is on collection of genetic material from migratory species in the Orinoco, Magdalena, Paranà and Uruguai systems.

IFGB's policy on collection and storage of wild fish germplasm is that in many cases the urgency of preserving such populations necessitates negotiation of "immediate response capability" so that the relatively straightforward collecting technologies can be put into use without delay. Experience with government agencies in Canada has shown that jurisdictional disagreements over ownership of fish genetic material, such as can occur when salmon stocks are jointly managed by federal, provincial and aboriginal governments, can result in hastily drafted and restrictive collecting arrangements that not only ignore the intense international effort to harmonize fish genetic resources conservation with the provisions of the Convention on Biological Diversity and multilateral implementation mechanisms like the FAO Global System for Conservation and Utilization of Plant Genetic Resources, but can actually work against the conservation of the stocks in question.

Discussion

Pullin: Have you had to consider 'standards' for accessions to fish genebanks and do these provide for the prevention of disease transmission? Also, the CGIAR crop centers categorize their *ex situ* genetic resources holdings as base collections, working collections, active collections, etc. You seem to have a mixture of material: some that is likely to be kept for a long time, as a conservation measure (insurance), and some upon which clients may wish to draw regularly for use in breeding programs and perhaps sell to others (as is done for bull semen).

Harvey: Absolutely, it is a mixed collection: a product of 'planning by doing'. There are records on all the accessions and their purposes. The material itself is all kept in the same facility. Regarding disease prevention, in the salmon genebanks that I have seen, only in Norway is there any screening for disease. The sperm from diseased fish is still frozen but their condition is noted as the accession is tagged. It is still an open question to what extent fish diseases could be vertically transmitted by sperm. The only published standards for a fish genebank came from the North Atlantic Salmon Conservation Organization Council Paper CNL (89)21(1989) NASCO, Edinburgh. 21 p. It does not mention disease screening. Nothing has really been done on this question at present. These are early days.

Toll: Separating base and active collections in a seed genebank aids in controlling the frequency of regeneration of the material. Base collection material is stored under optimal conditions and from the active collection material is made available for research, study etc. and regenerated as required. Base vs. active is a management concept; to avoid going back to the original sample for regeneration and for building up seed stock for distribution. The base collection remains as genetically close as possible to the original sample.

Harvey: Again, it is early days for fish genebanking. Some people are saying 'let's freeze this or that material' without really planning on how much to freeze and how long they will store it, when they will use it etc., and the consequent costs. This is a learning process. If they don't store enough, then there may be some separation into base and active categories because they would not wish to use it all. Of course, the shelf-life is always the same; unlike some seed storage systems.

Toll: How would you regenerate a stock from stored sperm?

Harvey: For salmon, there are many stocks that still have a couple of hundred fish returning to spawn. The idea is to have 50 or so males per stock represented in a genebank. Then, even with a minimum number of females, we can split up their eggs and increase the effective breeding number by fertilizing them with sperm from a variety of males. The best thing to do is to start such operations early enough so that they can become part of enhancement programs. In worse situations, females from a similar stock could be used - a compromise situation resulting in a mixed stock, which could then be further backcrossed. A future possibility ('high-tech' and not yet available) is to use androgenesis and to take any female parent and to knock out her genetic contributions. In Norway, streams from which salmon runs have vanished are being restocked with stocks from similar, close streams; and streams that have still a very few returning females are being enhanced as described above.

Bartley: In your training activities, do you include training on genetic principles? I realize that your priority is probably to train on the practicalities of cryopreservation, but it appears to me that you need to consider the following. First, for collection, although for small endangered populations one does not always have the luxury of getting a broad sample, it is important to aim for broad representative samples. For example, for a salmon spawning run, it would be inadvisable to collect all samples in just one day. Second, for fertilization, it is possible to use just one straw of cryopreserved sperm to fertilize a lot of eggs. However, it is better to use single pair matings and, where there is a limited number of breeders, to optimize N_e by, for example, not pooling sperm or eggs.

Harvey: We are still evolving our training courses. We appreciate that technology is a means to an end and we train with this in mind, covering all the points that you have mentioned, emphasizing the reasons for storing sperm. We also maintain contact with trainees after the courses. Regarding collection, I agree that it is not optimal to collect for a salmon run only one day, but this does happen because of logistical problems and costs. Keeping the material at a central facility and covering a wide area it is difficult to have a crew stationed on a river for a long period. This is why we emphasize training. Regarding maximizing N_e

in the use of stored sperm for artificial fertilization, I suspect that some operators, despite their training, will still do the easiest thing - which is just to use one straw to fertilize eggs. It is hard to check on this. Probably we should do more to emphasize these issues.

In situ Fish Genetic Resources Conservation, Approaches and Issues

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Abstract

Discussions on genetic resources must include considerations of the scope and nature of diversity in natural populations. Biodiversity is defined as the variability among living organisms from all sources including, i.e., terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. There are four levels of complexity: genetic diversity, species diversity, ecosystem diversity and landscape diversity. Ways of measuring genetic variation include 1) breeding tests of quantitative characters, 2) use of allozymes, 3) use of mitochondrial DNA and 4) use of nuclear DNA.

Molluscs have high heterozygosity (~15%), compared with fish (~6%), mammals (~4%) and crustaceans (~8%). Freshwater fish have greater heterozygosity than marine species. Problem areas include bottlenecks (in which effective population size falls owing to a contraction in the number of broodstock for a brief period), conservation of rare alleles, inequality of progeny size, adaptation to captive conditions, local adaptations and hybridization. Fishing and aquaculture can have large effects on genetic diversity.

Discussion

Pullin: You mentioned in your talk an example about genetic effects of shrimp farming in Southeast Asia. Could you please enlarge upon that?

Beardmore: Yes, the industry is based upon collecting wild seed: either larvae or gravid females. The scale of these operations must be having dramatic effects upon local natural populations. I'm not aware of any data on this, but this large-scale harvesting for seed supply for aquaculture must have large effects.

Pullin: Comparing this to the orange roughy fisheries example, the fishery there in New Zealand reduced the virgin biomass by, I think, 70%. However, the remaining 30% must have still constituted a large N_e. Yet Smith et al. (1991)[1] found significant genetic effects. The unharvested Southeast Asian shrimp stocks must also still constitute a large N_e. How then are these genetic impacts - already proven (orange roughy) or assumed (shrimp) - caused?

Beardmore: N_e's may still be large, but the fisheries may exert selection pressure with respect to genotypes. It's a pity that there are no baseline

[1]Smith, P.J., R.I.C.C. Francis and M. McVeagh. 1991. Loss of genetic diversity due to fishing pressure. Fish. Res. 10:309-310.

data for the shrimp situation. I don't think that the mechanisms for what has happened to the orange roughy stocks is really known.

Bartley: I agree with the caution that you expressed about the use of heterozygosity as a measure of genetic impacts. Allelic diversity, which you also mentioned, may be a more sensitive measure of impacts from perturbations. We need to look at a range of population and genetic parameters (N, N_e, allelic frequencies, heterozygosity) to work out what is happening to a population. Also, the statistics for some genetic parameters do not appear to me to be well worked out. For levels of genetic variability - whether at the high end where the common allele may be at 95% frequency or in the middle where it may be at 50% - the statistics act differently. Statistics in population genetics are difficult to interpret and apparent significant differences have to be looked at very carefully. Morphometric and meristic traits should be used wherever possible, as well as these other genetic parameters, especially in situations where there are no adequate facilities for electrophoresis or molecular genetics. Indigenous knowledge can also help to elucidate what is happening to fish populations. N_e data are very important. There may be very different relationships between N_e and population size for freshwater and marine fish in general.

Beardmore: I agree with you on the importance of meristic characters. When I talk about quantitative traits, I include meristic characters. N_e estimates for most fish populations are, of course, indirect.

Bartley: Regarding rare alleles - we do not really know what these are. Are they good alleles 'waiting to get better' or bad alleles that used to be common and are now being selected against? We once set some conservation goals for a breeding program and we used rare alleles to determine effective population size because we wanted to preserve, as far as possible in our hatchery, the natural population structure of the fish that we wanted to release for stock enhancement. So, we looked at the genetics of the natural population and found that rare alleles accounted for a lot of its variability. These rare alleles were at about 5-10%. We therefore aimed to have a large enough broodstock to get these alleles at 5-10%.

Beardmore: Yes, that is using rare alleles as a tool - which is absolutely legitimate.

Bartley: There is also criticism about interactions between stocked fish and native stocks. Could not the use of sterile fish (by genetic manipulation) be a way of avoiding this, thereby assisting fisheries enhancement?

Beardmore: Possibly, but in some situations (like the carps in South Asia, India and Bangladesh) the mixing of wild and stocked fish has been going on for a long time and perhaps the need is to continue to add more genetic material from the wild fish into this mixture. In all cases, I suspect that the real nature of these interactions is very poorly known.

Bartley: What about marine stock enhancement?

Beardmore: The ideal protocol would be to take breeders from the natural population to generate fry or fingerlings for release - avoiding, as far as possible predation, and thereby greatly enhancing recruitment. This is clearly only applicable in some situations.

Biosafety and Fish Genetic Resources*

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Abstract

Alien species have been widely utilized as an effective means of fishery management and to increase production from the aquatic sector; they have also been identified as one of the most significant threats to aquatic biological diversity. Aquatic environments and their biota are highly vulnerable to damage by human interventions. Moreover, fish and the flora and fauna are sometimes associated with them (including parasites, pathogens and predators) can escape from farms and from research establishments and can spread to adjacent waters and beyond, sometimes across national boundaries. Hence, introductions and transfers of fish for research and for the development of aquaculture and enhanced fisheries can pose risks and cause significant, sometimes irreversible, changes to aquatic environments and their biota. An introduction is the human assisted movement of an organism to an area outside its natural range, where it is then termed an alien or exotic species. A transfer is the human assisted movement of an organism within its established range.

Aquaculture and fisheries are increasing their use of genetic technologies that will also increase production and assist in fisheries management. Genetic analyses of natural populations have revealed unique stocks and genetic diversity that were previously unknown. Manipulation of the genome of aquatic species through selective breeding, hybridization, chromosome manipulation, sex reversal, and gene transfer can now produce plants and animals that are highly productive, but that may be genetically different from the native stocks. These technologies are complicating the definition of alien or exotic species, and even the very definition of "species". Terms such as genetically and living modified organisms (GMOs and LMOs) have been put forward to describe products of these technologies, but there is little agreement on their usage.

The new technologies also complicate the regulatory structure meant to control the use and movement of aquatic species. Currently in many countries and international fora that deal with biosafety, there is a trend for more regulatory oversight of transgenic organisms because this technology is perceived as having a greater risk. However, it is the change in the phenotype of an organism resulting from genetic manipulations that should be evaluated as to its risk and not the method used to create the organism. Certain technologies, such as gene transfer, will have more unknowns about the phenotypic change imparted by the gene transfer, and this will require more extensive testing and evaluation before approval by regulatory agencies. Similarly, with regard to the transfer of genetically distinct natural populations (stocks), these may be different from local populations of the same species in characters such as migration routes, spawning time and place, or feeding and should therefore be evaluated as potential exotic species

*ICLARM Contribution No. 1346.

with the ability to impact local aquatic diversity. The simple question of when is an organism an "alien" is no longer so simple.

FAO and ICLARM conform with national and international biosafety regulations in their work, but note that a broader application of the term biosafety may better protect the aquatic environment. Such an application would include appraisals of the possible environmental impacts of all genetically manipulated organisms and of unmodified alien species and genetically differentiated stocks, and adopt a precautionary approach in work that involves fish introductions and transfers.

FAO and ICLARM also contribute to the development of measures for protection of the aquatic environment and biosafety; for example:

- the FAO Code of Conduct for Responsible Fisheries contains articles on aquaculture, fisheries management and research that call for, *inter alia*, the precautionary approach, the conservation of aquatic habitats and their biological diversity and the minimization of harmful effects from the use of non-native species or genetically altered stock;
- cooperating in the elaboration, adoption and implementation of international Codes of Practice and guidelines, such as the ICES-EIFAC codes, on the introduction and transfer of aquatic organisms;
- participating in the activities of the various bodies of the CBD, especially the Subsidiary Body for Scientific, Technical and Technological Advice (SBSTTA);
- linkages with IUCN, UNEP and regional, national institutions and NGOs

ICLARM acts as the Member Coordinator of the International Network on Genetics in Aquaculture (INGA) (see p. 18), the developing-country members of which have evolved the following protocols for the responsible and safe sharing of fish germplasm, including quarantine arrangements and environmental safeguards, as follows.

Revised Recommended Protocols for Exchange of Fish Among the INGA Members (June 1995)

I. Exporting (transferring) Country

- Provide information on:
  - Numbers
  - Origin and nomenclature (scientific, common, and local names) of stocks[1]
  - Growth stage at time of export (eggs, yolk-sac larvae, post-larvae, fry, fingerlings)
  - Disease history
  - Parasite/predator history
  - Competition with other species[2]
  - Feeding habit
  - Reproductive characteristics (e.g., age at first maturity; spawning in stagnant or running waters)
- Certify freedom from prescribed parasites/pathogens/and other biota.
- If possible, disinfect stock prior to shipment.

II. Importing (receiving) Country

- Stocks should be imported as eggs or as other early life history stages.

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[1]Specify geographical location where stock is collected. If stock originally came from another locality, it would be useful if name of the locality is provided. Specify breeding history, if known.

[2]Include all possible aspects of competition such as food, habitat and reproduction, if available. If not, state as unknown.

- Qualified personnel should examine shipments for freedom from prescribed pathogens/parasites and other biota. If diseases are identified, shipment should be destroyed and disposed of in an appropriate manner, unless effective treatment can be guaranteed.
- Quarantine the imported fish for at least 30 days.
- Disinfect introduction upon arrival at quarantine unit if possible. If young fish are imported, give prophylactic bath.
- Upon arrival at quarantine unit, destroy or sterilize all water, packing materials, containers or other associated shipping materials.
- Quarantine sites must be secure against escapes and discharges of water. Water must be safely disposed of.
- If the quarantine unit suffers a disease outbreak that cannot be controlled, destroy diseased stocks and dispose of after sterilization in approved manner.
- Monitor quality of water at the quarantine unit at regular intervals.
- Continue periodic checks for introducible parasites and diseases.
- Original imports should not be transferred to natural environments.
- Compile a list and periodically update known parasites and diseases and pathogens.
- Advise exporter in case of unexpected occurrence of parasites or pathogens.

Session III - Discussion

Welcomme: The ICES-EIFAC Codes of Practice were developed through very substantial efforts involving expert consultations and reviews. If new Codes are to be developed, their formulation needs to be equally rigorous. Having said this, the existing Codes have a number of shortcomings. First, they operate only at the species level. It is quite clear that consideration of subspecies and other lower taxa are needed. Second, the Codes apply only to international introductions, yet there are many transfers that are much more significant than those which cross national boundaries. For example, the Codes would give a transfer between northern Switzerland and southern Germany, which are within the same basin of the Rhine, more weight than say transfers from the eastern to the western seaboard of the USA or from the eastern to the western areas of Russia. Some of the latter transfers across Russia have had damaging effects which are likely to spread to some other adjacent European countries. Third, the Codes operate on a 'once only' basis. They are concerned only with first introductions. For example, once a common carp introduction has been made, say from Romania to Argentina, that is it as far as the Codes are concerned. The major species in the Rio de la Plata *is* now *Cyprinus carpio*. New codes and protocols need to consider repeated introductions and transfers.

On the question of breadth of definition of GMOs, remember that it is the *effects* that these might have once released or escaped, not the techniques by what they were produced, that is important. The nightmare of cold-tolerant tilapias greatly extending their range applies whether they were produced by selective breeding (which some would advise should not be regulated) or by splicing in a cold-resistance flounder gene. The ecological impacts could be similar.

Toll: For plant transfers and introductions, there are established protocols similar to those developed by the INGA (p. 34) but there are also the same problems to be faced with respect to definitions and protocols for GMOs. It is interesting to hear that 'regular' breeding methods applied to fish might cause risks.

Pullin: There are recent publications from the UK on genetic modification of fish[3] and from the USA

[3]Department of Environment. 1994. Genetic modification of fish - a UK perspective. Department of Environment, London.

for performance standard for the safe conduct of research on aquatic GMOs[4]. They have flowcharts for estimating likely impacts. The UK publication, like some other writings in this field, has the flavor that these techniques exist and that people *are* going to use them: in other words, the 'train has left the station' and cannot be recalled. If this is so, then all concerned must strive for the highest standards of biosafety. However, in this context of this unstoppable trend, there is a tendency to frame definitions and to devise protocols, etc., that will not (or at least not appear to) restrain trade and the transfer of technology and its products; hence the current narrow definitions of GMOs that highlight this new technology. However, as Robin Welcomme has reminded us, genetic improvement methods other than gene transfer (for example, selective breeding) can still produce breeds different enough to have ecological impacts.

Beardmore: I have to take issue with that. There is a rationale to considering GMOs to be only those produced by genetic engineering techniques. The rationale is that these techniques are still rather inexact. The ways by which genes are inserted are still inexact, crude and imprecise. One frequently does not know where the gene is going in. That leads to understandable caution about being able to say what the overall effects are. You can say what the effects are only with respect to the product of the gene of interest - it increases growth rate or produced sterility or whatever. The need for caution arises because the products of these procedures are not the same as the products of conventional breeding. Regarding the hypothetical example that Robin Welcomme gave, if you produce something that is cold-tolerant under the conditions of aquaculture, then there is every reason to suppose that this would be successful in a wide range of culture conditions. There is not, I believe, any reason to suppose that it would be successful in a wide range of natural conditions. You have selected for only one characteristic, not for the ability to survive in those particular systems.

Welcomme: My concern is not with the definition of terms *per se* but that we risk *excluding* from safeguards and protocols a whole range of modifications to aquatic organisms because these are more 'naturally' produced. Moreover, the supposition in all current Codes of Practice is that a species, once it crosses a national border, whether for aquaculture or other purposes, is inherently an *introduction*. There are tilapias living in natural hot springs in Alberta. They may seek to expand beyond their very limited range. Saying that only genetically manipulated organisms qualify for these sorts of measures risks letting through a whole mass of other organisms that can have impacts.

Beardmore: I would agree with that.

Bartley: Regarding the 'unstoppable' movement towards genetic manipulation for aquaculture. It would be good to get some perspectives on this from the industry. A transgenic coho salmon, having the antifreeze protein cold tolerance gene, was offered to Chilean salmon culturists and they declined to use it. They felt that they did not need and that there would be adverse public reaction to a transgenic.

Beardmore: That is very understandable. My understanding is that at present if you set up an aquaculture operation in Chile you can recover all the investment costs, including interest, within 20 months. This is very different from the situation in other countries.

Bartley: Codes of Practice should also cover the movement of cryopreserved gametes.

Harvey: At present, the users of cryopreserved sperm are largely unaware of the Codes of Practice that we are discussing. We can help to remedy this in training courses.

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[4]US Department of Agriculture. 1995. Performance standards for safely conducting research with genetically modified fish and shellfish. Office of Agricultural Biotechnology, US Department of Agriculture, Washington, DC Document 94-04 Part I - Introduction and supporting flowcharts; Document 95-05 - Flowcharts and accompanying worksheets.

SESSION IV
DISCUSSIONS ON FISH GENETIC RESOURCES: NEEDS AND OPPORTUNITIES IN THE FACE OF RAPID CHANGE

Chairperson: Dr. Roger S.V. Pullin

Summary of Discussions

1. Strategic research on fish genetic resources; how should ICLARM and others plan their activities?

There are huge numbers of aquatic species and populations upon which research could be undertaken. However, organizations like ICLARM and its collaborators can work in depth on only a few of these. As indicators of what can be done for living aquatic resources management in general. ICLARM is not tied (as are some of the CGIAR's crop centers) to working on mandated species, but research on species like tilapias and carps can provide pointers to successful conservation and use scenarios for a wider range of aquatic species. This approach is very similar to that used in strategic forestry research.

There are huge knowledge gaps on the genetic differences and similarities among different populations of aquatic species. Strategic research is needed to characterize exploited and potentially exploitable populations for their management and sustainable use; including restoration of those in decline and reintroductions where extinctions have occurred. The data for this must be well structured and accessible in databases. Individual species can have large numbers of stocks or populations. Databases on these are still at a very early stage. FishBase has at present only about 100 records of stocks. It is hoped to extend this next year by including data on about 160 stocks from ICES records. FishBase also has data on about 116 strains or breeds of farmed fish (mainly tilapias and some carps) but has no records on the genetic characteristics of any populations of fish species that are not fished or farmed. All that exist in FishBase for the genetic resources of non-exploited species, are records and comments on their geographical range. FishBase has, in total, genetic information on only about 230 species and lower taxa (populations and strains): a fair coverage of what has been published to date. It does provide, however, a structure to receive more data as they are generated.

Prioritization of which species and stocks/populations to study should reflect human needs and trends in fisheries and aquaculture development. There are two major trends: 1) towards intensification; i.e., towards increased control for increased production and 2) towards rehabilitation, conservation and redeployment of stocks.

Regarding intensification, for freshwater fishes the focus remains on species like the carps and tilapias. These are frequently used in preference to other native species, about which information is often scarce. For example, the trend has been to farm exotic carps in Africa rather than to evaluate African native cyprinids and exotic tilapias and carps in Latin America rather than native freshwater fishes.

Stocking from hatcheries is another aspect of intensification that is very widespread and increasing. Its effectiveness and its genetic impacts are very imperfectly known. It is not known how to minimize the risks and to maximize the benefits from stock enhancement. Multispecies, wild stock, capture fisheries are another area in which almost nothing is known about genetic impacts, although there are substantial records of changes in catch composition by species.

Regarding rehabilitation, this is an increasing trend especially in the temperate zone. Aquatic habitats are being restored in the hope that they will again support living aquatic resources, as they did before becoming degraded. However, the capacity of remaining fish populations to adapt to restorative changes is not known. For example, some cyprinid populations in Europe have adapted over the last two hundred years from a semi-migratory existence in floodplain rivers to a highly lentic existence in almost totally controlled systems. If these systems reverted to a floodplain situation, could such populations re-adapt? On the river Rhone, the common carp is now present in two forms: a 'wild' form that lives in flowing waters and a 'domesticated' form that lives in backwaters or slow-flowing waters.

It was suggested that strategic research on fish genetic resources could be categorized and possibly prioritized as four main areas:

1. research on highly valued and used species and their populations (for example, carps, salmon and tilapias) and on species and populations that are already known to be endangered.
2. research on other economically important and potentially threatened species and populations, for example, sharks.
3. research on what is known already about the attributes and status of other species.
4. research on the unknown (or little known) remainder of aquatic biota and their habitats, following a precautionary approach.

Clearly, although gaps remain, there are many groups working on the most important species (category 1) and some (for example, the shark group of the IUCN Species Survival Commission) working on category 2. At present, ICLARM is focusing its strategic genetic resources research on categories 1, 2 and 3, largely through FishBase. However, projects and case studies for gathering primary data and for testing ideas and approaches are also on the future agenda for ICLARM and its partners, especially for the NARS who will use the methods and tools developed by ICLARM and others. All of the above is viewed as strategic research.

Researchers must recognize that there will not always be a direct relationship between the degree to which a species or population is threatened and the degree to which it is exploited. In Russia, some of the less exploited species of sturgeons have been afforded more protection than those species that are heavily exploited for caviar, the populations of which are almost entirely supported by hatcheries. Moreover, fish of no economic importance, like the snail darter in the USA (*Percina tanasi*) have been found to be threatened, usually because of threats to their habitats. Clearly, however, threats do occur from direct overexploitation of aquatic species.

It was pointed out that the secondary data that can be gathered from museums, while valuable as time series biodiversity data, usually lack information on population genetics *per se*. Museum collections could be subjected to further studies (for example, by DNA analysis) to gain population genetics data, but the sampling protocols by which the specimens were collected would have to be known and be appropriate to calculating population genetics parameters. In population genetics, sampling protocols are very important. Some museums do maintain details of these for their collections but, in general, keep few data on the delineation of aquatic populations rather than species. Therefore, most of the secondary data accessible to ICLARM and others is usually at the species level. This enables the ranges of species to be quantified, but not their stock or population structures. Moreover, although the taxonomy of finfish is fairly well-known at the species level, this is not so for most aquatic invertebrates.

It was also recognized that some of the most powerful tools for further research on population genetics (i.e., comparative DNA analyses) are not yet in wide use in developing countries and the data from the groups that are using these tools are scattered and published in many formats. It was also emphasized that DNA analysis, for example fingerprinting, is expensive and should only be used when the end justifies such means. For poor countries, with many pressing research needs and very limited resources, it may be, in the short-term, necessary to work with international institutions and agencies and to use international funding for molecular genetics research, integrating this with affordable national research agendas. Moreover, it is not always necessary to use expensive molecular genetics techniques to elucidate species or population diversity. A recent EU-funded study on salmon stocks showed that stock delineation can also be done by more traditional descriptive methods.

Drawing a parallel with forestry research, it was suggested that strategic research on aquatic genetic resources (and the databases containing the results of such research) should include baseline studies on diversity at the ecosystem level and time series studies of the degradation that may be occurring. Fragmentation of habitats is an important aspect of degradation. The genetic impact of the continuous use of fisheries resources is also an important strategic research topic, with parallels in forestry research.

Finally, strategic research on aquatic genetic resources must not neglect the human element in pursuing biosafety and in the management of aquatic genetic resources for their equitable and sustainable use. Understanding and addressing the perspectives and interests of users, especially indigenous peoples and local communities, are of paramount importance.

2. Training

It was recognized that there are very great needs, in many developing countries, for training on aquatic genetic resources research methods and for raising public awareness on the importance of aquatic genetic resources. However, the resources to provide such training and to reach as many persons as possible are scarce. Specific training courses usually help only small numbers of trainees. This means that the institutions involved in training in this area should explore multimedia technology and distance learning to reach more trainees. Even simple ideas, such as videotapes of lectures and laboratory methods, have not yet been used much. Well-made videos can reach thousands of trainees. For example, the International Fisheries Gene Bank has produced videos on fish genebanking in general and on the use and management of fish genetic resources by aboriginal groups. The key to getting the most impact out of such products is to secure the resources not only to make them but also to distribute them widely. Videos should also be of the style and length appropriate for inclusion in the educational series that are broadcast by TV channels. Networks, such as the INGA, are useful mechanisms for distributing videos and other training materials. CD-ROMs may become the preferred medium to videos.

The production of training manuals was also seen as important. Those researching on aquatic genetic resources, including ICLARM and its partners, could generate more material and methods for such manuals. FAO and ICLARM could be involved in their production and distribution. They could then be used for courses around the world, in various languages. For example, ICLARM and GTZ have published in 1996 a laboratory manual for characterization of tilapia species, principally by electrophoresis[1]. The European Union is also supporting, through ICLARM, a 4-year program of training on FishBase for over 50 of the Lomé Convention countries, in Africa, the Caribbean and the Pacific (ACP).

Maximizing the 'knock-on' effects of training courses has been discussed with respect to plant genetic resources and one solution has been to involve universities and to incorporate genetic resources topics into existing biological curricula. Another approach has been to develop long distance training modules. These same approaches could be used for aquatic genetic resources. One complication is that the priorities for training are not always clear and vary with circumstances. For example, where *in situ* conservation and aquatic protected area are considered a priority, the Marine Protected Areas program of IUCN could be a partner. However, for much of this entire subject area, what to use as training material is still not yet clear: many questions still need research to provide answers.

It was thought unlikely that FAO and its partners could organize a series of formal training courses in this area, similar to those organized previously for fish stock assessment (with funding from DANIDA) and for environmental issues. FAO is currently receiving more requests for training through unilateral trust funds (for example, from Chile and Iran) rather than from groups of countries.

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[1]Falk, T.M., E.K. Abban, S. Oberst, W. Villwock, R.S.V. Pullin and L. Renwrantz. 1996. A biochemical laboratory manual for species characterization of some tilapiine fishes. ICLARM Educ. Series No. 17, 93 p.

The Technical Cooperation among Developing Countries (TCDC) mechanisms of FAO can support the recruitment of resource persons to give training for individual countries or for groups of countries. Again, the development of training materials, manuals, etc., is the key to making this cost-effective, rather than preparing a new course every time. This TCDC mechanism could be explored for the member countries of the INGA and others. Training packages and workshops could be developed on a regional basis; for example, a bilingual (French and English) package for West Africa.

Developed-country universities can assist with training provided that sufficient funding is provided. Their financial position does not allow them to subsidize such activities in developing countries. They can offer training on-campus and in the developing regions. For example, for plant genetic resources, Birmingham University has a long history in training developing-country nationals on its campus and academic staff now travel increasingly to give courses in the developing regions. It is often more cost-effective to give the courses there. There are, however, at present far fewer resource persons available to give training on aquatic genetic resources than there are for plant genetic resources. Moreover, when training is given - for example in fish breeding - there should be some mechanisms for follow-up, such as a project, so that the trainees are not just left entirely on their own after the course. Ultimately, training should lead to the development of career professionals in the field of aquatic genetic resources, who can then sustain this area of work in their respective countries. The SGRP has genetic resources training as one of its major themes in its strategic plan.

The recent global publicity about the decline of fish stocks and the conflicts that have resulted have credited a climate favorable for increased efforts to raise public awareness about fish genetic resources, through popularization of issues in the mass media, especially television. This applies not only to large fisheries but also to environmental concerns, such as the effects of species introductions and transfers. For example, some anglers move live bait around without knowing the consequences. Anglers recently moved bait fish *(Pseudorasbora)* from the Danube basin to Northern Italy where this species is now spreading rapidly. The CGIAR is expanding its public awareness activities and the SGRP could provide materials for this.

3. Information

The amount of information generated globally on aquatic genetic resources is expected to increase rapidly, as the Convention on Biological Diversity becomes more fully implemented. It was recognized that ICLARM has a unique position, as a new CGIAR center that has chosen from the outset to work extensively on biological and resource system databases, to be a focal point for information on aquatic genetic resources. This position depends upon multiple partnerships and linkages with other institutions and individuals around the world.

Accurate and standardized nomenclature is essential for databases. ICLARM, through FishBase, is contributing to the Species 2000 project, which is developing a global checklist for all named living organisms: about 1.7 million species. Reference CD-ROMs for the list will be made available so that countries can use the same nomenclature for generating and checking their national databases. This standardized, international nomenclature is essential for making legislation and regulations for conservation and use. The names of organisms are frequently misspelled in legal documents.

Databases require continuous maintenance and upgrading, because the status of aquatic genetic resources changes with time. Therefore, databases are a long-term commitment and require ongoing, lower level funding and numbers of staff after their initial phases of development.

Clearly, there have to be some criteria for including data on aquatic genetic resources in a database like FishBase. FishBase sets as one criterion that a given category of information should be available for at least 100 species. Moreover, there has to be a minimum set of properly referenced information per species. By topic, the information has to be 'key' information, i.e., relevant to the purposes of conservation or use, or both.

Information derived from indigenous knowledge on aquatic genetic resources should be included in databases. Such knowledge is particularly important for *in situ* conservation efforts. Indigenous peoples are among the most important guardians and users of fish genetic resources.

Regarding museums and their holdings of information and specimens, it was recognized that for fish, many of these were gathered during the colonial periods for many of the developing countries. There is now a need to set up mechanisms for comparing these records and specimens with material that is available from more recent and ongoing activities. There is in fact a need to invest more resources in collecting and studying aquatic genetic resources and comparing the results with collections of the past: in effect, to generate biodiversity time series data.

Institutions like ICLARM, that maintain databases, can help to stimulate this by soliciting such data and showing that it has added value when it can be compared and correlated with other data. The Convention on Biological Diversity may also help to revitalize national interests in assembling collections of aquatic organisms in national museums etc., but there is little evidence so far that this has happened. Taxonomy and systematics worldwide receive little support and museums are facing difficult financial situations. The development of and continued support for taxonomists, especially in the national programs of developing countries, are essential for the CBD to function effectively and for the success of conservation programs.

4. Policy

It was recognized that very little attention has yet been given to policy issues for aquatic genetic resources. The collection and study of aquatic genetic resources are proceeding largely in a policy vacuum. Moreover, the CBD and its various bodies, such as the SBSTTA, have so far considered only marine biodiversity and not freshwater genetic resources.

It was agreed that there is an urgent need for an international conference towards policymaking for the conservation and sustainable use of aquatic genetic resources. Such a conference should be convened as soon as possible. Its results would assist FAO's new Commission on Genetic Resources for Food and Agriculture. Substantial reviews of existing policies and issues of concern would be necessary as information for this proposed international conference.

SESSION V
CONCLUSIONS AND RECOMMENDATIONS

Chairperson: Dr. Robin L. Welcomme

This final session commenced with a discussion on rights and access to genetic resources, comparing the situation for plant genetic resources to likely scenarios for fish genetic resources. After this discussion, the participants finalized the conclusions and recommendations of the meeting.

1. Rights and Access to Genetic Resources

Concerning access to genetic resources, the Convention on Biological Diversity is often interpreted as being framed largely for bilateral agreements. This is, however, being questioned regarding access to plant genetic resources. The CBD's text contains nothing that requires agreements over genetic resources to be bilateral. It rather requires the country of origin to be briefed and to give 'prior informed consent' on access. Moreover, there is nothing in the CBD that prevents countries entering into multilateral agreements.

For aquatic genetic resources, as for plants, bilateral arrangements could be appropriate for resources that have a limited distribution and in which interest may also be limited. However, for species which are distributed broadly and in which there is wide interest, multilateral arrangements are likely to be more appropriate. Bilateral agreements could become very complex and cumbersome where material from different countries of origin is combined in breeding programs, pedigree lines etc. Tilapias might become an example of this. Groups of countries that possess such resources could forge multilateral agreements for access and for sharing benefits. When the CBD was written, there was also a general assumption that benefits would normally be in the form of royalties, payable from the commercialization of genetic resources, especially from plants used by the pharmaceutical industry. That now seems unlikely, except in a minority of cases. The total profits of worldwide trade in plant seeds in 1993 were about US$700 million. Assuming that 10% of that came from materials received under the CBD (and estimate is not likely to be reached for several years) then there would be about US$70 million/year in profits to be shared. If 10% of that were to be distributed as royalties, this would provide only US$7 million/year to be shared among source countries. The administrative costs of estimating and distributing such benefits could well exceed this figure. For aquatic genetic resources, the figures would be very much smaller, except in very rare cases. Hence, the realization is spreading that the kind of 'windfall' profits that occur occasionally through commercialization of biological materials in the pharmaceutical industry are much rarer in the field of agrobiodiversity. For crop plants, there is a move towards multilateral sharing arrangements, with benefits other than cash benefits, e.g., access to other resources, especially information; transfer of technology, training, and access to the products of breeding programs. The same might evolve for aquatic genetic resources.

The CBD's text has little to say on intellectual property rights (IPRs). The World Trade Agreements/ Trade Related Intellectual Property Rights (WTA/TRIPS) that came into force in January 1996, require all member countries to enact patent legislation, but exclude plants and animals in general from this. It is assumed that this exclusion applies to aquatic plants and animals. However, this does not prevent member countries from patenting plants and animals. It merely says that they are not obliged to do so. They are obliged to have patenting arrangements for cell lines. The position for genes is not clear, but it is possible that genes will be patentable internationally. Plant varieties, under the WTA/TRIPS agreements should be patented or protected by a *sui generis* system, in order to protect plant breeders' rights. These rights provide for royalties to the breeders of plant varieties for a given number of years; but anyone else can then take protected varieties and then breed for further characteristics using them as new parental lines.

Plant varietal protection and patenting tend to be applied more extensively in horticulture and to fruits and vegetable rather than to agricultural crops. An analogy for aquatic genetic resources might be future attempts of ornamental fish breeders to protect new varieties, as opposed to fish breeders for the aquaculture of food fish.

It is hard, however, to see any system comparable to plant varietal protection evolving rapidly for fish breeders. Plant breeders' rights arose largely from strong lobbying by private sector seed traders who wanted to protect their investments in breeding new varieties. The mechanisms for administering such a system are costly. A plant variety has to be proven to be distinct, uniform and stable in order to be protected and there has to be a governmental system for registering varieties and documenting their release, etc. Fish breeding for aquaculture is currently a long way from this situation, but this position could change if there was heavy investment in improved fish breeds. Moreover, patents on fish genes, gene constructs, organelles, etc. might be sought, as is likely for other organisms, especially in the USA. Patenting such resources, unlike breeders rights and varietal protection, *would* prevent others from using the patented material in further breeding work.

Attempts to patent genes from wild fish would create a very complicated situation. Suppose that a patented wild fish gene got into other fish populations against the wishes of their users, would they have a case for compensation against the patent holders? This could happen if patented transgenic fish escaped from farms and interbred with fish in open waters or on other farms. Given the relatively small number of fish breeders, compared to plant breeders, there is scope for developing mechanisms for equitable sharing of benefits and for avoiding some of the acrimony that has developed in the plant breeding world through rushing to patent products.

A global network of interested scientists and fish breeders, willing to share technologies and information and to assist in disseminating these could avoid many of the difficulties that now beset the world of plant breeding.

One immediate concern for the use of aquatic genetic resources in breeding programs is that some private sector interests, for example, commercial salmon farmers, are bioprospecting for breeding material from wild stocks that occur in aboriginal territories. The expectation of benefits from such activities tend to be unrealistic, from the points of view of some of the prospectors and from those who control access to the resources. Royalties and cash benefits would be difficult to administer in such circumstances and some other mechanisms for development assistance and sharing of ultimate benefits might be preferable.

Despite the limited progress made in the domestication of aquatic species, some species like Nile tilapia have become popular farmed species in many countries beyond their natural range. This means that those who are now interested in starting breeding programs seek material from sources of domesticated strains and from wild populations. An example of the latter would be the various subspecies of Nile tilapia in Lake Baringo and in certain Ethiopian lakes. The value of such material in meeting different breeding objectives is, of course, unproven until the material is collected and tried. However, apart from the general provisions of the CBD on sovereignty over biodiversity within national boundaries, there are not as yet any mechanisms for governing access to and for sharing the benefits from such resources. Where such resources are distributed naturally across national boundaries, countries could make regional or subregional agreements. Nevertheless, as breeding programs develop, the number of source countries contributing material to a particular breed could become large. For example, some modern rice cultivars have been bred with material that can be traced back to about 20 different countries. Estimating their percentage contributions to a breed (and this can only be done on a theoretical basis) and considering the time over which the various materials were developed and changed hands is a very complicated process. The CBD has no mechanisms to cope with such complexities. The solution for plant genetic resources, and ultimately for aquatic genetic resources, may be multilateral sharing arrangements, with clear benefits (often other than cash benefits, but not excluding cash benefits where these can be well estimated or effectively administered) to all concerned. This would not undermine the CBD. It would rather help the conservation and sustainable use of genetic resources on a practical basis. The INGA (see p. 18) is already, to a small extent, an example of such multilateral sharing of information, technology, and occasionally of germplasm.

2. Conclusions and Recommendations

The conclusions and recommendations from the meeting were as follows:

a. Research Needs

It was recommended that research can be undertaken on the following priorities (not ranked here in any order of importance):

i. Characterization and Evaluation of Fish Genetic Resources (FiGR)
- Cost-effective methods for characterizing and evaluating FiGR.
- Screening and choosing the best species for aquaculture.
- Determining the conservation status of fish populations (stocks) and species and the implications of reduced genetic diversity.
- Determining the genetic distances among fish populations (stocks).
- Valuation of FiGR.
- Effects of reduced genetic diversity on the ability of farmed fish populations to respond to selective breeding.

ii. Conservation of Fish Genetic Resources, with Sustainable Use
- Policy aspects of the establishment and management of Aquatic Protected Areas (APAs).
- Site selection and design of APAs.
- Effectiveness of APAs in maintaining FiGR, with sustainable use.
- Fisheries management approaches, policies, tools and practices with respect to FiGR; especially community-based management and comanagement and their social and economic consequences.
- Tools for the sustainable use of aquatic biodiversity.

iii. Management and Genetic Impacts of Fisheries, Enhanced Fisheries and Aquaculture
- Genetic effects of fisheries and multispecies assemblages.
- Capacity of fish stocks modified by fisheries or by environmental degradation to respond to rehabilitation.
- Threats to and impacts on FiGR from fisheries (especially intensive fishing, e.g., trawling) at the ecosystem and species community levels.
- Genetic strategies for fish stock enhancement.
- Genetic impacts of stocked fish populations on fish stocks.
- Genetic impacts of aquaculture, including those of farmed exotic species.

iv. Intellectual Property Rights (IPR) and Related Policies for Fish Genetic Resources
- IPR policies for aquatic organisms.
- IPR boundaries, mechanisms and ownership (by nation, community, company, institution, individual) for FiGR.
- Germplasm Acquisition Agreements and Material Transfer Agreements for FiGR.

b. Training and Capacity Building on Fish Genetic Resources

- It was recognized that many NARS and other institutions need training and capacity building for characterizing, evaluating, conserving and sustainably using FiGR.
- It was recommended that a Training Consortium be established to provide trainers, training materials and curriculum development for FiGR.
- The CGIAR's involvement in FiGR training could be on a regional basis, with courses hosted by those IARCs or other institutions (national, regional and international) that have appropriate facilities in each region.

c. Information and Policy

- It was emphasized that ICLARM should be the focal point for processing and maintaining information on FiGR and that gathering and disseminating such information should be through multiple linkages, especially with the NARS that are members of the ICLARM-coordinated International Network on Genetics in Aquaculture (INGA) and with NGOs.
- It was emphasized that public opinion is the key to effective conservation and sustainable use of FiGR worldwide. Hence, a systematic effort is needed to raise public awareness of the importance of FiGR. National decisionmakers need to apportion resources for this, in order to underpin their efforts to establish conservation areas and programs.
- It was recommended that an International Conference on FiGR be held; with the objectives of more fully defining and categorizing FiGR, assessing the value of FiGR, and especially for developing a policy framework for the effective management of FiGR.

d. Institutional Relationships and Funding

- It was recommended that existing and future *ex situ* collections of FiGR cooperate as a network. The International Fisheries Gene Bank (IFGB) is interested in taking a major role in this.
- It was recommended that donor interest be sought to support the analysis and development of appropriate institutional arrangements (at national, regional and international levels; including intersectoral linkages and coordination) for conserving and using FiGR sustainably.
- It was recommended that interim mechanisms be developed for the collection and preservation of FiGR from threatened fish populations.

APPENDIX I
CONSULTATION ON FISH GENETIC RESOURCES - AGENDA

A workshop convened by the International Center for Living Aquatic Resources Management (ICLARM) as part of the CGIAR System-wide Genetic Resources Programme (SGRP), and supported by the System-wide Initiative on Genetic Resources (SIGR)
11-13 December 1995

December 11

Session I	Opening/Introductions/Purposes of the Consultation/Overviews of International Programs and Linkages
	Chairman: Dr. Geoffrey Hawtin, Director General (IPGRI) Rapporteur: Dr. Roger S.V. Pullin (ICLARM)
0830 - 0845	Welcome and Introductions - *Geoffrey Hawtin*
0845 - 0900	Purposes of the Consultation - *Roger S.V. Pullin*
0900 - 0915	Origin, structure, management and aims of the System-wide Genetic Resources Programme (SGRP) - *Jane Toll*
0915 - 0930	The System-wide Information Network for Genetic Resources (SINGER) and Fish Genetic Resources[1] - *Mark Perry*
0930 - 0945	Goals and Activities of FAO in Relation to Fish Genetic Resources - *Devin M. Bartley/Robin L. Welcomme*
0945 - 1000	IUCN and Fish Genetic Resources - *Paul Holthus*
1000 - 1030	Coffee Break
1030 - 1100	Animal Genetic Resources Activities at the International Livestock Research Institute: Commonalities and Differences with Fish Genetic Resources - *Valentine Yapi-Gnaore*
1100 - 1130	Forestry, Fish and Crop Genetic Resources: Commonalities and Differences for Effective Conservation, Sustainable Management and Use - *Toby Hodgkin and Abdou-Salam Ouedraogo*
1130 - 1145	Regulatory Frameworks: A Summary of Issues - *Elizabeth Cromwell (written contribution; could not attend the meeting)*
1145 - 1230	Discussion on the morning's presentations
1230 - 1330	L U N C H

[1]FiGR = Fish Genetic Resources, defined here as all exploited or exploitable aquatic animals (principally finfish, crustaceans, molluscs and other invertebrates).

Session II ICLARM's Activities and Linkages

Chairman: Dr. John L. Munro (ICLARM)
Rapporteur: Dr. Devin M. Bartley (FAO)

1330 - 1400	ICLARM's Fish Genetic Resources Activities - *Roger S.V. Pullin*
1400 - 1415	Fish Genetic Resources Databases, present and future - *Rainer Froese*
1415 - 1430	Fish Genetic Resources and the Coastal Aquaculture Centre - *John L. Munro*
1430 - 1500	Fish Genetic Resources, the International Network on Genetics in Aquaculture (INGA) and Breeding Programs - *Roger S.V. Pullin*
1500 - 1530	Coffee Break
1530 - 1545	An Example of a NARS (IAB)-ASI (ZIM)-IARC (ICLARM) Partnership for Research, Training and Information - *Eddie K. Abban and Wolfgang Villwock*
1545 - 1700	Discussion

December 12

Session III Special Topics

Chairman: Dr. John A. Beardmore (SIFR)
Rapporteur: Dr. John L. Munro (ICLARM)

0830 - 0930	*Ex situ* Genetic Conservation and Policy Development at the International Fisheries Gene Bank - *Brian J. Harvey*
0930 - 1030	*In situ* Fish Genetic Resources conservation, approaches and issues - *John A. Beardmore*
1030 - 1130	Coffee Break
1100 - 1200	Biosafety and Fish Genetic Resources - *Roger S.V. Pullin and Devin M. Bartley*
1200 - 1230	Discussion
1230 - 1330	L U N C H

Session IV Future Fish Genetic Resources Activities: Needs and Opportunities in the Face of Rapid Change

Chairman: Dr. Roger S.V. Pullin (ICLARM)
Rapporteurs: Dr. Rainer Froese, Ms. Christine Marie V. Casal (ICLARM)

1330 - 1700 A round-table discussion on the following topics:

1. Strategic research
2. Training
3. Information
4. Policy
5. Funding

December 13

Session V	Conclusions and Recommendations
	Chairman: Dr. Robin L. Welcomme (FAO) Rapporteur: Dr. Roger S.V. Pullin (ICLARM)
0800 - 1230	A concluding session to frame a set of agreed recommendations with respect to future FiGR strategic research, training and information activities and partnerships.

APPENDIX II
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APPENDIX III
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APPENDIX IV
LIST OF ACRONYMS

ACP	-	African, Caribbean and Pacific Countries of the Lomé Convention
AFSSRN	-	Asian Fisheries Social Science Research Network
AnGR	-	Animal Genetic Resources
APA	-	Aquatic Protected Area
ASI	-	Advanced Scientific Institution
BGRP	-	Biodiversity and Genetic Resources Program
CAC	-	Coastal Aquaculture Centre
CBD	-	Convention on Biological Diversity
CHM	-	Clearinghouse Mechanism
CIAT	-	Centro Internacional de Agricultura Tropical
CIFOR	-	Center for International Forestry Research
CIMMYT	-	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	-	Centro Internacional de la Papa
COP-CBD	-	Conference of the Parties to the Convention on Biological Diversity
CNPPA	-	Commission on National Parks and Protected Areas
DAGRID	-	Domestic Animal Genetic Resources Information Databases
DANIDA	-	Danish International Development Agency
EIFAC	-	European Inland Fisheries Advisory Commission
ESU	-	Evolutionarily Significant Unit
EU	-	European Union
FAO	-	Food and Agriculture Organization of the United Nations, Rome, Italy
FiGR	-	Fish Genetic Resources
FoGR	-	Forest Genetic Resources
GBA	-	Global Biodiversity Assessment
GIFT	-	Genetic Improvement of Farmed Tilapias
GIS	-	Geographical Information Systems
GMO	-	Genetically Modified Organisms
GTZ	-	Deutsche Gesellschaft für Technische Zusammenarbeit
IAA	-	Integrated Aquaculture-Agriculture
IAB	-	Institute of Aquatic Biology, Accra, Ghana
IARC	-	International Agricultural Research Center (of the CGIAR)

ICARDA	-	International Center for Agricultural Research in Dry Areas
ICES	-	International Council for the Exploration of the Sea
ICLARM	-	International Center for Living Aquatic Resources Management
ICRAF	-	International Centre for Research in Agroforestry
ICRISAT	-	International Crops Research Institute for Semi-Arid Tropics
ICWG-GR	-	InterCenter Working Group on Genetic Resources
IFGB	-	International Fisheries Gene Bank
IFPRI	-	International Food Policy Research Institute
IITA	-	International Institute of Tropical Agriculture
ILRI	-	International Livestock Research Institute
INGA	-	International Network on Genetics in Aquaculture
IPGRI	-	International Plant Genetic Resources Institute
IPR's	-	Intellectual Property Rights
IRRI	-	International Rice Research Institute
ISNAR	-	International Service for National Agricultural Research
IUCN	-	World Conservation Union
IYOR	-	International Year of the Reef
MPA	-	Marine Protected Area
NACA	-	Network of Aquaculture Centers in Asia-Pacific
NARS	-	National Agricultural Research System
NGO	-	Non-government Organization
NTAS	-	Network of Tropical Aquaculture Scientists
NTFS	-	Network of Tropical Fisheries Scientists
ODA	-	Overseas Development Administration, London, UK
PGR	-	Plant Genetic Resources
RESTORE	-	Research Tool for Natural Resource Management, Monitoring and Evaluation
SGRI	-	System-wide Genetic Resources Initiative
SGRP	-	System-wide Genetic Resources Programme
SINGER	-	System-wide Information Network for Genetic Resources
SSBSTA	-	Subsidiary Body on Scientific, Technical and Technological Advice
TCDC	-	Technical Cooperation among Developing Countries
UNCED	-	United Nations Conference on Environment and Development

UNDP	-	United Nations Development Program
UNEP	-	United Nations Environment Program
UWS	-	University of Wales, Swansea, UK
WARDA	-	West Africa Rice Development Association
WTA/TRIPS	-	World Trade Agreements/Trade Related Intellectual Property Rights
ZIM	-	Zoologisches Institut und Zoologisches Museum, Universität Hamburg

APPENDIX V
ICLARM'S PLAN FOR A NEW BIODIVERSITY AND GENETIC RESOURCES PROGRAM COMMENCING IN 1996

Title of Program: BIODIVERSITY AND GENETIC RESOURCES

Objectives:

Overall Objective: To contribute, through multiple partnerships, to the characterization, evaluation and conservation of aquatic biodiversity and genetic resources, for their use in providing food, employment and a healthy environment. The beneficiaries will be all who depend upon living aquatic resources; especially the resource-poor fishers, farmers and consumers of aquatic produce in the developing regions.

Specific Objectives:

- To generate, through strategic research partnerships, new knowledge, methods and tools for characterizing, evaluating and sustainably using aquatic biodiversity and genetic resources.
- To provide training courses and materials that will increase the capacity of those concerned with the conservation and use of aquatic biodiversity and genetic resources (researchers, developers, teachers, policymakers, and the private sector, including farmers and fishers) to manage these assets widely, for the needs of the present and future generations.
- To assemble, through global partnerships and networking, comprehensive databases on aquatic biodiversity and genetic resources; accessible to all who require such information for research, development, policymaking and education.
- To participate in international, regional, national and local fora in which research, training and information on aquatic biodiversity and genetic resources are discussed and advice is sought for their conservation and sustainable use.

Shifts in Emphasis and Priorities

1. Short-Term (1996-97)

The Biodiversity and Genetic Resources Program (BGRP) commences in 1996 with the priority to consolidate ongoing biodiversity and genetic resources activities within the Center, so that these will achieve their full potential over this period and during the subsequent medium-term period (1998-2000) and will contribute to the development of a balanced program of strategic research, training, information and advisory services and consultations. This will involve interactions with all other programs of the Center, and with a wide range of international, regional and national partnerships.

In 1996-97, the BGRP will continue its work on biological databases, expanding the coverage for finfish (FishBase) to include all extant species and exploring mechanisms and partnerships for assembling databases and disseminating information on the other major groups of exploited aquatic organisms: principally, the crustaceans and molluscs. All such databases will be relational and will be globally accessible for researching correlation, trends and interrelationships among aquatic biota. Such databases are powerful tools for research, teaching and planning.

The BGRP's interactions with ICLARM's other programs will include:

- Germplasm Enhancement and Breeding - receiving data from the Center's genebanking operations and integrating this with the Center's databases and others, including the CGIAR's System-wide Information Network on Genetic Resources (SINGER); preparing guidelines and standards for aquatic genebanks and assisting the development of networking for replication of and access to cryopreserved aquatic germplasm.

- Aquatic Environments - developing interactions among the Center's biological databases [FishBase for the finfish and the initiation of a shellfish (crustaceans and molluscs) database] and resource system databases (ReefBase); exploring methods for the characterization, evaluation and conservation of aquatic biodiversity and genetic resources in the coastal zone; incorporating biodiversity and genetic resources activities into the proposal for a System-wide Coastal Environments Program.
- Policy Research and Impact Assessment - helping to formulate policy guidelines for aquatic biodiversity and genetic resources, by convening an international conference on fish genetic resources policy; assisting the members of ICLARM-coordinated networks [Asian Fisheries Social Science Research Network (AFSSRN); International Network on Genetics in Aquaculture (INGA), Network of Tropical Aquaculture Scientists (NTAS), Network of Tropical Fisheries Scientists (NTFS)] with biodiversity and genetic resources information and advice.
- Documentation, Publication and Information - providing information on aquatic biodiversity and genetic resources Center-wide; assembling publications, CD-ROMs and InterNet material on aquatic biodiversity and genetic resources.
- Fisheries Resource Assessment and Management - gathering information on the impacts of aquaculture and fisheries on biodiversity and genetic resources, and providing this to the Center's staff and partners; planning for future activities on the characterization and evaluation of biodiversity and genetic resources in aquatic protected areas.
- Integrated Agriculture-Aquaculture Systems (IAAS) - exploring methods for the characterization, evaluation and monitoring of biodiversity and genetic resources on farms, to strengthen this dimension of the RESTORE (Research Tools for Natural Resource Management, Monitoring and Evaluation) software and to research on sustainability indicators for integrated agriculture-aquaculture systems.
- Coastal Aquaculture and Stock Enhancement - planning the incorporation of biodiversity and genetic resources research in coastal aquaculture and stock enhancement.

Interactions with international and regional bodies and mechanisms will include:

- FAO - contributing to the development of guidelines, codes of conduct and other instruments for the conservation and sustainable use of aquatic biodiversity and genetic resources, including the designation of *ex-situ* collections of aquatic germplasm.
- The International Convention on Biological Diversity (CBD) and its Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) and Clearing House Mechanism (CHM) - contributing information and advice on aquatic biodiversity and genetic resources to the CBD, SBSTTA and CHM and to related fora, such as the Global Biodiversity Forum (GBF).
- The World Conservation Union (IUCN) - contributing information and advice on aquatic biodiversity and genetic resources and implementing a global project on assessing threats to freshwater fishes.
- Species 2000 - providing information on all the world's finfishes and exploring how to do the same for other major groups of exploited aquatic organisms, as contributions to this global database effort.
- System-wide Programs of the CGIAR - participating in the InterCenter Working Group on Genetic Resources (ICWG-GR) of the System-wide Genetic Resources Programme (SGRP)

leading its activities on databases for *in situ* conservation of genetic resources, and providing advice on database establishment; helping to plan the System-wide Program on Coastal Environments; seeking assistance from other IARCs on building ICLARM's capacity in molecular genetics.

- Others - participation in international and regional network events to which the Center can contribute on biodiversity and genetic resources issues, e.g., The International Network on Genetics in Aquaculture (INGA), The Network of Aquaculture Centres in Asia-Pacific (NACA).,

2. Medium-Term 1998-2000

During this period, the BGRP's interactions within and beyond the Center will continue as outlined above for 1996-97.

The 1996-97 BGRP activities outlined above [principally the database on finfish (FishBase), genetic characterization research (West African tilapias), and assessment of threats to freshwater fishes] will near completion of their original objectives and new opportunities will arise for research, database design and training at the gene, populations and ecosystem levels. These opportunities will add new dimensions to FishBase, incorporating comprehensive molecular genetics, population and ecological function data on the world's finfish. Databases on aquatic invertebrates will also begin to incorporate these new elements, as will related research, information and training.

At the molecular genetics level, the BGRP will work towards both generating and acquiring data. However the generation of substantial primary data will require the establishment of a molecular genetics laboratory (at ICLARM's proposed new HQ) to which tissue and DNA samples can be sent for analysis, from outreach teams and collaborators. This will be a significant step, opening up new strategic research and training possibilities, including closer links with aquatic conservation breeding programs worldwide.

At the population and ecosystem levels, the BGRP will work with the Center's ecological modellers and software developers and their partners to incorporate biodiversity and genetic resources data and interrelationships, e.g., genetic erosion, gene flow, etc. This will bring consideration of biodiversity and genetic resources conservation and use into efforts such as ecological modeling software (e.g., ECOPATH), the use of GIS Center-wide, and the planning of strategic research on the ecological function of aquatic biota.

3. Long-Term - Beyond 2000

Beyond 2000, the Center, through the BGRP and its multiple partners can become one of the world's primary sources of reference and information on aquatic biodiversity and genetic resources, through on-line services, CD-ROMs, biodiversity and genetic resources software, field kits and other tools to build capacity in NARS and other institutions involved in biodiversity and genetic resources research and utilization. The Center will also be the focal point for advice on aquatic biodiversity and genetic resources to other IARCs within the CGIAR and for its System-wide programs, and to international, regional and national collaborators and clients.

ICLARM ORGANIZATIONAL STATEMENT

"For those who use and depend on fish and aquatic life in the developing world"

ICLARM's VISION

Our Goal : To enhance the well-being of present and future generations of poor people in the developing world through production, management and conservation of living aquatic resources.

Our Objectives : Through international research and related activities, and in partnership with national research and other institutions, to:

1. Improve the biological, socioeconomic and institutional management mechanisms for sustainable use of aquatic resource systems.
2. Devise and improve production systems that will provide increasing yet sustainable yields.
3. Help develop the capacity of national programs to ensure sustainable development of aquatic resources.

The Functions of ICLARM are to:

- Conduct and catalyze multidisciplinary strategic research and policy analysis of an international public goods nature on all aspects of aquatic resource management, conservation and use;
- Undertake research, training and information activities in partnership with others in national organizations in the developing and developed world;
- Develop global knowledge bases for living aquatic resources;
- Undertake global reviews and assessments of the status of aquatic resource and those who depend on them;
- Publish and disseminate widely research findings;
- Hold conferences, meetings and workshops to discuss current and future issues related to aquatic resources and to formulate advice for users and decisionmakers;
- Participate fully as a Center in the Consultative Group on International Agricultural Research (CGIAR) and in appropriate international intergovernmental activities.

The Guiding Principles for our Work Program are:

- Sustainability;
- Equity;
- Gender role in development;
- Participation;
- Systems approach; and
- Anticipatory research.

Our Values:

In our work, we are committed to:

- Excellence in achievement;
- Relevance to our beneficiaries' needs;
- Partnerships;
- Centerwide teamwork;
- Communication;
- Efficiency and flexibility in program delivery;
- Continual growth in our knowledge and understanding.

Consultation on fish genetic resources. R.S.V. Pullin and C.M.V. Casal, Editors. 1996. ICLARM Conf. Proc. 51, 61 p.

TITLES OF RELATED INTEREST

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Genetic aspects of conservation and cultivation of giant clams. P. Munro, Editor. 1993. ICLARM Conf. Proc. 39, 47 p.

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