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ICLARM REPORT 1993



ICLARM

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

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1993

**INTERNATIONAL CENTER FOR LIVING AQUATIC
RESOURCES MANAGEMENT**

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Cover: Tropical underwater 'forest': soft coral on a
Philippine reef. Strategic research on coral
reefs is a major thrust at ICLARM. Their similarity
to tropical rain forests is striking, in terms of their
biodiversity, fragility and slow recovery after
disturbance. Photo by Roger Pullin

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FOREWORD

ICLARM ended 1993 in a consolidated position following difficult changes which occurred within the Board of Trustees, senior management, among the staff and in the work program during the year. Despite the extent of changes which occurred during 1993, the ICLARM work program still performed strongly. In terms of scientific research achievements, research networking and training activities, and information services, the total of the achievements of 1993 represented a substantial contribution to the furthering of knowledge and tools for improved aquatic resource management in the developing world.

Research Highlights

Using an ecosystems approach and taking account of ICLARM's small size, the Center's research was reorganized into two research programs: Coastal and Coral Reef Resource Systems Program (CRRSP) and Inland and Aquatic Resource Systems Program (IARSP). A feature of the new programs is the greater emphasis on social science research to complement biophysical science research, and a greater integration of the respective disciplines.

Some key research achievements for 1993 were:

- Extended fish stock assessment methodologies to examine global aspects of biodiversity relevant to fisheries exploitation. Studies were also started to examine recent historical changes in fish biodiversity using detailed survey data in western Indonesia.
- Developed a much enhanced and more user-friendly version of the analytical package, ECOPATH II, which is used in studies of the functioning of aquatic ecosystems with special reference to their sustained exploitation and management. The new version of ECOPATH II was distributed to over 350 users in developing and developed countries.
- Commenced the first planning phase of a comparative analysis of fisheries management rules and rights and how sharing of management responsibility between the national and local levels (co-management) affects the outcome. This project is being conducted in collaboration with the North Sea Centre, Denmark, and the first phase was funded by DANIDA and IDRC.
- Commenced a global research database of information on coral reefs, their resources, stresses and other factors relevant to the

management, conservation and sustainable utilization of reefs. This project is a collaboration with the World Conservation Monitoring Centre and reef research management and research agencies worldwide and is funded by the Commission of the European Communities.

- Extended village growout trials of giant clams at the Coastal Aquaculture Centre (CAC), Solomon Islands to involve far greater numbers of clams, a wider variety of species and a wider range of marketable clam types including small clams for the aquarium and sashimi markets. In 1993, research commenced into pearl oysters and sea cucumbers at the CAC. The CAC now holds an increasingly large and valuable collection of brood stock of 6 species of giant clams, including some five-year-old clams from spawning at the CAC in 1988.
- Continued excellent progress on the projects involved with the Genetic Improvement of Farmed Tilapia (GIFT), including conduct of trials to estimate genetic gains, on-farm trials comparing the GIFT and other selected strains and the establishment of a new unit for the cryopreservation of Tilapia spermatozoa. In 1993, the President of the Republic of the Philippines, Fidel V. Ramos, launched the Philippine National Tilapia Breeding Program, to be supported by the Department of Agriculture's Bureau of Fisheries and Aquaculture Research, a partner of ICLARM in the research project.

In the lead up to the Mid-Term Review of ICLARM by the CGIAR System, reviews were conducted in 1993 of the IARSP's GIFT project and of the thrust on integrated resource management research. ICLARM's management is presently responding to recommendations from these reviews. In 1994, internal reviews will be conducted of the CRRSP and of the Center's management services.

Networks, Training and Information Services

ICLARM contributed to the strengthening of national research systems in partner countries through the conduct of many partnership research projects and through continuing to coordinate established research networks (the Asian Fisheries Social Science Research Network, Network of Tropical Aquaculture Scientists, and Network of Tropical Fisheries Scientists). In addition, a new research network, the International Network on Genetics in Aquaculture (INGA) was established in June 1993 to form a research coalition for the exchange of germplasm and research methods in the improvement of carp and tilapia breeds for aquaculture production.

ICLARM continued a vigorous program of publishing fisheries and aquaculture research material and disseminating this widely to scientists and managers around the world. ICLARM also continued to publish the refereed journal, *Asian Fisheries Science*, on behalf of the Asian Fisheries Society.

A quantitative study of the output and impact of ICLARM's publications indicated that the Centre has indeed been highly

productive. Further analyses of the scientific impact of the works will be published in 1994 and show a high scientific citation rate.

Board of Trustees

The former Chair of the Board of Trustees, Dr. Peter Larkin, resigned from his position in April 1993 and Dr. Barry Filshie assumed the role of Acting Chair until August 1993 when John Dillon was appointed. The Board has now developed and adopted its own Mission Statement and Code of Conduct, has appointed the first of three proposed CGIAR-nominees and has instituted a process of self evaluation and evaluation of the Chair.

The full Board met on 19-23 April, 17-19 July, and 2-4 December 1993, and, in addition, the DG Search Committee met 22-24 September in Seattle and 28-29 October 1993 in Washington.

The Executive Committee had a special meeting by telephone conference on 17 May 1993 and another meeting on 30-31 October 1993.

Management

Dr. Ken MacKay resigned as Director General on 23 April 1993 and Mr. B.M. Rodriguez acted as Officer in Charge until mid-July 1993 when Dr. Larry Stifel agreed to act as Interim Director General. Following an extensive search process, Dr. Meryl Williams was offered the position of Director General in December 1993. She takes up the position in April 1994.

In April 1993, ICLARM formally became an international organization through an agreement signed by the Philippines, Denmark, Malawi, and Vietnam. Other nations are being approached to sign.

During 1993, ICLARM strengthened its financial management systems and began developing and implementing a comprehensive set of human resource management policies.

The Outlook

ICLARM's mission is a challenging one. As this report was being prepared, there was considerable international attention on the state of the world's fisheries and aquatic resources. ICLARM has been a major research force in developing fisheries assessment methods for the tropical marine fisheries and new technologies for aquaculture. The challenge for the Center is to continue to develop as a research and service provider to assist sustainable food production, poverty alleviation, environmental quality and social equity.

John L. Dillon
Chair, Board of Trustees

Laurence D. Stifel
Director General

ICLARM Board of Trustees

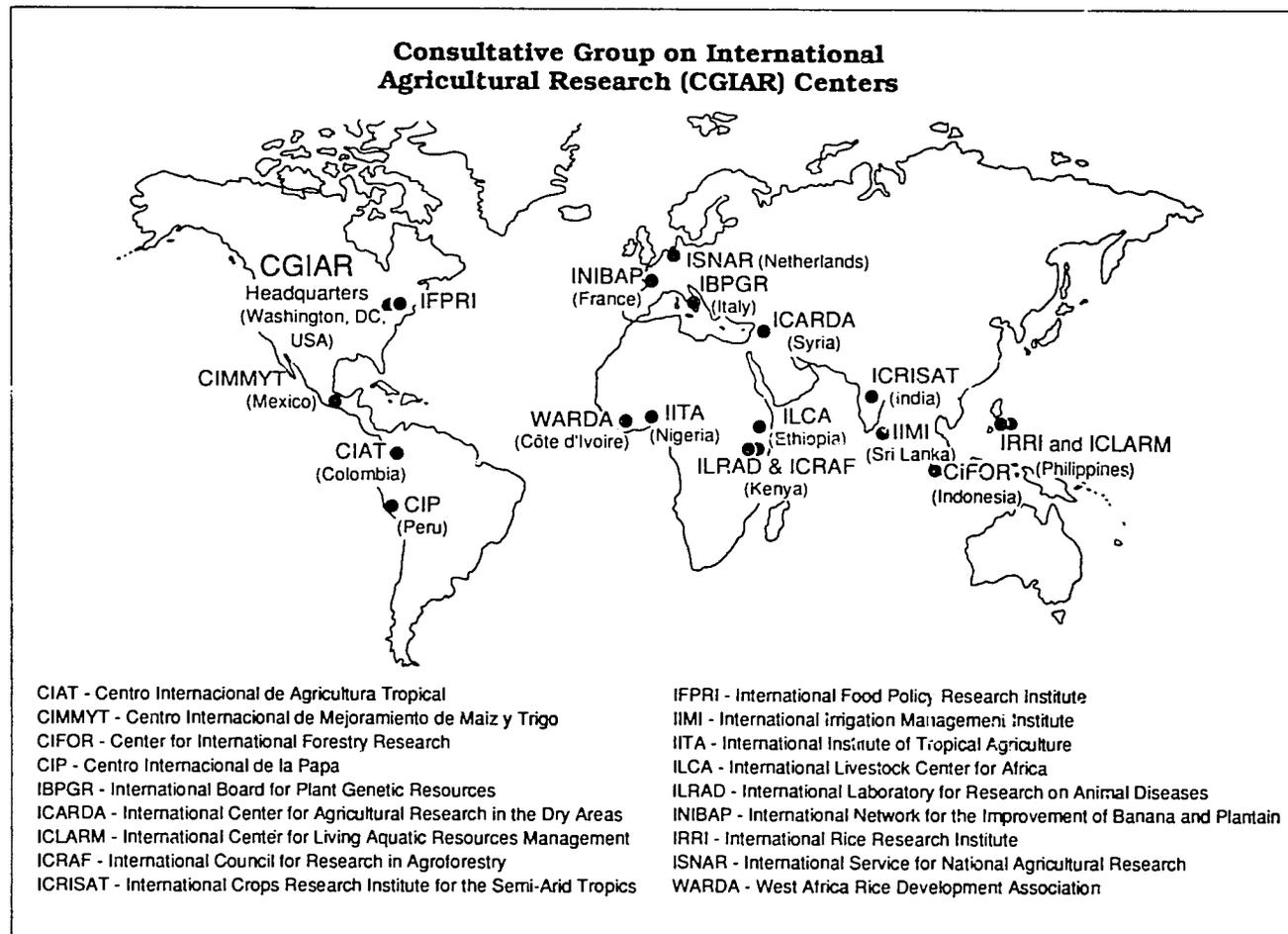
- Dr. Dayton L. Alverson: Owner/President of Natural Resources Consultants, Inc., Seattle (1980 to present). Board Member since 1991.
- Dr. Agustin Ayala-Castañares: Institute of Marine Science and Limnology, National Autonomous University of Mexico (UNAM) - Senior Researcher (1973 to present). Board Member since 1988.
- Dr. Nyle Brady: Senior Consultant, United Nations Development Programme. Board Member since 1992.
- Dr. John Dillon: Head, Department of Agricultural Economics and Business Management, University of New England, Armidale, Australia. Board Chair since July 1993.
- Dr. Barry K. Filshie: Officer-In-Charge, Commonwealth Scientific and Industrial Research Organisation (CSIRO), International Relations Centre, Australia (1983 to present). Board Member since 1991.
- Dr. Masaru Fujiya: Senior Advisor and Consultant, Overseas Fisheries Cooperation, Tokyo (until 1993). Board Member since 1992.
- Dr. Serge Garcia: FAO Fisheries Department. Board Member since 1993.
- Dr. Edgardo D. Gomez: University of the Philippines - Director, Marine Science Institute (1975 to present). Board Member since 1989.
- Dr. Zimani David Kadzamira: Malaŵi Government's Ambassador to Japan (1993- present). Board Member since 1989.
- Prof. Jacqueline McGlade: Professor, Department of Biological Sciences, Ecosystems Analysis and Management Group, University of Warwick, UK. Board Member since 1993.
- Ms. Britha Mikkelsen: Education and Training Planner, COWI/Consult., Consulting Engineers and Planners A/S, Denmark. Board Member since 1992.
- Dr. David Adolph Philipp Muller: South Pacific Forum Fisheries Agency - Director (1981 to present). Board Member since 1989.
- Dr. Cornelia Nauen: Senior Fisheries Cooperation Officer, Commission of the European Communities. Board Member since 1990.
- Dr. Benedict Satia: Programme Coordinator, International Development of Artisanal Fisheries. Board Member since 1993.
- Mr. Roberto Sebastian: Minister, Philippine Department of Agriculture. Board Member since 1992.
- Dr. Laurence Stifel: Visiting Professor, Cornell University, New York, USA. (Director General since July 1993).



**Dr. John Dillon
Board Chair**

Details of Board membership and committees are on p. 30-32.

The Consultative Group on International Agricultural Research (CGIAR) is an informal association of 41 public and private sector donors that supports a network of 18 international agricultural research centers. The group was established in 1971.



X



CHANGING COURSE

This year ICLARM embarked on some new areas of research and modified the directions of some ongoing work. Research programs ended and new ones began.

The reason: a chain of events beginning in 1990 with a conditional invitation to join the prestigious Consultative Group on International Agricultural Research (CGIAR), an informal but highly successful association of public and private sector donors supporting a number of international agricultural research centers (see p. x); development of a Strategic Plan for future research; and, following entry into the CGIAR in 1992, preparation of a Mid-Term (1994-1998) Plan.

During the strategic planning it became clear that our work would be most efficient if based on major aquatic resource systems, a concept we developed because it was in some ways akin to agroecological zonation used in agricultural research. A resource system consists of the resources, their habitats or environments and the human populations using the resources. We divided the aquatic world into nine such systems - uplands; ponds; reservoirs and lakes; streams; rivers and flood plains; coasts (bays, estuaries, lagoons, swamps); coral reefs; soft-bottom shelves; upwelling shelves; and high seas.

Through the planning process, which took into account not only what other institutions were doing and the Center's comparative advantage based on its research experience and expertise, but also such factors as numbers of beneficiaries and likely impact on them; extent to which results will strengthen national programs, contribution to



ICLARM was enthusiastic about joining the CGIAR. The upper figure, which appeared in *Naga, the ICLARM Quarterly*, shows a smiling ICLARM after the Center became a CGIAR member. The lower figure was the motif on "pre-CGIAR" T-shirts provided by the Board to staff in 1991.

sustainability of the resources and their environments; probability of the research succeeding; "spillover" benefits to other (nonbeneficiary) groups; and the cost-benefit ratio of the research.

On these criteria, ICLARM selected three resource systems for investigation - Coastal (especially estuaries and lagoons), Coral Reef and Inland (ponds and rice paddies).

ICLARM's research, in collaboration with many partners, will be directed at the social, economic, biological and technical factors that determine the productivity of the resource systems. From an understanding of these factors, the research will seek to find better management schemes and ways of improving the productivity of key species in the systems.

The resource systems were adopted as research programs and a fourth program, National Research Support, was created to take over and enlarge upon ICLARM's strengthening activities for national aquatic research systems.

However, by midyear, it was learnt that there were insufficient funds in the CGIAR system to support four aquatic resource programs. As a result, the coral and coastal programs were merged and the national support program removed. The two remaining programs are:

- Coastal and Coral Reef Resource Systems
- Inland Aquatic Resource Systems

Fortunately, the two programs, while reduced in scope from the original vision, retain most of their flavor and excitement. A summary of their content follows.

ICLARM's New Research Programs

1. Coastal and Coral Reef Resource Systems Program (CCRRSP)

Two basic issues drive the urgent need for global research efforts on coastal and coral reef resource systems - overfishing, exacerbated by poverty; and competition with other sectors and pollution from them.

For coastal resources in general, the aim is to make advances in fisheries management and resource use based on improved understanding of the coastal fisheries resource base, the social and economic structure of the fishing communities, and the interaction between these and other sectors.

For coral reefs, the objective is to seek ways to realize the potential of their fisheries in a sustainable manner by improving coral reef management and by increasing the productivity of

selected "new" species, notably bivalve molluscs, through aquaculture and fisheries enhancement.

The program has three research thrusts:

1.1 Dynamics of Resource Systems

This work includes development and dissemination of (i) tools for the assessment of fisheries resources and their ecosystems and (ii) global documentation of fish biodiversity and of coral reef systems.

1.2 Management of Resource Systems in a Social Context

Based on the understanding of the social and economic forces and of the legal and institutional aspects of small-scale fisheries, management regimes that optimize yields of coastal fisheries will be developed and tested. Research activities include development of tools and methods for valuation of coastal and coral reef resources.

An analytical framework to allow comparisons of different coral reef and coastal communities and areas is also being developed.

1.3 Improving Coral Reef Productivity

The research here includes development and evaluation of simple hatchery and nursery technologies for selected "new" species of fishes and invertebrates, improvement of farming methods and selective breeding of giant clams and the evaluation of fisheries enhancement or "ranching" systems.

2. Inland Aquatic Resource Systems Program (IARSP)

The basis for this Program is the present vast underdevelopment of tropical inland aquaculture. A key to sustainable use of inland aquatic resource systems is integration of agriculture and aquaculture to raise total farm productivity and profitability, particularly among resource-poor families. New breeds of fish and new approaches to natural resources management are needed.

There are two interactive research thrusts:

2.1 Fish Productivity

This research is aimed at establishing and maintaining breeding programs for fish that resource-poor farmers can use

in low-cost, low-input systems (mainly carps and tilapias), and at finding the best genetic management techniques for these purposes. The research will also assist national institutions in biodiversity conservation through documentation of fish genetic resources.

2.2 Integrated Resources Management

This research thrust involves farmers' participation towards the integrated use of all their natural resources.

Social scientists and biologists work interactively in three areas: evolving participatory strategies for transforming farming systems to more sustainable integrated agriculture-aquaculture; modeling the ecological and bioeconomic consequences of system transformation; and evaluating the social, economic and institutional factors that may affect the adoption and retention of such systems by new entrant farmers.

Transition

How do these two new programs relate to the previous four programs? Up to 1992, there were three research programs and a fourth on Information. Due to administrative restructuring, Information has become a Division, while parts of the former research programs have been merged with new thrusts into the two new programs. The Table below gives details. For the New Programs, only activities in the Mid-Term Plan (up to 1988) are indicated.

ICLARM Research Programs

| Old (pre-1993) | New |
|--|---|
| Aquaculture Program. Earlier focus on use of farm by-products in fish ponds; genetic improvement of fish. | Inland Aquatic Resource Systems Program. Focus on improved management of whole farms through addition of fish crop; breeding programs and methodology. |
| Coastal Area Management Program. Mainly technical assistance and coordination of planning at national pilot sites. | Coastal and Coral Reef Resource Systems Program. Coastal work focus on new research methodology for characterizing coasts; alternative management methods; use of ecosystem approach to fisheries management; coral reef thrusts on consolidating information and improving reef productivity. |
| Capture Fisheries Management Program. Single species approach to fisheries management; development of ecosystem approach. | |

WORKING IN RESOURCE SYSTEMS

This year marked the first year of the Center's new resource-system based research programs (p. 2), characterized by a blending of 'old' and new projects in new thematic thrusts. Although the research year was disrupted by management problems (p. 24), a surprising amount of new information was generated in the Center's 30 current projects. The principal results were:

1. Inland Aquatic Resource Systems Program

In Integrated Resources Management

- New information on the effects, both positive and negative, of fish in ricefields (Philippines, p. 85)
- New knowledge on constraints to agriculture-aquaculture integration, leading to recommendations for planners and extension agents (Malaŵi, p. 93)
- On-farm experiments of crop-fish integration showed marked benefits (Ghana, p. 91)
- New knowledge on trophic and nutrient dynamics of small pond systems (Malaŵi, p. 93)
- New methods for conduct of on-station integrated aquaculture experimentation (Malaŵi, p. 94)
- Benchmark studies on identifying problems and opportunities in inland fishing communities (Bangladesh, p. 68)



- A new set of tools for studying growth and mortality in aquaculture systems (Global, p. 84)

In Productivity Improvement

- Testing new indigenous fish species for polyculture in subSaharan Africa; several species are proving useful (Malaŵi, p. 93)
- Beginning of a typology of farming systems, classified on a scale of increasing ecological sustainability (Philippines, p. 84)
- Release of the first "Super Tilapia", a new tilapia strain with 60% better growth and 50% better survival rate than presently farmed strains (Philippines, p. 80)
- Formation of an International Network on Genetics in Aquaculture, a collaborative research network in which ICLARM is member-coordinator (Global, p. 81)

2. Coastal and Coral Reef Resource Systems Program

In Dynamics of Resource Systems

- A simple method of comparing fish biodiversity at different latitudes, using FishBase (Global, p. 55)
- A new way of determining how much of the ocean's primary productivity is used directly or indirectly in fisheries - a measure of human impact - using ECOPATH II (Global, p. 57)

In Management of Resource Systems in a Social Context

- Development of plans for long-term research on the potential applicability of co-management in coastal fisheries (Global, p. 67)

In Improving Coral Reef Productivity

- Initiation of a relational database. ReefBase, to become an electronic encyclopedia for use in reef management, conservation and research (Global, p. 72)

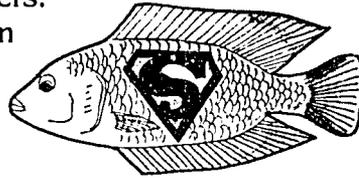


- Development of markets for giant clams (Indo-Pacific, p. 74)
- Initiation of work to determine the viability of pearl oyster hatcheries and sea cucumber cultivation (Indo-Pacific, p. 76)

More details of these results can be found in the appropriate pages of the Annex. In this section, we describe the stories behind some of the "older" projects and why some new ones were chosen.

The "Super Tilapia" Story

This year, a new tilapia strain, the 'Super Tilapia' developed by ICLARM and collaborators, was ceremonially handed over by Philippine President Fidel V. Ramos to farmers. The new strain marked the culmination of research and other activities that began in 1979. Here is the story of the 'super tilapia'.



Background

Tilapias are a group of prized, tropical freshwater fish originally from Africa which are farmed or under experimentation for farming in over 60 tropical developing countries. Tilapia has been called an 'aquatic chicken' and can be farmed in intensive factory farms or by low input 'backyard' methods. Tilapia flesh is fast becoming an international white fish commodity.

From 1979, one of ICLARM's founder staff and a former Director General, Dr. Ziad Shehadeh, and ICLARM scientist Roger Pullin prepared for a Bellagio conference on the Biology and Culture of Tilapias, which was held in 1980. The proceedings of the Bellagio Conference have become ICLARM's most cited publication and helped to spur an increased global effort on tilapia farming research, including the series of International Symposia on Tilapia in Aquaculture: inaugurated by Israeli scientists in 1983 in Nazareth and continued by ICLARM in Bangkok in 1987 and Abidjan in 1991.



The Bellagio conference identified the lack of attention to tilapia genetics as one of the major research gaps. The tilapia conference series has since included an increasing number of genetics research contributions, but back in those early days, the application of genetics in tropical aquaculture had scarcely begun. The very first international symposium on genetics in aquaculture was held in 1982. Many of the most widely farmed freshwater fish species were not even bred in captivity until the 1960s and tropical farmed fish stocks remained close to wildtypes or have very recent, largely undocumented breeding histories. The tilapias were bred in captivity but with almost no attention to the genetics of breeding and harvesting. Indeed, the general scientific opinion up to the commencement of ICLARM's work was that selective breeding of fish like tilapia would not yield appreciable genetic gain and would be too time-consuming and costly.

The Basic Strategy

From the early 1980s, ICLARM, largely in collaboration with Philippine national institutions - the Marine Science Institute of the University of the Philippines (UPMSI) and the Freshwater Aquaculture Center of Central Luzon State University - undertook studies on Asian farmed tilapia stocks and found a poorly documented and worrying situation. Farmers spoke of poor growth performance. Population genetics studies (using biochemical markers) revealed introgressive hybridization of farmed Nile tilapia stocks with feral populations of a much less desirable species for farming - the Mozambique tilapia (*O. mossambicus*). Clearly, the lack of any systematic attempt to breed tilapias for aquaculture was handicapping the productivity and expansion of the industry,

as was a fear that introductions of Nile tilapia might have ecological side effects, such as some countries had experienced with *O. mossambicus*: establishment in open waters through prolific breeding and tolerance to extreme environments, occasionally displacing native wild and other farmed species. Also at this time, ICLARM scientists and their collaborators, particularly the Aquaculture Research Organization of Israel, made wide reviews of the history of tilapia genetics research, most of which was on hybridization

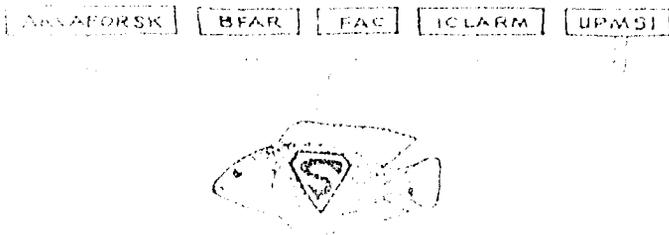


and genetic manipulations. Selective breeding had not been attempted to any significant degree.

An ICLARM workshop on Tilapia Genetic Resources for Aquaculture in March 1987 in Bangkok, confirmed that in Asia presently available stocks of the most widely preferred tilapia species, Nile tilapia (*O. niloticus*), were inadequate for genetic improvement programs because of their small founder populations, inbreeding, and introgression of genes from other species. These problems were documented and decisions were taken to collect and evaluate new tilapia broodstocks collected from open waters in Africa. This ICLARM decision to collect new founder stocks from the wild, upon which to base genetic improvement research using selective breeding, was made in the face of opposition from some fish genetics experts who said that, even in Asia, the work should start with the existing farmed stocks, poor though they were, and that a selective breeding strategy would fail. However, ICLARM found staunch supporters and colleagues in the Institute of Aquaculture Research of Norway (AKVAFORSK), who had pioneered this approach with Atlantic salmon.

With their help, ICLARM, encouraged by the growing importance of tilapia in its client countries in Asia and the needs of African clients to document tilapia biodiversity for future aquaculture development, conceived a strategy to investigate the potential for genetic improvement of farmed tilapia by simple selective breeding. The short generation time of tilapia (4-6 months in the tropics) suggested that results could be fairly rapid.

GIFT Project



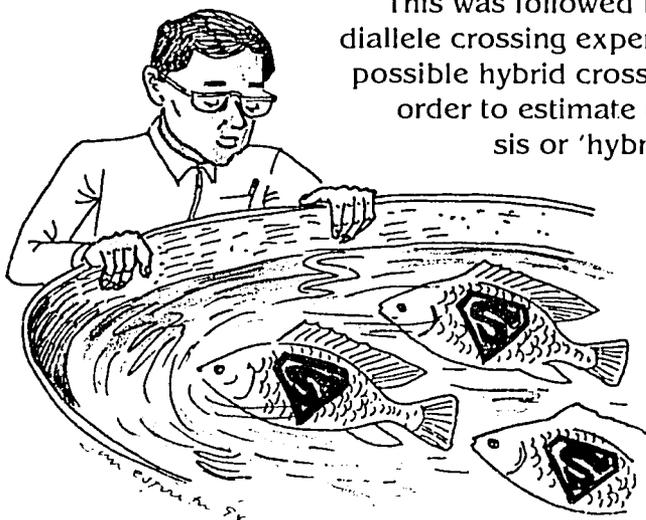
The Genetic Improvement of Farmed Tilapias (GIFT) project was established in 1988 in the Philippines. Dr. Ambekar Eknath was hired to lead the research. The team implementing the project brought together institutions with experience in: tilapia farming (BFAR, FAC, ICLARM); genetic status of wild and cultured tilapia stocks (UPMSI, ICLARM); and application of genetic improvement strategies in fish (AKVAFORSK and ICLARM). Support came from ADB and UNDP.

Based upon the 1987 identification of sources of pure tilapia stocks, the GIFT team made, in 1988, the first ever collections and direct transfers of *Oreochromis niloticus* from Africa to tropical Southeast Asia. Breeders (150-160) or fingerlings (200-800) were collected in Egypt, Ghana, Kenya and Sénégal, in collaboration with, among many, the University of Hamburg; the Musée Royal de l'Afrique Centrale, Tervuren, Belgium; the Institute of Aquatic Biology, Ghana; the Suez Canal University, Egypt; and Baobab Farms, Mombasa, Kenya.

The new fish were held in isolation at the National Freshwater Fisheries Technology Research Center/Bureau of Fisheries and Agriculture Research (NFFTRC/BFAR). The team worked with the BFAR-IDRC Fish Health Unit in developing three- to seven-month quarantine procedures. Experimental stocks of four Philippine commercial *O. niloticus* strains (known as 'Israel', 'Singapore', 'Taiwan' and 'Thailand' strains) were also gathered, giving a total of eight strains for study. All eight strains were thoroughly described using biochemical and morphometric techniques and were kept in a newly constructed Tilapia Germplasm Reference Collection Center at the NFFTRC/BFAR and in indoor tanks at FAC.

Research methods for evaluation of culture performance in different test environments were then refined. Procedures were standardized for controlled mating, anesthesia, mass individual tagging and recording of ancestry, hatching data, growth and survival. No program of this magnitude and scientific rigor had ever been attempted before with tropical farmed fish.

The first generation trial consisted of purebred individuals of all eight strains: 11,400 tagged fingerlings were distributed to 11 test environments and communally reared for 90 days to estimate genotype x environment interactions. The interaction was very low, indicating no need to develop specialized strains for each of the different farming systems used in the test. Some of the African wild strains grew faster than the farmed strains.



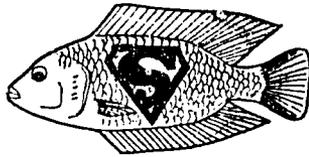
This was followed by a complete 8 x 8 diallele crossing experiment, producing all 64 possible hybrid crosses among the strains in order to estimate the magnitude of heterosis or 'hybrid vigor'; 21,000 tagged

fingerlings were communally tested in eight environments. The gain in growth and survival by cross-breeding was too low to be of significance in an applied breeding

program. A simple pure breeding strategy was then started by selecting best growing breeders from the 25 best performing pure-bred and crossbred groups (out of the 64 evaluated) to build a genetically mixed base population (synthetic breed). The synthetic breed served as the base for further generations of selection and purebreeding.

After only one generation of selection in the synthetic breed, the selected fish grew 26% faster in on-station trials than the previous generation and 75% faster than the most commonly farmed strain. In on-farm trials, the GIFT fish grew an average 60% faster than present farm breeds. Their survival was almost 50% better.

The GIFT breed became known as 'super tilapia' and in 1993, the Philippine President, Fidel V. Ramos, launched their national distribution. The Philippines has since initiated a self-sustaining National Tilapia Breeding Program and the ADB has agreed to support more ICLARM research in five of its Asian developing member countries (Bangladesh, China, Indonesia, Thailand and Vietnam) on the social, economic and environmental impact of new tilapia breeds. A regional testing program in these countries is about to commence.



Strengthening/Networking

ICLARM has no freshwater aquaculture facilities of its own. All the genetic research has been done in strengthened national facilities in the Philippines. Moreover, the achievements of the GIFT project have encouraged its principal donor (UNDP) to assist ICLARM in establishing an International Network on Genetics in Aquaculture (INGA), modeled on a similar network for rice breeding. The INGA has started with 11 countries collaborating in research and training activities: Bangladesh, China, Côte d'Ivoire, Egypt, Ghana, India, Indonesia, Malawi, the Philippines, Thailand and Vietnam. The INGA was formally established in July 1993.

ELEFAN to FiSAT - Development and Methodology

ICLARM's present prominent role in stock assessment of tropical fisheries is no overnight success. It is based on collaboration going back to 1978 when Daniel Pauly, then at the Institute for Marine Sciences, Kiel, Germany, undertook a consultancy at ICLARM to develop a program for research in this field. His



published review and earlier collaboration with G. Gaschütz also of Kiel University set the stage for developing ways of assessing fish stocks based on the length of fish: length, because the methods used in temperate waters based on age of fish don't work well in tropical fish for which it is quite difficult to obtain age estimates.

In 1979, Pauly accepted a position in ICLARM and began developing length-based assessment methods for calculators and microcomputers. The first models were designed with Noel David on a futuristic - at the time - 32K Radioshack microcomputer which ran from a cassette drive. Nevertheless, the important decision was taken to work within the limitations of microcomputers rather than to use mini- or mainframe computers, because the micros would be far cheaper and thus more accessible in developing countries.

Some of the earlier material ("Simple methods for the assessment of tropical fish stocks") was first published by FAO in 1980.

In 1981, ICLARM and the Commonwealth Scientific and Industrial Research Organisation of Australia conducted an international conference on "Theory and Management of Tropical Multispecies Stocks," which helped set directions for future research. By 1982, ICLARM's stock assessment packages had been presented in Denmark to the International Council for the Exploration of the Sea and in Australia to the Indo-Pacific Fisheries Commission. The major tool was called ELEFAN (**E**lectronic **L**ength-**F**requency **A**nalysis).

Developments and applications continued in the Philippines with John Munro who joined ICLARM in 1982, intern Jose Ingles (later to do his Ph.D. in Hamburg) and ICLARM programmer Mina Soriano; in Peru with I. Tsukayama; in Myanmar (then Burma) with Sann Aung; in Kuwait with G. Morgan and C.P. Mathews; and with colleagues in FAO - J. Caddy, J. Csirke, S. Garcia, P. Sparre and S. Venema.

By 1985, it was time to evaluate progress. This was done at an international meeting held in Sicily on Length-Based Methods in Fisheries Research, jointly organized with the Kuwait Institute for Scientific Research. A consensus emerged on the appropriate use of such methods and ELEFAN became standard methodology.

In 1986, the German-funded project hired programmer F. (Nonong) Gayanilo to prepare a version of ELEFAN for Hewlett Packard Computers. ICLARM then hired Gayanilo to program the conceptual developments leading to the final



The first computer at ICLARM was this 32K Radioshack used in developing ELEFAN. Versions for calculators (upper left) enjoyed popularity for several years.

final ICLARM product, the Compleat ELEFAN. Gayarilo has since taken on a teaching role, bringing ELEFAN to a wide range of users.

More researchers joined the work in later years - J. Moreau in France, P. Kleiber in the USA (who ran ELEFAN on a CRAY supercomputer), and postdoctoral fellows and interns in ICLARM - M. Vakily, M. Palomares and G. Silvestre to name a few.

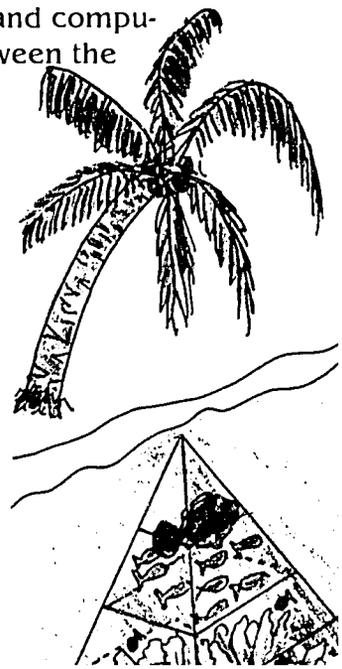
The collaboration with FAO was particularly important. Throughout the years of development of ELEFAN, FAO had invited ICLARM to teach length-based methods at its DANIDA-funded national and regional workshops on stock assessment, virtually all around the developing world, and at which the use of both ICLARM's ELEFAN and FAO's LFSA package, which emphasized simulations of length-frequency samples, were taught. By 1989, it was agreed that a single product should be made available, combining ELEFAN and LFSA and which would become the basic training tool for future FAO and ICLARM courses in stock assessment. The new product called FiSAT (FAO-ICLARM Stock Assessment Tools) was being refined and was tested on a pilot-scale during 1993.

ECOPATH - Ways

In 1990, we were able to attract Danish scientist Villy Christensen to ICLARM to develop a software called ECOPATH. It was originally conceived by US scientist Dr. J.J. Polovina to quantify energy flow in reef ecosystems. It had an elegant simplicity which stemmed from the fact that there are usually not enough data in tropical situations to construct more complex models. Polovina used it to model coral reefs but took it no further at the time.

Christensen's task was to carry on the developmental work. In collaboration with D. Pauly, he increased the flexibility and computational power of ECOPATH and increased the links between the theory behind ECOPATH and of the network flow analysis approach of R.E. Ulanovicz of the University of Maryland. The user-friendly product that emerged from this is called ECOPATH II; its comprehensive manual is available in English, French and Spanish.

In 1993, the significance of this development became apparent to the scientific world in our publication of a compilation of studies of ecosystems large and small around the world, mostly using ECOPATH II. ECOPATH II has been found through the work of scientists from many institutions to be equally at home describing how mulberry leaves and silkworm



manure drive fish ponds in China, the functioning of ecosystems of lakes in France or Africa, lagoons in Mexico or the Mediterranean, the tropical South China Sea or the Wedell Sea in Antarctica.

At the request of various institutions, Christensen taught ECOPATH II methodology in Canada, Germany, Malaysia and Thailand, as well as further improving the software.

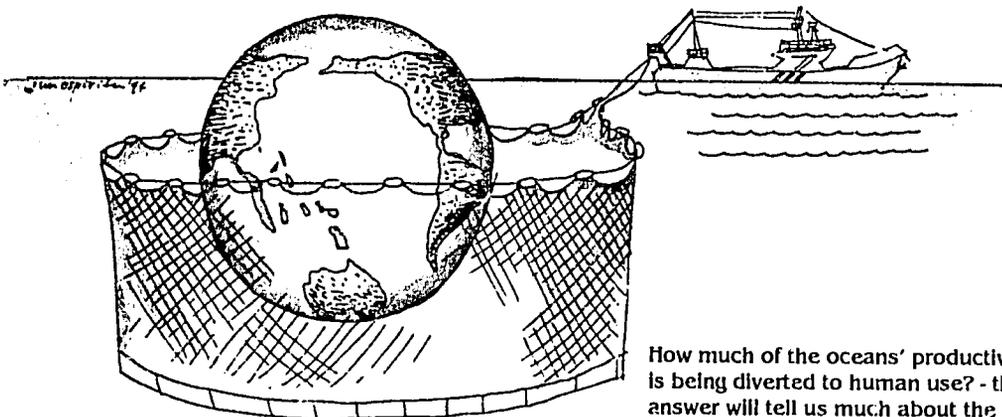
We now have a fairly simple, robust tool which can describe the reverberations that pass through any ecosystem when it is disturbed, for instance by catching all the predatory fish on a coast, or dynamiting the living coral on a reef, or intensifying rice production in a paddy field. ECOPATH II is a unifying tool for all our research thrusts and beyond: fish are not a necessary component for the model to work.

ECOPATH II and Ecosystem Carrying Capacity

At the heart of discussions on managing and enhancing fisheries (adding hatchery-reared fish into the resource system), is determining the biological limits of the system.

In late 1993, Pauly and Christensen realized that ECOPATH II could be used to describe how much of the oceans' primary productivity (algal production) is being used by humans either directly, or indirectly, e.g., through fish that eat fish that eat zooplankton that eat algae. The more we use of the oceans' productivity, the less there is available for all the other, particularly nontarget species. Tentative findings in 1993 in several resource systems are that the fraction humans use is high, perhaps as high as 40-60% for coastal systems such as the North Sea, or for tropical systems such as Lake Victoria.

ICLARM will continue to investigate the consequences of these preliminary findings in 1994.



How much of the oceans' productivity is being diverted to human use? - the answer will tell us much about the health of the seas.

ReefBase - A Global Database of Coral Reef Systems and their Resources



A project to develop a global database on coral reefs, to be called ReefBase, was initiated at ICLARM in November 1993. The Commission of the European Communities (CEC) provided funding for the first two years, and the database will be developed in collaboration with the World Conservation Monitoring Centre (WCMC) in Cambridge, UK, as well as other national, regional and international institutions.

Coral reefs, the marine equivalents of tropical rain forests, are under threat in many parts of the world as a result of habitat degradation, overexploitation and, possibly, global climate change. Although fragile, coral reefs are highly productive and can support high levels of sustained fishing if the fishing is sensibly regulated. If they are in good condition, they also have great value as tourist attractions. In many parts of the world these economic benefits are being eroded by siltation from poor land management, nutrient enrichment from sewage, other forms of pollution, destructive fishing practices, and intensive use by tourists. However, the magnitudes of these impacts are largely undetermined and undocumented. Basic questions such as 'what is the total area of coral reefs in the world?' and 'what is the contribution of reefs to the world's fisheries?' are still unanswered.

As currently envisaged, ReefBase users, through a global map on their computer screen, will be able to focus in on any country, reef system or individual reef to obtain details of reef area, species composition, coral cover, catch rates and composition of reef fish and invertebrates, recreation and other forms of resource use, human impacts, management efforts and indigenous knowledge. Current discussions among



reef scientists on common methodologies and terminology are being used as a starting point for designing the data entry fields.

The preliminary focus will be on obtaining estimates for reef areas, which in many cases will necessitate literature searches and correspondence with a wide range of individuals. Initial figures may well be approximate but will be replaced with more reliable data as the project progresses. Information on other aspects will initially be entered on a more *ad hoc* basis, the emphasis being on linking with other data-collection programs, rather than collecting and inputting raw data. Each data entry will be flagged according to its reliability, and will be referenced and acknowledged.

ReefBase will provide data from which it should be possible to quantify changes in reef health at national and global levels, thus providing conservation organizations, governments and the media with the statistics and information that are needed to implement policy changes. ReefBase will also be useful in identifying future research priorities and could serve as a framework for the development of analytical tools. This has been done on a small scale in Australia, where data compiled for the Great Barrier Reef are being used to identify patterns of ecology and structure and as a management tool.

ReefBase will draw on the experience gained from FishBase, a large database on fish biology, also developed at ICLARM with CEC funding. It will link with this database as well as national and regional databases.

In order to accomplish these objectives, ICLARM will develop a global network of collaborating scientists and institutions. In developing countries, where coral reefs are most extensive and most threatened, means will also be sought to provide technical assistance in data acquisition and to enable developing-country scientists to develop their skills fully by further training or appropriate linkages with advanced research laboratories and universities. It should be possible for researchers who can obtain appropriate funding, to work on particular areas of ReefBase, benefiting from the global context that the database will provide and augmenting and contributing themselves to the information that is stored, an activity for which they will be fully credited.

The first version of ReefBase will be distributed to all collaborators in 1996.

Coast to Coast

ICLARM's first major activity in coastal management was the US/ASEAN Coastal Resource Management Project (CRMP), 1986-1992, which included some 200 ASEAN scientists and was coordinated by ICLARM. The project has been fully described elsewhere*. It was also a starting point for other projects in coastal management (see pp. 67, 69, 71). Perhaps the most innovative product from the ICLARM staff involved was a decisionmaking software that was successfully applied in one of the project sites. Here we present the philosophy behind the software.

B:Run

One of the architects of modern fisheries science, the late John Gulland, wrote that the results of fisheries research nearly always come too late to be of use to decisionmakers. Numerous commentators have also observed that the information is often incomprehensible to the decisionmakers. Finally, and related to tardiness, it is difficult for researchers to select, in highly complex aquatic systems, only those few processes that really matter.

Trawl surveys in the Brunei EEZ before and during the CRMP showed local decline of demersal resources. Yet, the government proposed expanding the fishing fleet to exploit the relatively high biomass of fish in more distant parts of EEZ. How many trawlers should be bought and what are the constraints to development? Why had the existing fleet not expanded to offshore areas?

Economic and/or operational constraints were suspected, so we decided to use a Geographic Information System (GIS) in analyses of cost/benefits. However, the commercial GIS systems are expensive and their very precision, requiring exacting inputs, would distract us from processes that really mattered, i.e., fish abundance and sailing distances from port to fishing grounds.

Thus a 'low-level' approach was taken. Information was stored in a spreadsheet format and plotted on low-resolution maps. The result was a quickly-developed, cheap software called B:Run adaptable to any fishery, and with none of the copyright restrictions that apply to commercial GIS.

To overcome the communication barriers, the software was enriched with color overlays showing coral reefs, oil structures, red tide areas, and later, animated simulation of oil spills, incorporated from a program developed by the Shell Oil Company.



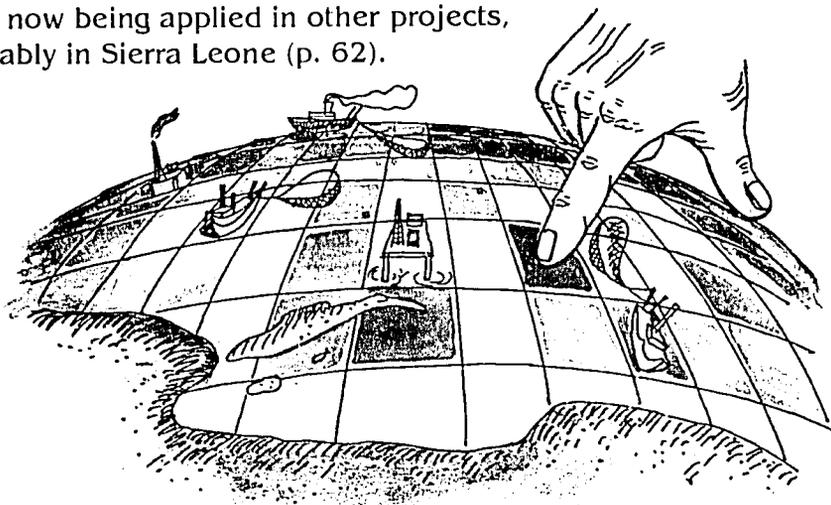
B: Run was created by programmer Nonong Gayanillo (foreground) and his mentor Daniel Pauly.

*The ASEAN/US Coastal Resources Management Project: Initiation, Implementation and Management, by T.E. Chua, 1992, p. 71-92. In T.E. Chua and L. Fallon-Scura (eds.) Integrative Framework and Methods for Coastal Area Management. ICLARM Conf. Proc. 37, 169 p.

The screen shows colored grid squares of marine areas. For any square, the costs of fishing based on fixed and variable costs of the existing fleet at different levels of effort along with biological parameters of the resources, can be used to estimate the economic viability of fishing. The results are portrayed graphically and in figures, such that the decisionmaker can see instantly the viability of fishing at any effort level anywhere in the EEZ.

B:Run showed Brunei Darussalam decisionmakers in a timely and "user-friendly" manner that under present constraints, further development of their demersal trawl fishery was impractical. An investment failure of over \$3 million was thus averted.

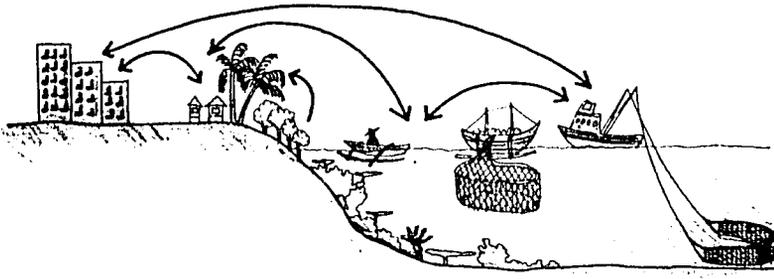
Modified versions of the B:Run software are now being applied in other projects, notably in Sierra Leone (p. 62).



Coastal Management Research

Bearing in mind that ICLARM's Medium-Term Plan (MTP 1994-1998) was only approved by the CGIAR in mid-year, there was a hiatus in coastal management activities during 1993, as we moved from the technical assistance mode of the US/ASEAN Coastal Resources Management Project (1986-1992) to a coastal management research mode of the MTP. There are two major projects being developed, both of which are expected to be funded in 1994:

- 1) **Coastal Cross Sections.** Coastal cross sections are based on agroecosystem analysis and farming systems research, disciplines far removed from traditional fisheries research. Sections representing the offshore/onshore axis of a coast allow easy comparison and the processes can be represented through icons. The cross sections will show the effects of changes in any one part of the coastal resource system on all the other parts.

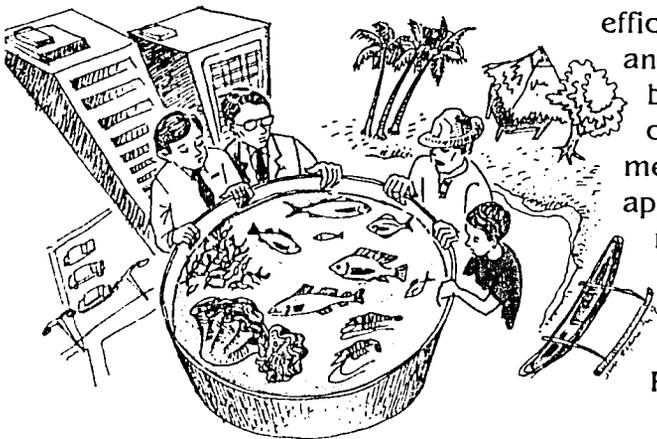


Coastal cross sections: arrows show some of the flows of resources which maybe quantified using a two-dimensional approach.

It will be developed in part though linkages to existing ICLARM software, including ECOPATH II, RESTORE, FishBase, FiSAT and low-level GIS programs. Bioeconomic modeling will also be incorporated.

- 1) **Co-Management.** There is a need for rapid and substantial evolution of existing fisheries management systems to support sustainable resource use. It is unlikely that local communities can accomplish this change on their own. But neither can the various national, provincial/state or municipal/district levels of government accomplish it entirely through bureaucratic instruments. A more dynamic partnership must evolve, using the capacities and interests of the local community, complemented by the ability of the national government to provide enabling legislation and administrative assistance. This partnership can be called co-management, where the government and the community share authority for fisheries management. Community-based management is a central element of co-management. The amount of authority that the government and the community have will differ and depend upon country and site-specific conditions.

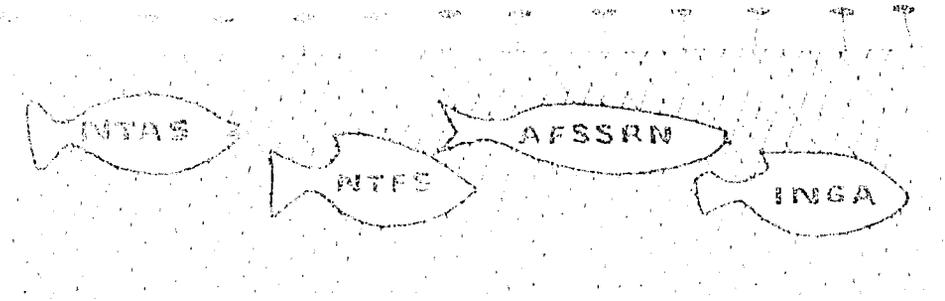
ICLARM's primary objective is to investigate the utility of fisheries co-management as a sustainable, equitable and efficient management strategy; and to develop a set of globally or regionally applicable fisheries co-management tools which can be applied in various coastal resource systems in a selected number of countries and pilot sites in Asia, Africa and the Pacific.



Passing the Message

Dissemination of information between ICLARM and its colleagues, partners and clients takes many forms from "invisible colleges" to conference presentations and videos. The most important forms are networking and publications, the latter including translations. The ICLARM library is also a major source, not only for staff but also for visiting researchers.

Networks

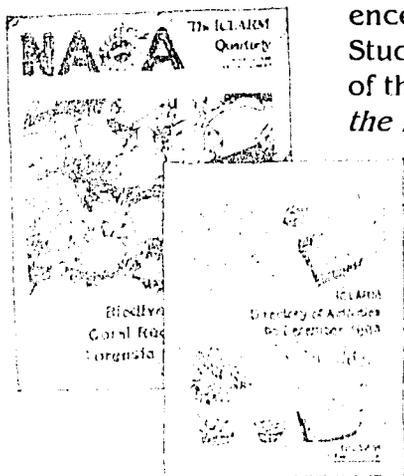


This year ICLARM's networking activities saw changes with the commencement of INGA, the International Network on Genetics in Aquaculture (p. 81). ICLARM is member-coordinator of INGA. Also, The Coastal Aquaculture Network, which consisted of collaborative research teams which formed temporarily to work on specific topics, was dissolved. A collaborative giant clam research group continues within the Center's coastal and coral reef work. However, other special interest groups have been established by the South Pacific Commission and ICLARM now contributes actively to them.

Three other networks are managed by ICLARM: two information networks, the Network of Tropical Aquaculture Scientists (NTAS, p. 78), and the Network of Tropical Fisheries Scientists (NTFS, p. 56); and a research network, the Asian Fisheries Social Science Research Network, a group of national Asian institutions (p. 65).

Publications

The Center produces seven technical publication series - Studies and Reviews, Conference Proceedings (both series externally peer reviewed), Technical Reports, Bibliographies, Education, Translations and Software. In addition there are: *Naga*, the ICLARM Quarterly which includes articles and other information of general interest as well as the newsletters of the Networks (and that of the Asian Fisheries Society); *ICLARM Newsbriefs*, an irregular newsheet for donors and colleagues; videos; the Annual Report; an internal fortnightly *ICLARM Bulletin*; and various brochures and posters.



Publications in 1993 included three Conference Proceedings, three Technical Reports, one Studies and Reviews, one Software, five issues of the *ICLARM Newsbriefs*, three issues of *Naga*, the *ICLARM Quarterly* (one was a combined issue), three brochures, one poster, a video, the annual Report, and nine issues of the new *ICLARM Bulletin*.

From sales, library exchange and free issue, the total number of books in ICLARM's seven technical series distributed since the first publication in 1980 is over 142,500. *Naga* recipients exceeded 4,000 in 1993.

ICLARM also published three issues of the journal *Asian Fisheries Science* in 1993 for the Asian Fisheries Society.

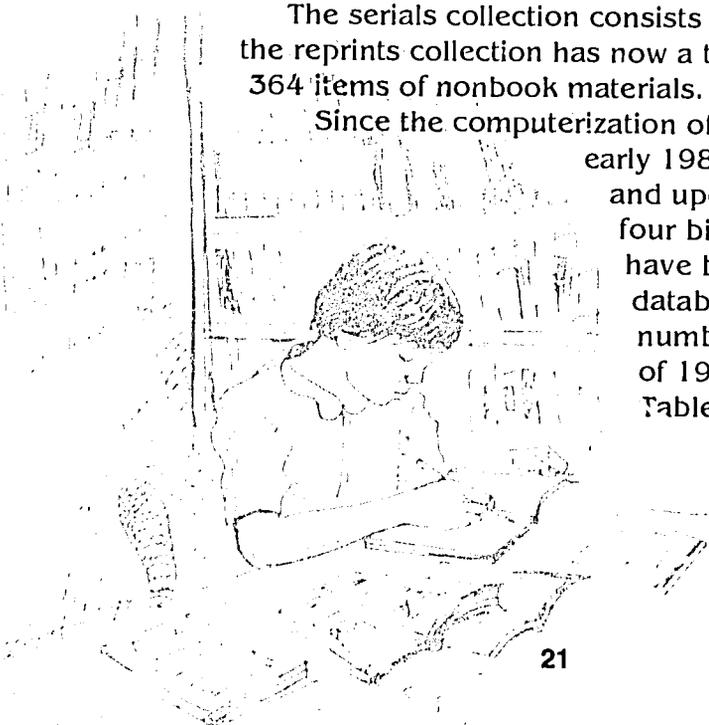
ICLARM staff also publish externally in the primary literature and elsewhere. By the end of 1993, the total number of contributions, both internal and externally published (or in press) was 1,022, of which 148 were produced in 1993.

Library

Since the establishment in September 1978 of the ICLARM library (renamed the *Ian R. Smith Memorial Library and Documentation Center* in May 1990) its collection of books and monographs has continuously been growing and now totals 12,611 volumes. A total of 893 volumes of new materials was added during the year.

The serials collection consists of 1,167 titles while the reprints collection has now a total of 5,884 titles and 364 items of nonbook materials.

Since the computerization of library holdings in early 1987, the maintenance and updating of the library's four bibliographic database have become routine. These databases and their total number of entries as of end of 1993 are shown in the Table.



ICLARM Library Databases (as of December 1993)

| DATABASE | CONTENTS | SIZE |
|----------|--|--------|
| LIBRI | <p>Bibliographic records beginning with January 1987 library holdings on tropical fisheries and aquaculture literature</p> <p>Products:</p> <ol style="list-style-type: none"> 1. Bimonthly Acquisitions List 2. Annual Book Catalogue 3. Specialized Bibliographies | 7,870 |
| NAGA | <p>Bibliographic records beginning in 1978 of selected articles from serials, monographs, proceedings, unpublished materials and other pertinent sources on fisheries, aquaculture and coastal resources management relevant to tropical and developing countries</p> <p>Products:</p> <ol style="list-style-type: none"> 1. Information Dept of <i>Naga, the ICLARM Quarterly</i> 2. Specialized Bibliographies | 12,350 |
| RED | <p>Bibliographic records on Indo-Pacific red tides selected from serials, monographs, proceedings, unpublished materials and other pertinent sources, i.e., newspapers, etc.</p> <p>Products:</p> <ol style="list-style-type: none"> 1. Red Tides Bibliography 2. Literature Reviews | 445 |
| SERIE | <p>Bibliographic records of all serials held in the library</p> <p>Product:</p> <ol style="list-style-type: none"> 1. Serial Holdings List | 1,166 |
| CITEANAL | <p>Bibliographic records of ICLARM Publications/Contribution Series cited in articles from serials, monographs, proceedings, and other materials (published/unpublished)</p> <p>Product:</p> <ol style="list-style-type: none"> 1. Citation Analysis (Bibliographic impact of ICLARM publications) | 8,335 |

ICLARM continues to provide an information service within budget constraints. A service fee of \$5 in developing countries and \$20 in developed countries is charged. There were 272 enquiries during the year from 56 countries/territories worldwide. The majority (78%) were from developing countries. However, 71% of the enquiries were answered free of charge, due to inability of most recipients to pay.

During the year, Information staff assisted the Strategy for International Fisheries Research (SIFR) in its progress towards identifying critical needs of research in developing countries, through: a two-week consultancy at SIFR's office in Canada to develop a plan for a global information survey; organizing a Philippine national workshop on fisheries information and statistics, held

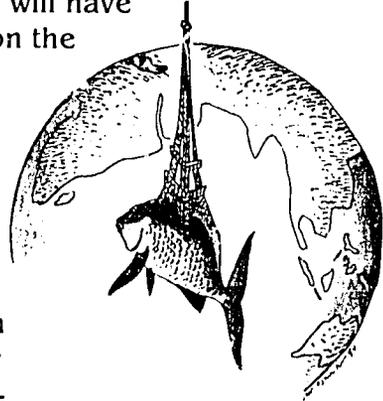
at HQ on 31 August with 70 participants; and preparation of a review of fisheries information sources in Asia.

As part of the information review, ICLARM began to assemble lists of serial holdings in prominent Asian libraries. A user-friendly database has been developed and when completed will be an electronic union catalogue of Asian fisheries.

The ICLARM integrated farming project in Malaŵi (p. 93) and the Malaŵi Fisheries Department maintain an aquaculture information center and library, set up by ICLARM in 1987. The center has over 1,000 books, theses and dissertations, 900 reprints and 101 serial titles. In 1993, the center handled a number of enquiries and is expected to be absorbed into the national system in the future. Meanwhile, ICLARM staff are taking part in activities that may lead to an Anglophone aquaculture information network.

One such activity was assistance to the library of the Institute of Marine Biology and Oceanography (IMBO) in Sierra Leone. A special budget was provided by the CEC to ICLARM's project there (p. 62) to revive the facilities. A librarian was also hired and books repaired. Dr. J.M. Vakily and Dr. Findlay, the new IMBO Director, edited a special issue of the IMBO Bulletin, containing reimpres-sions of papers published in the late 70s and early 80s in irregular issues of the Bull. IMBO, now largely inaccessible. It is expected that upon completion (in August 1994), the project will not only have achieved its stated objectives, but will have also succeeded in putting IMBO "back on the map".

In Francophone Africa, ICLARM's French-government sponsored project on Asia-Africa Cooperation (p. 79) continues to translate relevant material between English and French. The aim is to assist Francophone African re-searchers by translating relevant English articles into French and translating their French papers into English for wider dissemination.



GOVERNANCE AND MANAGEMENT

ICLARM had severe difficulties following the April 1993 Board Meeting, which culminated in the resignations of the Board Chair, Dr. Peter Larkin, and Director General Dr. Kenneth T. MacKay. Mr. Basilio Rodriguez, Jr., Director of Management Services, served as Officer-in-Charge until Dr. Larry Stifel joined as Director General in mid-July; and Dr. Barry Filshie served as Acting Chair until August 1.

Mission Statement

Recognizing that certain of the problems of management at ICLARM had their origins in poor performance by the Board, the Board now has in place a Board Mission Statement. A copy of the statement is appended (p. 27). This statement incorporates the general principles and values identified as being important for an international center within the CGIAR and includes those highlighted by its Oversight Committee. This statement represents the unified view of the Board on how it will best serve ICLARM, its partners and beneficiaries, and represents the benchmark against which the Board will continue to monitor and evaluate its performance.

Board Action Plan

The Board has identified several issues which require action. These fall broadly under the headings of code of conduct; improvement of internal and external relations; improvement of Board operations; improvement of the Board's oversight function; establishment of the Center's international status; and the search for the new Director General. To these were added the other matters identified by the CGIAR Oversight Committee - makeup of the Board; and linkages with IRRI. A copy of the Board Action Plan for 1993-94 is attached to this report on p. 28.

Code of Conduct

A small subcommittee was formed to draft a code of conduct for the Board. The approved text is appended (p. 29).

Internal and External Relations

There is a need to improve communications and flow of information between Board members and between the Board and the Center. More importantly under this heading is the urgent need to develop

plans to rebuild confidence between the Board, the Center's staff, the donors and our national partners. These plans will be drawn up in close cooperation with the Director General.

Board Operations

Actions required to bring ICLARM into line with other CGIAR centers include:

- establishment of Board rules of procedure,
- review of ICLARM's Constitution and By-Laws,
- clarification of roles and responsibilities and streamlining of committee operations,
- review of frequency of Board meetings (linked to Board size), and
- induction and orientation of new trustees, including finalization of the Board Handbook.

A sub-committee led by the new Board Chair is addressing these issues for consideration by the Board at its April 1994 meeting.

Board's Oversight Function

The Board pledged its full support to the Director General and empowered him with full responsibility for managing the day-to-day operations of the Center. High priority was to be given to:

- support to the DG to restore institutional discipline;
- development of human resource management systems, including personnel manuals, staff developing and performance review processes, and grievance and appeals procedures; and
- having a Board-approved investment policy.

Dr. William Gormbley, a consultant familiar with the human resource systems of CGIAR centers, visited ICLARM in late July to assist with development of the Center's personnel manual, the draft of which was considered and approved by the Board at its December meeting.

International Status

The Board identified the need to review the international status of ICLARM to ensure that it is aligned with that of other CGIAR centers and to finalize a host-country agreement. The Director General is undertaking this latter task in consultation with the Philippine Government's ex-officio member of the Board.

Search for a New Director General

Ninety applications or nominations were received following advertisement and extensive canvass of relevant people and agencies. These were considered by the Search Committee at its first meeting held in Seattle on September 21- 23. A short list of three candidates came to Manila for interview during the Board's December meeting. Dr. Meryl Williams, presently Director of the Australian Institute of Marine Science, was chosen as the Director General designate. She will join ICLARM in April 1994.

Board Officers

Following the resignation of Dr. Peter Larkin after the April Board meeting, Dr. Barry Filshie became Acting Board Chair, subsequently, Professor John Dillon was elected to the Board as its Chairperson at the Board's Extraordinary Meeting in July. Dr. Barry Filshie resumed his role as Chair of the Board's Finance and Management Committee and Dr. Nyle Brady was elected as Board Vice-Chair.

Makeup of the Board

The Board's Nominations Committee has been directed by the Board to examine carefully the makeup of the Board to ensure that a proper balance and rotation in terms of geographic distribution, scientific and management qualifications of members, etc., is achieved and maintained. The Nominations Committee has noted the suggestions from the Oversight Committee about the necessity of having CGIAR-nominated individuals on the Board and also the problem of the untoward association of some Board members with donor agencies and projects. These issues are being addressed in the overall context of size and makeup of the Board. It is proposed that, at its April 1994 meeting, the Board will reduce the size of the Board from 16 to 12 and thenceforth have two meetings per year rather than, as at present, only one. Steps are being taken to ensure the cohesiveness and better culture of the ICLARM Board.

Linkages with IRRI

Since Dr. Stifel's arrival in July, ICLARM's management has had the benefit of most useful consultations with IRRI management on a wide range of matters including personnel practices, relations with the host-government and housing of a former IRRI scientist now serving as an ICLARM consultant.

Internal Management

- A Personnel Policy Manual has been prepared for international staff; a Personnel Manager has been hired, and she has started to develop a comparable personnel manual for national staff of ICLARM.
- A biweekly internal staff bulletin has been introduced in order to improve communication within the Center. The amount of material contributed to the bulletin demonstrates the need for such a mechanism.
- A staff performance-evaluation system is being developed and it will be introduced next year. It replaces a complex quantitative system used for setting salaries and salary increments that confuses and irritates the staff.
- The personnel salary structure and compensation policy have been revised to strengthen ICLARM's ability to recruit outstanding professional staff in the national market. Review has begun of the salary structure and compensation policy for internationally recruited staff.

- A Financial Controller has been appointed and the first of a series of staff seminars was held on management and financial services at ICLARM. After having been suspended for many months due to systems changes, monthly financial reporting to Directors was resumed in October.

In the past, program evaluations were conducted in response to requirements built into specific projects. There were no systematic or program-wide reviews of the type that most CGIAR centers undertake to assure the quality and relevance of their research. Management, therefore, has designed an internal program review process that will be initiated next April with participation of all international scientists, external evaluators selected by the Director General, and Trustees on the Program Committee.

Relations with Donors

After the Mid-Term Meeting of the CGIAR in Puerto Rico, a number of ICLARM donors deferred funding ICLARM until they were satisfied that our internal management problems were being satisfactorily resolved. Heartened by the reforms on board governance agreed upon at the July Board Meeting and other internal developments, these donors have all resumed normal funding. Donors are supporting a range of new projects.

Board of Trustees Mission Statement

The Board's primary mission is the setting of policy to ensure achievement of the Center's stated goals and objectives within the mandate of the CGIAR System. In so doing, it will ensure both the scientific excellence of the Center and the relevance of the Center's work for its partners and beneficiaries. The Trustees will promote stewardship, foresight and responsibility by upholding the values of mutual trust, confidence and transparency, thereby demonstrating loyalty to the Center and to the CGIAR mandate.

The Board will act in trust for all the Center's stakeholders - its partners, donors, management and staff, the CGIAR System and the general public. The Board recognizes that it has final responsibility for the good functioning of the Center in a scientific, administrative, financial, managerial and organizational sense and for the Center's international image.

In order to ensure the success of the Center, the Board will monitor policy implementation, actively interact with management and staff, and oversee the preparation of clear rules and guidelines for the operation of the Center. The Board will ensure its own success through a regular process of planning, monitoring and evaluation of its performance.

Board Action Plan for 1993-94

1. Develop a Board mission statement and action plan
2. Develop a code of conduct for Trustees
 - work as a team/promote cohesiveness and loyalty
 - prepare well for meetings
 - being more proactive (not reactive)
 - assume full responsibility
 - promote ICLARM and its good work outside
 - preserve the Center's autonomy
 - respect and protect the Board's wish for confidentiality
 - being aware of Trustee roles in relation to staff
3. Improve internal/external relations
 - improve communication and flow of information
 - develop plans (with DG) to rebuild confidence of staff, donors and NARS
4. Improve Board operations
 - review ICLARM constitution and by-laws
 - review selection/election procedures for new Trustees, Board Officers
 - establish Board rules of procedure
 - establish and implement procedures to evaluate and improve Board performance
 - clarify Board committee roles/responsibilities and streamline committee operations
 - review frequency of Board meetings and size of Board
 - educate ourselves on roles of Boards within the CGIAR
 - arrange induction/orientation of new Trustees
5. Improve oversight function
 - review selection procedures for DG
 - give attention to substantive policy issues
 - give full responsibility and support to DG to restore institutional discipline
 - ensure that management:
 - . develops a staff manual
 - . establishes staff development policies
 - . establishes grievance/appeals procedures
6. Elect a new Chair
7. Ensure the Center's international status by finalization of host-country agreement

ICLARM Board of Trustees Code of Conduct

We care about our behavior as Board members and how we get results.

We, the Board of Trustees of ICLARM apply the principles in this Code to our relationships with each other and with all those people with whom we deal in our work for ICLARM. Our Code of Conduct is a guide for us all in the way we do business as Trustees of ICLARM and members of the CGIAR System.

In our individual capacity as members of the Board of ICLARM and in our collective capacity as the Board of ICLARM, we will abide by the following minimum standards:

1. *We respect the law and act accordingly.*
 - Our objective is always to comply with the laws of the country in which we are operating.*
 - Every one of us will notify our Chair of any failure to comply with the law.*
 - In interpreting the law, we will always endeavor to adopt a course which reinforces our reputation for integrity.*

2. *We conduct ourselves with integrity, are fair and honest in our dealings and treat others with dignity.*
 - Integrity for us means doing the right thing and behaving properly.*
 - We do not use oppressive or misleading practices or falsify or wrongfully withhold information to achieve a benefit for ourselves or for ICLARM.*
 - We operate in countries with many different laws, customs and business practices. We recognize these but do not compromise the principles embodied in this Code. Honesty is valued in every culture.*
 - Dignity for us means that everyone is entitled to be treated with respect as a person, regardless of individual difference.*
 - We aim to work as a team and to promote cohesiveness and loyalty among us.*

3. *We do not place ourselves in situations which result in divided loyalties. For us, divided loyalties arise:*
 - when our private or professional interests conflict directly or indirectly with our obligations to ICLARM and the CGIAR.*
 - when we receive benefits (such as gifts or entertainment) from a person doing or seeking to do business with ICLARM which could be seen as creating an obligation to someone other than ICLARM.*
 - We do not act in ways which may cause others to question our loyalty to ICLARM.*

4. *We use ICLARM assets (including funds, equipment and information) responsibly and in the best interests of ICLARM.*
 - Using ICLARM's funds to provide excessive benefits (such as gifts or entertainment) for ourselves or others is unacceptable.*

- Using ICLARM's assets (such as equipment or stores) other than for ICLARM's business purposes or interests is unacceptable.*
 - We respect the nature of Board information and do not disclose confidential information relating to the Board or ICLARM without authorization by the Board Chair.*
5. *We are responsible for our actions and accountable to the ICLARM Board for their consequences.*
We take responsibility for:
- being well prepared for Board meetings.*
 - ensuring ICLARM's good name and its role as a CGIAR center.*
 - informing the Chair and/or the Board of any possible conflicts of interest we may face.*
 - being proactive in seeking to achieve the objectives assigned to us.*
 - the way in which we achieve those objectives.*
 - the attitude we adopt in achieving those objectives.*
 - honestly and fully reporting the results of our actions.*
 - For us, accountability means we take responsibility for and will be judged by the outcome of all matters over which we have control.*

Board Officers and Committees as of December 1993

Board Officers

1993:

| | | |
|-------------------------|---|----------------------------|
| Chairperson | - | Dr. John Dillon |
| First Vice Chairperson | - | Sec. Roberto Sebastian |
| Second Vice Chairperson | - | Dr. Nyle Brady |
| Secretary | - | Mr. Basilio Rodriguez, Jr. |

Board Committees

1. Executive Committee

- Functions:
- To exercise the powers and perform the duties delegated by the Board.
 - To act for the Board between Board of Trustees meetings on matters requiring immediate attention.

Members:

1993:

- Dr. John L. Dillon - Chairperson
- Mr. Roberto Sebastian
- Dr. Barry K. Filshie
- Dr. Dayton L. Alverson
- Dr. Zimani Kadzamira
- Dr. Nyle Brady
- Dr. Laurence D. Stife!

2. Finance and Management Committee

- Functions:
- To review the external auditor's report and the Center's financial statements and recommend their acceptance by the Board of Trustees.
 - To review budget recommendations made by the Director General.
 - To make budget and financial policy recommendations for adoption by the Board of Trustees.
 - To evaluate the management performance of the Center in relation to policies and budgets established by the Board of Trustees.
 - To evaluate the performance of the external auditors.
 - To review management issues, including personnel matters, appropriate to the Board of Trustees' responsibilities and make recommendations thereon to the Board of Trustees.
 - Other duties and functions delegated to it by the Board of Trustees.

Members:

1993: Dr. Barry K. Fishie - Chairperson
Dr. John L. Dillon
Mr. Roberto Sebastian
Dr. Zimani Kadzamira
Dr. Nyle Brady
Ms. Britha Mikkelsen
Dr. Laurence Stifel

3. Program Committee

- Functions:
- To receive and review, on behalf of the Board of Trustees, the Director General's annual report on the Center's research, training and information programs.
 - To review and evaluate proposed changes in and/or additions to the Center's program structure.
 - To review and evaluate the Center's annual and long-term program plans.
 - To conduct all the above functions and duties with due consideration to the Center's mandate and previously established program plans, directions and priorities.
 - To review the results of any external reviews conducted of the Center's programs, as well as the Center's responses as proposed by the Director General, to recommendations made by the external reviewers.

Members:

1993: Dr. Dayton L. Alverson - Chairperson
Dr. Agustin Ayala-Castañares
Dr. Edgardo Gomez - Alternate Chairperson
Dr. Philipp Muller
Dr. Jacqueline McGlade
Dr. Masaru Fujiya
Dr. Laurence Stifel

4. Nominating Committee

- Functions:
- To assist the Board in establishing criteria and procedures for the selection of members to fill vacancies on the Board.
 - To review and identify potential candidates who meet established criteria.
 - To recommend and present to the Board of Trustees a short list of possible members for election to the Board and its subsidiary committees.
 - To nominate persons who would be required to serve in the positions of Chairperson, Vice-Chairpersons and Secretary and any other officers as may be deemed necessary by the Board of Trustees.

Members:

1993: Dr. Zimani Kadzamira - Chairperson
Dr. Agustin Ayala-Castañares
Dr. Cornelia Nauen
Dr. Laurence D. Stifel



Statement of Activities and Operating Fund Balance

| | US Dollars | |
|---|------------------|------------------|
| | 1993 | 1992 |
| REVENUES | | |
| Grants | \$6,839,581 | \$6,760,944 |
| Gain on foreign exchange | 149,460 | 7,947 |
| Consultancy and service fees | 49,537 | 9,061 |
| Publications | 51,313 | 39,370 |
| Miscellaneous | 65,266 | 116,109 |
| | 7,155,157 | 6,933,431 |
| EXPENSES | | |
| Research and research related expenses | 4,910,957 | 4,470,896 |
| Administrative | 1,464,164 | 1,176,402 |
| Information services | 495,486 | 767,524 |
| Translation loss | 77,389 | 59,706 |
| | 6,947,996 | 6,474,528 |
| EXCESS OF REVENUES OVER EXPENSES BEFORE OTHER CHARGES | 207,161 | 458,903 |
| OTHER CHARGES | 421,810 | 136,693 |
| EXCESS (DEFICIENCY) OF REVENUES OVER EXPENSES | (214,649) | 322,210 |
| OPERATING FUND BALANCE AT BEGINNING OF YEAR | | |
| As previously reported | 795,926 | 325,339 |
| Adjustments | (382,159) | (168,764) |
| As restated | 413,767 | 156,575 |
| | 199,118 | 478,785 |
| APPROPRIATED FOR ACQUISITION OF PROPERTY AND EQUIPMENT | (84,406) | (65,018) |
| OPERATING FUND BALANCE AT END OF YEAR | \$114,712 | \$413,767 |
| ASSETS | | |
| Cash | \$584,229 | \$1,261,325 |
| Receivables | | |
| Projects | 82,306 | 189,934 |
| Grants | 1,082,623 | 990,378 |
| Officers and employees | 141,027 | 82,845 |
| Others | 75,677 | 78,789 |
| Prepaid Expenses | 95,890 | 141,841 |
| Refundable Deposits | 93,773 | 36,755 |
| Property and Equipment - net | 249,424 | 238,053 |
| | \$2,404,949 | \$3,019,919 |

| | US Dollars | |
|--|-------------|-------------|
| | 1993 | 1992 |
| LIABILITIES AND NET ASSETS | | |
| Accounts Payable and Accrued Expenses | \$737,238 | \$592,520 |
| Grants Applicable to Succeeding Years | 348,381 | 1,393,421 |
| Short-term Loans Payable (90 days, noninterest bearing) | 500,000 | - |
| Net Assets | | |
| Invested in property and equipment | 249,424 | 238,052 |
| Capital fund | 455,194 | 382,159 |
| Operating fund balance | 114,712 | 413,767 |
| | 819,330 | 1,033,978 |
| | \$2,404,949 | \$3,019,919 |

STATEMENT OF CASH FLOWS

CASH FLOWS FROM OPERATING ACTIVITIES

| | | |
|--|-------------|-----------|
| Excess (deficiency) of revenues over expenses | (\$214,649) | \$322,210 |
| Adjustments to reconcile excess (deficiency) of revenues over expenses to net cash provided by (used in) operating activities: | | |
| Depreciation | 73,035 | 213,395 |
| Decrease (increase) in assets: | | |
| Receivables - projects | 92,677 | 140,360 |
| Receivable - grants | (191,298) | (474,670) |
| Receivable - officers and employees | (68,097) | 145,859 |
| Receivable - others | (4,431) | (64,730) |
| Prepaid expenses | 33,674 | (64,682) |
| Increase in accounts payable and accrued expenses | 206,926 | 316,010 |
| Net cash provided by (used in) operating activities | (72,163) | 533,752 |

CASH FLOWS FROM INVESTING ACTIVITIES

| | | |
|---------------------------------------|-----------|----------|
| Acquisition of property and equipment | (84,406) | (65,018) |
| Refundable deposits | (60,472) | (15,804) |
| Cash used in investing activities | (144,878) | (80,822) |

CASH FLOWS FROM FINANCING ACTIVITIES

| | | |
|---|-----------|---------|
| Grants applicable to succeeding years | (943,602) | 242,077 |
| Short-term loans payable | 500,000 | - |
| Net cash provided by (used in) financing activities | (443,602) | 242,077 |

EFFECT OF EXCHANGE RATE CHANGES IN CASH (16,453) 10,636

NET INCREASE (DECREASE) IN CASH (677,096) 705,643

CASH BALANCE AT BEGINNING OF YEAR 1,261,325 555,682

CASH BALANCE AT END OF YEAR \$584,229 \$1,261,325

1993 Sources of Support

| 1. | UNRESTRICTED SUPPORT | GRANT |
|----|--|---------------------|
| | Australian International Development Assistance Bureau (AIDAB) | 198,694.00 |
| | Canadian International Development Agency (CIDA) | 176,028.79 |
| | Commission of the European Communities (CEC) | 281,750.00 |
| | Danish International Development Assistance (DANIDA) | 273,871.73 |
| | Der Bundesminister für Wirtschaftliche Zusammenarbeit (BMZ) | 303,655.77 |
| | Ford Foundation | 150,000.00 |
| | Government of France | 97,707.18 |
| | Government of Norway | 215,193.03 |
| | Government of Netherlands | 267,240.44 |
| | Philippine Government | 68,908.60 |
| | United States Agency for International Development (USAID) | 225,000.00 |
| | World Bank (WB) | 500,000.00 |
| | | 2,758,049.54 |

| ACTIVITY | SOURCES OF 1993 SUPPORT | GRANT |
|--|---|---|
| 2. RESTRICTED SUPPORT | | |
| <ul style="list-style-type: none"> • Economics of Integrating Fish into Rice-Based Farming Systems in Asia • Bellagio Conference on Aquaculture and Environment • Aquaculture Development in Africa: Learning from the Past and Advancing Strategic Research for the Improvement of Small-Scale Farms | <ul style="list-style-type: none"> German Agency for Technical Cooperation (GTZ) | <ul style="list-style-type: none"> 18,011.38 22,300.68 470,425.07 |
| <ul style="list-style-type: none"> • Two-Year Extension of the FishBase Project | <ul style="list-style-type: none"> Commission of the European Communities (CEC) | <ul style="list-style-type: none"> 348,563.32 |
| <ul style="list-style-type: none"> • Research Cooperation on Fisheries Resources between IMBO and ICLARM • Rider to the Contract on the Establishment of a Database (FishBase) for Developing Countries Fisheries Development • ReefBase - A Global Database of Coral Reef Systems and their Resources | <ul style="list-style-type: none"> Commission of the European Communities (CEC) | <ul style="list-style-type: none"> 204,326.43 9,124.00 51,963.34 |
| <ul style="list-style-type: none"> • Training of J.P.T. Dalsgaard | <ul style="list-style-type: none"> Danish International Development Assistance (DANIDA) | <ul style="list-style-type: none"> 91,379.41 |
| <ul style="list-style-type: none"> • Management & Planning Assistance to ICLARM - Phase 1 • Management & Planning Assistance to ICLARM - Phase 2 • Global Comparisons of Multispecies Trophic Modelling • ICLARM-North Sea Centre Collaborative Research Project on Fisheries Co-Management • Infoterra Special Sectoral Source | <ul style="list-style-type: none"> Danish International Development Assistance (DANIDA) | <ul style="list-style-type: none"> 99,891.00 39,519.50 120,172.57 38,870.71 |
| <ul style="list-style-type: none"> • Expansion of Giant Clam Production: • Coral Reef Conservation Booklet | <ul style="list-style-type: none"> United Nations Environment Programme (UNEP) | <ul style="list-style-type: none"> 1,298.58 |
| <ul style="list-style-type: none"> • Rice-Fish Asia Working Group (CLSU-FAC/ICLARM) | <ul style="list-style-type: none"> Forum Fisheries Agency (FFA) Greenpeace Foundation | <ul style="list-style-type: none"> 5,509.00 2,163.34 |
| <ul style="list-style-type: none"> • Rice-Fish Asia Working Group (CLSU-FAC/ICLARM) | <ul style="list-style-type: none"> International Development Research Centre (IDRC) of Canada | <ul style="list-style-type: none"> 78,871.18 |

| ACTIVITY | SOURCES OF 1993 SUPPORT | GRANT |
|--|--|------------|
| • Asian Fisheries Social Sciences Research Network III | | 171,009.79 |
| • Review of Strategies for Common Property in Coastal Fisheries Management | | 11,467.03 |
| • Bibliography of St. Mary's University | | 2,086.91 |
| • Workshop on Community Management and Common Property | | 24,532.93 |
| • Research Program on the Impact of Fish Culture within the Farming Systems in Bangladesh | International Fund for Agricultural Development (IFAD) | 10,900.79 |
| • Collaboration between MRAG and Fishbase | Marine Resources Assessment Group, London | 3,101.14 |
| • Research in Rice Fish Farming | Overseas Development Administration, UK | 4,655.96 |
| • Impact of Aquaculture on Rural Households | Rockefeller Foundation | 53,814.69 |
| • Social Science Research Fellowship | | 41,999.67 |
| • Genetic Improvement of Farmed Tilapia (Phase I) | United Nations Development Programme (UNDP) | 787,352.10 |
| • Preparatory Assistance Support for ICLARM's Future Programme | | 44,979.05 |
| • Bangladesh Aquacultural Research Project III | United States Agency for International Development (USAID) | 235,019.10 |
| • Sustainable Aquaculture Development for Poverty Alleviation and Improved Nutrition in Rural Bangladesh | | 148,178.64 |
| • ASEAN Coastal Resources Management Project | | 169,311.83 |
| • Environment and Natural Resources Policy and Training Project | University of Wisconsin | 4,852.00 |
| 3. COMPLEMENTARY SUPPORT | | |
| • Atlas of the Freshwater Fishes of Africa | Agente de Cooperacion Culturette et Technique (ACCT) | 3,484.42 |
| • Resources and Ecological Assessment for San Miguel Bay | Philippine Department of Agriculture (DA) | 192,362.50 |
| • Resources and Ecological Assessment for Lagonoy Bay | | 123,034.33 |
| • Socio-Economic Study of the Impact of a Fish Culture Extension Program on the Farming System in Bangladesh | Danish International Development Assistance (DANIDA) | 69,719.43 |
| • Research for the Future Development of Aquaculture in Ghana | German Agency for Technical Cooperation (GTZ) | 674.97 |
| • Research Collaboration between ICLARM and the Institute of Aquatic Biology, Ghana | | 184,099.98 |
| • Evaluation and Publication of the Jetindofish Data for Practical Application | | 25,923.97 |
| • New Approaches to Managing Open Water Fisheries in Bangladesh | Ford Foundation | 60,000.00 |
| • Hilsa Bangladesh Project | International Development Research Centre (IDRC) of Canada | 18,526.19 |
| • Geographic Information System for Coastal Area Management and Planning (GISCAMP) | | 77,510.55 |

MEETINGS ATTENDED, PAFERS PRESENTED

- National Workshop on Research Needs for Fisheries Development in Bangladesh, organized by FRI/UNDP, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 25-26 January. (M.V. Gupta)
- Technical Consultation on Small Waterbody Fisheries in Southern Africa, Harare, Zimbabwe, 25-29 January. (D. Jamu)
- Symposium sur l'évaluation des ressources exploitées par la pêche artisanale au Sénégal [Symposium on the assessment of the resources exploited by the Senegalese artisanal fisheries] Centre de Recherches Océanographiques de Dakar-Thiaroye, Sénégal, 8-13 February. (D. Pauly; J.M. Vakily)
- Paper presented:
Pauly, D. Un mécanisme explicatif des migrations des poissons le long des côtes du Nord-Ouest Africain [A mechanism explaining fish migration along the Northwest African Coast]
- Workshop on the "Base de Données Régionales Maritimes" (BDRM), Centre de Recherches Océanographiques de Dakar-Thiaroye, Sénégal, 15-19 February. (D. Pauly and J.M. Vakily)
- Papers presented:
Pauly, D. Use of FishBase in the context of the BDRM.
Vakily, J.L. A fisheries data acquisition system for Sierra Leone, and a software for their analysis in a geographic context
- General Fisheries Council for Mediterranean Technical Consultation on Stock Assessment in the Black Sea, Ankara, Turkey, 15-19 February.
- Paper presented:
Christensen, V. and J.F. Caddy. Reflections on the pelagic food web structure in the Black Sea.
- Sixth ALCOM Steering Committee Meeting, Maputo, Mozambique, 16-19 February. (R. Brummett; R. Noble)
- Economic and Information Technology Forecast 1993, Makati, Metro Manila, Philippines, 18-19 February. (F.C. Gayanilo, Jr.)
- Seminar Workshop on Recent Fish Health Problems and Management Concerns, FAC/CLSU, Muñoz, Nueva Ecija, Philippines, 19 February. (H. Bolivar)
- IAB/ICLARM Workshop on "Research for the Future Development of Aquaculture in Ghana", Institute of Aquatic Biology, CSIR, Accra, Ghana, 11-13 March. (C. Lightfoot; M. Prein; R.S.V. Pullin)
- Papers presented:
Lightfoot, C., M. Prein and J.K. Ofori. Analytical framework for rethinking aquaculture development for smallholder farmers
Lightfoot, C., M. Prein and J.K. Ofori. Potential impact of integrated agriculture-aquaculture systems on sustainable farming
Ofori, J.K., A. Asamoah and M. Prein. Experiments for integrated agriculture-aquaculture system design
Ofori, J.K. and M. Prein. Rapid appraisal of low-input aquaculture systems
Prein, M. and J.K. Ofori. Mapping of bio-physical characteristics of aquatic resource systems in Ghana
Prein, M. and J.K. Ofori. Past initiatives for promoting aquaculture in Ghana
- Association of Special Libraries of the Philippines (ASLP) Seminar: Workshop: The Library in the Year 2000-vision: New Trends, New Images, Development Academy of the Philippines, Manila, Philippines, 18 March. (N.I. Jhocson; E.B. Gonzalez)

- United Nations University Conference on Sustainable Environmental and Resource Management Futures for Sub-Saharan Africa, Accra, Ghana, 22-26 March. (M. Prein)
- Internationally Developed Data Analysis and Management Software (IDAMS) Training Course, SEARCA, Los Baños, Philippines, 22-26 March. (A.P. Mendoza)
- Professional Development Course for Librarians, Baguio City, Philippines, 28-30 April. (E.B. Gonzalez)
- National Workshop on Food, Agriculture and Nutrition Policy Research in Malaŵi (IFPRI/UNICEF/University of Malaŵi), Lilongwe, Malaŵi, 3-6 May. (R. Brummett)
- Paper presented:
Brummett, R. Future directions in aquaculture development
- Short-term training on Fisheries Research Planning and Management, Fisheries Research Institute, Mymensingh, Bangladesh, 3-8 May. (M.V. Gupta, Lecturer)
- Lecture note presented:
Gupta, M.V. Communication of research results to users
- 18th SAS Users Group International Conference (SUGI 18), New York, New York, USA, 9-12 May. (C. Janagap)
- Paper presented:
Janagap, C. and E. Eknath. The evolving role of SQL in genetics, breeding and selection work.
- Sixth Genetic Improvement of Farmed Tilapia (GIFT) Training Workshop: Formulating Strategies for the Establishment of Philippine National Tilapia Breeding Program, NFFTRC/BFAR, Muñoz, Nueva Ecija, Philippines, 10-13 May. (B.O. Acosta, H. Bolivar, A.E. Eknath, J. Rius, D. Rosales, R. Velasco, M. de Vera)
- Christian Services Committee Field Officers Training Workshop, Zomba, Malaŵi, 17-21 May. (F. Chikafumbwa, E. Kambewa)
- Farming Systems Seminar Series, University of Florida, USA, 18 May. (C. Lightfoot)
- Paper presented:
C. Lightfoot. Living in the fast lane: farmer first research on sustainability
- CGIAR-US Universities Conference: Reconciling Sustainability with Productivity Growth, University of Florida, USA, 19-21 May. (C. Lightfoot)
- Report presented:
Lightfoot, C. Favorable farmers in unfavorable natural resources environments
- CIIFAD Forum, The CIIFAD Natural Resource Management Working Group Seminar Series, Cornell University, 26 May. (C. Lightfoot)
- Paper presented:
Lightfoot, C. Living in the fast lane: agricultural sustainability with farmers
- World Aquaculture '93, Torremolinos, Spain, 26-28 May. (M. Gervis)
- Paper presented
J.L. Munro, H. Govan, M.H. Gervis, I. Lane and J.B. Hambrey. Giant clam cultivation in the South Pacific: present status and future prospects
- CGIAR Mid-Term Meeting, San Juan Puerto Rico, 27-28 May. (C. Lightfoot)
- CGIAR Workshop on Ecoregional Approaches to Integrated Research for Sustainable Agriculture, San Juan, Puerto Rico, 29 May. (C. Lightfoot)
- Farming Systems Research and Extension for Southern Africa, Mbabane, Swaziland, 31 May - 4 June (R. Noble)
- CDS/ISIS User Group Meeting, Lilongwe, Malaŵi, 4 June. (C. Jamu)
- Regional Workshop on Integrated Rice-Fish Research and Development at the Sukamandi Research Institute for Food Crops, West Java, Indonesia, 6-11 June. (C. dela Cruz, G. Horstkotte, J.D. Sollows)
- Paper presented:
Cagauan, A.G., C.R. dela Cruz, and C. Lightfoot. Nitrogen models of lowland irrigated ecosystems with and without fish using ECOPATH
- Kohinoor, A.K.M., S.B. Saha, M. Akhteruzzaman and M.V. Gupta. Sustainability of short-cycle species *Puntius gonionotus* (Bleeker) for culture in rice fields
- Akhteruzzaman M., M.V. Gupta, J. Sollows and A.H.M. Kohinoor. Feasibility of integrating aquaculture in rainfed rice fields and possible implications for integrated pest management
- Third Regional Rice-Fish Workshop, Sukamandi Research Institute for Food Crops (SURIF), Subang, West Java, Indonesia. 6-11 June 1993.

Papers presented:

Horstkotte, G. 1993. 'Socioeconomic complementarities between Integrated Pest Management and Aquatic Life Management - the key to make adoption more sustainable?'

Waibel, H., G. Horstkotte and S. Purba. 1993. The Economics of Rice-Fish Production Systems in Asia. *Entwicklung und ländlicher Raum* 3/93.

Cornell University Automated Land Evaluation System (ALES) Workshop, Quezon City, Philippines, 7-10 June. (C. Lightfoot; M. Prein)

Integrated Natural Resource Management Research for the Highlands of East and Central Africa, Nairobi, Kenya, 7-11 June (R. Brummett).

Capability Building for Environmental Management Planning and Monitoring, Land-Use Planning and the EIA Process", Dipolog City, Philippines, 20 May and Iloilo City, Philippines, 10 June. (J. Padilla).

Papers presented:

Padilla, J.E. Training on Environmental Management for Middle Management Government Planners and Environmental Officers for the Asia-Pacific Region, Quezon City, Philippines.

Padilla, J.E., M.S. de los Angeles and H.A. Francisco. Towards fishery resources valuation and accounting in the Philippines

The International Symposium on Sea Ranching of Cod and other Marine Fish Species, Arendal, Norway, 15-18 June. (J. Munro and J. Bell)

Fourth Annual Conference of the International Association for the Study of Common Property, Manila, Philippines, 16-19 June. (M. Ahmed; J. Padilla)

Paper presented:

Ahmed, A. Rights, benefits and social justice: keeping common property freshwater wetland ecosystems common

Padilla, J.E., G. Silvestre and M. Dalusung. Bioeconomic stress indicators for fisheries: conceptual exposition and preliminary applications

International Council for the Exploration of the Sea Symposium on the Mass Rearing of Juvenile Fish, Bergen, Norway, 21-23 June. (J. Bell)

Symposium on Water-Based Industries, Center for Research and Communication, Pasig, Metro Manila, 22 June. (J. Padilla)

Paper presented:

Padilla, J.E. and M. Dalusung. Assessing the value of natural resources and the environment using resource accounting: selected applications

Advanced Tropical Fisheries Analysis Workshop (ATFAW/USAID), Bolinao Marine Laboratory, Pangasinan, Philippines, 21-25 June. (D. Pauly; M.L.D. Palomares; M.C. Binohlan; F. Gayanilo, Jr.)

Software presented:

FishBase, B:RUN, FiSAT

SADC Regional Aquaculture Curriculum Workshop, Dedza, Malaŵi, 24-25 June. (R. Brummett; R. Noble)

International Network on Genetics in Aquaculture - Network Planning Workshop, ICLARM HQ, Makati, Metro Manila, Philippines, 17-22 July. (B.O. Acosta, A.E. Eknath, C. Janagap, J. Rius, D. Rosales).

Paper presented:

Eknath, A.E. Highlights of GIFT Project experiences.

Helvetas/IIRR Participatory Rural Appraisal Consultation and Planning Workshop by James Mascarenhas, Quezon City, Philippines, 20-22 July. (J.P.T. Dalsgaard; M. Prein)

Mid-Term MAGFAD Planning Workshop, Mangochi, Malaŵi, 20-22 July. (R. Brummett; D. Jamu; F. Chikafumbwa)

National Symposium/Workshop on Reservoir Fisheries Management and Development, FAC/CLSU, Muñoz, Nueva Ecija, Philippines, 29-30 July. (H. Bolivar, R. Velasco, M. de Vera)

Second National Conference of SAS Users in the Philippines, Shangrila EDSA Plaza Hotel, Manila, Philippines, 26 August. (C. Janagap, J. Rius, D. Rosales)

Workshop on Fishery Information and Statistics, ICLARM Headquarters, Makati, Metro Manila, Philippines, 31 August. (All Library Staff; J. Maclean; L.B. Dizon)

Second Annual Review of the Fisheries Sector Program - National Fisheries Program, Quezon City, Philippines, 1-3 September. (G. Silvestre, R. Pomeroy, C. Luna, M. Pido, L. Garces and E. Cinco).

- Committee for the Inland Fisheries of Africa/Working Party on Aquaculture Second Session, Harare, Zimbabwe, 13-17 September. (R. Brummett)
- Council Meeting, International Council for the Exploration of the Seas (ICES), Dublin, Ireland, 23-28 September. (D. Pauly; R. Froese)
- Papers presented:
 Froese, R. Report of the ICES study group on FishBase
 Froese, R. and D. Pauly. Presentation of Fishbase (Poster and presentation of the theme session on "Computers in Fisheries Research")
 Garcia, S., F. Gayanilo, Jr. and D. Die. Software for tropical fisheries research: the need and response by FAO and ICLARM
- First National Workshop on the YY-male Technology for the Production of Genetically Male Tilapia (GMT), FAC/CLSU-UCS Genetic Manipulations for Improved Tilapia Project, Freshwater Aquaculture Center, Central Luzon State University, Muñoz, Philippines, 24 September. (M. Prein; M. de Vera; R. Velasco)
- Consultation Meeting on Low-External Input Rice Production Program, Quezon City, Philippines, 5 October. (T.S. Lopez; F. Villanueva)
- Second International Flatfish Symposium, Texel, The Netherlands, 29 September - 6 October. (D. Pauly, Keynote Speaker)
- Papers presented:
 Pauly, D. A framework for latitudinal comparisons of flatfish recruitment
 Froese, R. and D. Pauly. FishBase as a tool for comparing the life history patterns of flatfish (Poster and Computer presentation)
- Fourth Session of the Intergovernmental Oceanographic Commission of the Data and Information Exchange (IODE) Group of Experts on Marine Information Management, Washington D.C., USA. 6-9 October. (R.M. Temprosa, *Rapporteur*)
- Third Fisheries Forum, Pantnagar, India, 11-14 October (A.E. Eknath; M.V. Gupta)
- Paper presented:
 M.A. Mazid, M.V. Gupta and J.D. Sollows. Integrated rice-fish farming - A way to increase farmers' incomes and to a better environment
- WHO Meeting of the Study Group on the Control of Food-Borne Trematode Infections, Manila, 18-26 October. (R.S.V. Pullin; M. Prein)
- International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC) 19th Annual Conference, Bethesda, Maryland, USA, 11-15 October. (R.M. Temprosa)
- CNRFFP Workshop on Economics of Aquaculture, Mzuzu, Malawi, 24-29 October. (R. Brummett; D. Jamu)
- International Workshop on Tropical snapper and groupers. Campeche, Mexico, 26-29 October. (J.L. Munro, Workshop Co-chairperson and D. Pauly, Organizing Committee Member).
- Papers presented:
 Pauly, D. FishBase and AUXIM as software tools for growth comparisons in snappers and groupers (poster and lecture cum computer demonstration)
- National Workshop on Strategies for Aquaculture Technology Transfer Through NGOs jointly organized by FRI, BARC, DOC and ICLARM, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 31 October. (M.V. Gupta and E. Worby)
- UNDP/DGIP Tripartite Review Meeting for the GIFT Project, ICLARM HQ, Manila, Philippines, 10 November. (B.O. Acosta, H. Bolivar, A.E. Eknath, C. Janagap, R.S.V. Pullin, J. Rius, D. Rosales)
- SAARC Workshop on Fisheries Socioeconomics and Marketing, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 16-17 November. (M.V. Gupta)
- Fourth International Conference on Translation, Selangor, Malaysia, 16-18 November (C.L. Binudin)
- Lecture presented:
 Binudin, C.L. Attitudes towards machine translation
- CDS/ISIS Executive Committee Meeting, Lilongwe, Malawi, 19 November. (C. Jamu)
- International Workshop on Integrated Quantitative Analysis and Coastal Zone Management, San Jose, Costa Rica, 22-26 November. (J. Padilla)

- Paper presented:
 Padilla, J.E. Towards the bioeconomic analysis of tropical fisheries: summary of a conceptual paper
 Third National Symposium on Tilapia Farming, University of the Philippines in the Visayas, Iloilo City, Philippines, 25-27 November. (B.O. Acosta, G. Bimbao, H. Bolivar, A.E. Eknath, C. Janagap, J. Rius, D. Rosales, P. Virly)
- Paper presented:
 Eknath, A.E. Genetic Improvement of Farmed Tilapia Project (GIFT) project: from modest beginnings to an international network
 Fourth Indo-Pacific Fish Conference, Bangkok, Thailand, 28 November - 4 December. (A.S. Cabanban)
- Paper presented:
 Capuli, E.E.C., A.S. Cobanban and R. Froese. Preliminary checklist of the Philippine fishes produced with FishBase, a biological database on fishes
- 7th Session of the Standing Committee on Resources Research and Development of the Indo-Pacific Fisheries Commission, Bangkok, Thailand, 29 November - 1 December. (J. Padilla)
- Paper presented:
 Padilla, J.E. A bioeconomic model for fisheries management in tropical countries
 IIRI/FAC/ICLARM Rice-Fish Farming Systems Research Course, Los Baños, Manila and Muñoz, Philippines, 29 November - 17 December. (R.S.V. Pullin; C. Lightfoot; M. Prein; G. Horsikotte; V. Christensen; M. Bimbao; T. Lopez; F. Villanueva; L. Temprosa)
- AADC-EEC Training on Semi-intensive Milkfish and Prawn Culture for ASEAN Extension Officers, National Brackishwater Aquaculture Technology for Research Center, Pagbilao, Quezon, Philippines, 1 December (G. Bimbao)
- Lecture presented:
 Bimbao, G. Pond Economics
- Workshop on the Conservation and Sustainable Use of Wetlands, Calcutta, India, 4-6 December. (M. Ahmed)
- CNRFFP Final Project Review and Planning Workshop, Mzuzu, Malaŵi, 6-8 December. (R. Brummett)
- International Congress on Modeling and Simulation, The University of Western Australia, Perth, Australia, 6-10 December. (J.P.T. Dalsgaard)
- Paper presented:
 Dalsgaard, J.P.T., C. Lightfoot and V. Christensen. Towards the quantification of ecological sustainability in farming systems analysis
- 12th Regional Commission on Farm Management for Asia and the Far East, Dhaka, Bangladesh, 11-14 December. (M.V. Gupta)
- Paper presented:
 Gupta, M.V. and M.A. Mazid. Feasibility and potentials for integrated rice-fish farming systems in Bangladesh
- International Symposium on Socioeconomics of Aquaculture, Keelung, Taiwan, 14-18 December. (M. Ahmed, M.P. Bimbao; J. Padilla)
- Papers presented:
 Ahmed, M., M.A. Rab and M.P. Bimbao. Socioeconomic factors affecting adoption of aquaculture technologies in Bangladesh
 Bimbao, M.P., M. Ahmed, R.S. Pomeroy and R.S.V. Pullin. The economic potential of tilapia farming in Asia: the Philippine experience
 Padilla, J.E. Economies of scale and factor elasticities in seaweed farming in the Philippines
- NGO Intervention in Enterprise Development, Blantyre, Malaŵi, 15 December. (F. Chikafumbwa)
- Review Meeting on FRI Research Progress, Fisheries Research Institute, Mymensingh, Bangladesh, 22-23 December. (M.V. Gupta)

NATIONAL RESEARCH SUPPORT

ICLARM staff undertake many activities in addition to research, in support of national institutions and researchers. These may be categorized as: education and training, advisory services, and workshops.

Education and Training

Over the years, ICLARM staff have supervised or been advisors to many M.S. and Ph.D. students; taught in courses at tertiary institutions in both developing and developed countries; assisted in curriculum development; published educational materials; and provided training in specialized nondegree courses, in specific techniques, through on-the-job training, through networking and through study tours. Details of such activities in 1993 are given in Table 1.

Table 1. Education and training activities by ICLARM staff during 1993.

| Scope | Title | Collaborating Institution(s) | Duration |
|--------------------------|--|------------------------------|-------------------------|
| International | Two-week ECOPATH course for developing-country students at ZMT, Bremen | ZMT | March |
| | Three of Dr. Pauly's graduate students successfully complete studies: a Philippine scientist's Ph.D. in Germany; another Philippine scientist's M.S. in the Philippines; and a Mexican scientist's Ph.D. in France | | Continuous |
| Regional, Asia | Rice-Fish Farming Systems Research Course | IRRI, FAC | 29 November-17 December |
| | Visiting Professor at AIT, teaching Ecological Engineering and Modeling | AIT | 2 weeks, February |
| Regional, Southeast Asia | 10-day course on fisheries management/ ECOPATH for SEAFDEC Marine Fishery Resources Development and Management Department, Malaysia | SEAFDEC | September |
| National, Bangladesh | Provided Study tour to Malaysia and Thailand for Joint-Secretary, Ministry of Fisheries and Livestock | BDOF, IDRC, FF | 10-17 May |
| | Training in electrophoretic analysis for BFRI scientist | BFRI, IDRC, FF | 10 May-9 June |

continued...

Table 1. continued.

| Scope | Title | Collaborating Institution(s) | Duration |
|--------------|--|------------------------------|---------------------------------------|
| | Conducted training for BFRI library staff | BFRI | 3 weeks, February |
| | There were many activities during the year in two projects: the Agricultural Research Project (see Table 2); and the Socioeconomic Impact of Aquaculture Extension Project (see Table 3) | - | Continuous |
| | Dr. Ahmed was advisor for two M.Sc. students in aquaculture economics | - | Continuous |
| Djibouti | Training of national scientist in stock assessment | GTZ | 19 March-21 April |
| Ghana | Training at HQ on use of ICLARM's RESTORE framework for IAB scientist | IAB | 16-31 August |
| Malaŵi | Fourteen different seminars and short courses in rapid rural appraisal, resource mapping, experimental methods and computer analysis of data for NARS technicians | GTZ, MDOF, CNRFFP, MAGFAD | |
| Mexico | Lecturer, FAO/DANIDA course on fish stock assessment, Mazatlan, for 30 national researchers | FAO, DANIDA | 11 January- 6 February |
| | Course on Aspects of Fish Recruitment for 10 staff of INP | EPOMEX, INP | One week, October |
| Philippines | Two lecturers over 6 days on stock assessment for Silliman University, Dumaguete | SU | October |
| | Lecture at Course on Training in Technical Writing in Fisheries | CLSU, PDA | 30 April-1 May |
| | Training for NEDA staff on use of Geographic Information Systems (GIS) and SPANS software, Manila | IDRC, NEDA | 26 February-13 March |
| | Lectures by consultant for NEDA staff on GIS | IDRC, NEDA | 28 February-5 March 27 June-3 July |
| | Training course on Assessment of Coastal Habitats | PDA, BUCF | 4-27 October |
| | Training course on Fish Stock Assessment | PDA, BUCF | 15-26 November |
| | Four graduate students undertaking M.S. studies through the tilapia genetics project were supervised | FAC, BFAR | Continuous |
| Sierra Leone | Lectures at IMBO and supervision of 1 B.Sc. and 2 Ph.D. level theses | CEC, IMBO | Continuous |
| | Formal and on-the-job training in computer use for 20 staff of IMBO, WNW, AFCOD and SLFD | IMBO, WNW-AFCOD, SLFD, CEC | Continuous |

continued...

Table 1. continued.

| Scope | Title | Collaborating Institution(s) | Duration |
|-----------------|--|------------------------------|-----------------------|
| | Course on fish population dynamics for 21 scientists of IMBO, SLFD and Fourah Bay College | CEC, IMBO, SLFD | 28 January-3 February |
| Solomon Islands | Officer of the GSI Fisheries Division received training in village-based giant clam farming | GSI | from mid-year |
| | Officer of Marine School of the Solomon Islands College for Higher Education trained in giant clam farming and marketing | | September-December |
| | Two one-week training courses for participants in village growout trials for giant clams | USPC | September |
| | Workshop to train 38 field officers of SIDT on value of coral reef animals | SIDT | December |
| Vanuatu | Volunteer trainee in village-based giant clam and pearl oyster farming | | from December |
| Vietnam | Training at HQ on use of ICLARM's RESTORE framework for two scientists from Mekong Delta Farming Systems Research and Development Center, CTUV | MDFSRDC, CTUV | 1 February-2 March |
| | Two-day training at the University of Can Tho in Social Sciences for national scientists. There were 40 participants | IDRC | 1-2 December |

AIT = Asian Institute of Technology, Thailand

BDOF = Bangladesh Department of Fisheries

BFAR = Bureau of Fisheries and Aquatic Resources, Philippines

BFRI = Bangladesh Fisheries Research Institute

BUCF = Bicol University, College of Fisheries, Philippines

CEC = Commission of the European Communities

CLSU = Central Luzon State University, Philippines

CNRFFP = Central and Northern Regions Fish Farming Project, Malaŵi

CTUV = Can Tho University Vietnam

DANIDA = Danish International Development Assistance

EPOMEX = Programa Ecología, Pesquerías y Oceanografía del Golfo de México

FAC = Freshwater Aquaculture Center of CLSU, Philippines

FAO = Food and Agriculture Organization of the United Nations

FF = Ford Foundation

GSI = Government of Solomon Islands

GTZ = Deutsche Gesellschaft für Technische Zusammenarbeit, GmbH

IAB = Institute of Aquatic Biology, Achimota, Ghana

IDRC = International Development Research Centre, Canada

IMBO = Institute of Marine Biology and Oceanography, University of Sierra Leone

INP = Instituto Nacional de Pesca, Mexico

IRRI = International Rice Research Institute, Los Baños, Philippines

MAGFAD = Malaŵi/German Fisheries and Aquaculture Development Project

MDFSRDC = Mekong Delta Farming Systems Research and Development Center, Vietnam

MDOF = Malaŵi Department of Fisheries

NEDA = National Economic and Development Authority, Philippines

PDA = Philippine Department of Agriculture

SEAFDEC = Southeast Asian Fisheries Development Center

SIDT = Solomon Islands Development Trust

SLFD = Sierra Leone Fisheries Department

SU = Silliman University, Dumaguete, Philippines

USPC = United States Peace Corps

WNW-AFCOD = West Northwest Artisanal Fisheries and Community Development Programme

ZMT = Center for Tropical Marine Ecology, Germany

Table 2. List of training programs conducted with ICLARM assistance in 1993 under the BARC/FRI/USAID-supported Agricultural Research Project-II (Supplement) in Bangladesh (p. 94).

| Course | Date |
|---|-------------------|
| Economics of fish production: basic concepts, acquisition of data and information and methods of analysis for 16 FRI scientists | 6-27 January 1993 |
| Integrated rice-fish farming for 31 agricultural extension officers | 16 February 1993 |
| Integrated rice-fish farming for 50 DAE extension officers and farmers | 17 February 1993 |
| Integrated rice-fish farming for 36 DAE extension officers and farmers | 18 February 1993 |
| Aquaculture technologies and management for 25 primary school teachers | 1-4 March 1993 |
| Aquaculture technologies and management for 23 NGO extension workers | 9-13 March 1993 |

Table 3. Training and extension activities during 1993 in the project Socioeconomic Impact of a Fish Culture Extension Program (p. 89).

| Type/Name of Activities | Title/Descriptions | Duration | Unit | Participants |
|-------------------------------------|--|------------------------|--------------------|-----------------------------------|
| Selection of new cooperator farmers | Expansion of extension service | January | 270 | Cooperator farmers |
| Nursery assistance | To ensure fingerlings supply | January-September | 53 (39 farmers) | Cooperator farmers |
| Farming training | Basic fish culture techniques | 27 February-10 August | 268 | Newly included cooperator farmers |
| | Poultry raising | 9 July | 13 | Cooperator farmers |
| Assistance in beel fish culture | Expanded application of aquaculture technology | May-December | 620 | Cooperator farmers |
| Assistance in rice-fish culture | Expanded application of aquaculture technology | May-December | 15 | Cooperator farmers |
| Extension service | Pond preparation and fingerling stocking | March-August | 618 | Cooperator farmers |
| Extension service | Pond visit and post stocking management | Continued since August | 618 | Cooperator farmers |
| Farmers' rally | On-farm demonstration and discussion among the farmers | 5 January-14 August | 605 | Cooperator farmers |
| Study tour | Visit other project | 2 March-1 April | 15 | Cooperator farmers |
| Poultry-fish farming | Integrated farming | July-December | 6 | Cooperator farmers |

Advisory Services

Formal advisory services by staff during 1993 are summarized in Table 4.

Table 4. Advisory services by ICLARM staff during 1993.

| Scope | Title | Collaborating Institution(s) | Duration |
|------------------|--|------------------------------|-------------------------------------|
| International | Member of external evaluation panel of USAID-funded CRSP research | USAID | from 1992 |
| Regional, Asia | Consultancy to assist in planning regional information survey and workshop for SIFR; prepare material for workshop | SIFR | 2 weeks, July, 2 weeks, November |
| National, Brazil | Consultancy for CEC on database design for and sustainable use of Amazonian rain forests | CEC | 3-10 October |
| Vietnam | Assistance in formulating project on strengthening aquaculture in southern Vietnam | IAC | September, October, |

CEC = Commission of the European Communities

IAC = International Agricultural Centre, the Netherlands

SIFR = Strategy on International Fisheries Research Needs in Developing Countries (World Bank)

USAID = United States Agency for International Development

Workshops

Most workshops conducted by ICLARM and collaborators have a national strengthening component. Those organized in 1993 are summarized in Table 5.

ICLARM runs a seminar series, to which colleagues in a wide variety of nearby national and regional institutions are invited. The 1993 seminars are shown in Table 6.

In addition to these various activities, ICLARM staff, particularly in outreach project sites, are called upon almost daily for assistance in one form or another. For example in 1993, the Malaŵi project staff provided daily advice, support and guidance for students, extension agents and technicians from the Fisheries Department, the University of Malaŵi and a wide variety of regional aquaculture development programs — as well as participating in more formal institutions concerned with national and regional fisheries development. At the Coastal Aquaculture Centre in the Solomon Islands, staff produced extension newsletters, provided guided tours of the facilities to about 4,000 visitors and gave interviews to environmental radio programs — apart from the formal training activities reported in Table 1.

At headquarters also, library staff answer many queries as well as giving demonstrations and lectures on the library's sophisticated storage and retrieval systems, while scientific staff spend considerable time answering queries from colleagues around the world, particularly those in the ICLARM-coordinated networks (p. 20).

Table 5. Workshops organized in 1993.

| Scope | Title | Collaborating Institution(s) | Duration |
|----------------------|--|------------------------------|-----------------|
| Regional, Asia | Sixth Training Workshop on Quantitative Genetics of Farmed Tilapias, Philippines | FAC, BFAR | 10-13 May |
| | Third Asian Regional Rice-Fish Farming Research and Development Workshop, Indonesia | SRIFC | 6-11 June |
| | Community Management and Common Property of Coastal Fisheries and Upland Resources in Asia and the Pacific: Concepts, Methods and Experiences, Philippines | IDRC, FF | 21-23 June |
| National, Bangladesh | Improved Management of Inland Fisheries in Bangladesh, with 200 participants | BFRI, BDOF | 15-16 September |
| | Biological Assessment of Small Fishes in Bangladesh | BDOF | 28-29 September |
| Ghana | Workshop on disseminating project results, for West African researchers | IAB | 8-10 March |
| Indonesia | National Workshop on Priority Setting for Fisheries Socioeconomic Research | AFSSRN | 23-24 August |
| Malaysia | National Workshop on Regional and Cooperative Approach in Fisheries Management - Is it Viable for Malaysia? | AFSSRN | 26 October |
| Philippines | National Workshop on Fisheries Information and Statistics; 70 participants | SIFR | 31 August |

AFSSRN = Asian Fisheries Social Science Research Network

BDOF = Bangladesh Department of Fisheries

BFRI = Bangladesh Fisheries Research Institute

BFAR = Bureau of Fisheries and Aquatic Resources, Philippines

FAC = Freshwater Aquaculture Center of CLSU, Philippines

FF = Ford Foundation

IAB = Institute of Aquatic Biology, Achimota, Ghana

IDRC = International Development Research Centre, Canada

SRIFC = Sukamandi Research Institute for Food Crops

SIFR = Strategy on International Fisheries Research Needs in Developing Countries (World Bank)

Table 6. ICLARM seminars held at headquarters, 1993.

| Seminar | Date | Speaker | Title |
|---------|---------|---|---|
| 93/1 | 5 Mar. | Dr. Kam Suan Pheng School of Biological Sciences Universiti Sains Malaysia Penang, Malaysia | Geographic Information Systems and Modeling |
| 93/2 | 10 Mar. | Dr. Robert S. Pomeroy Research Scientist Coordinator, AFSSRN ICLARM | Socioeconomic Analysis for Coastal and Coral Reef Fisheries Co-Management |
| 93/3 | 31 May | Dr. Geoffrey Kirkwood RRAG, Centre for Environmental Technology, Imperial College of London, London, UK | Guidelines for Harvesting Fish Species of Different Lifespans |
| 93/4 | 3 Sept. | Dr. Rainer Froese Project Leader, FishBase + FishBase Project staff ICLARM | All You Ever Wanted to Know About Fish or FishBase as a Global Database Relevant to Individual Countries |
| 93/5 | 7 Oct. | Ms. Shakuntala Haraksingh Thilsted Research Dept. of Human Nutrition The Royal Veterinary and Agricultural University Copenhagen, Denmark | A comparison of the Nutritional Value of Indigenous Fish and Cultured Fish in Bangladesh — The Contribution to the Dietary Intake of Essential Nutrients |
| 93/6 | 7 Oct. | Mr. Bjorn Braaten and Mr. Halvor Hoktoen Norwegian Institute of Water Res. (NIVA) Oslo, Norway | Aspects of the Effect of Aquaculture on the Environment — Lessons from Norwegian Net Cages Fish Culture |
| 93/7 | 21 Oct. | Dr. Pat Foster-Turley AAAS Fellow/US-AEP United States-Asia Environmental Partnership 1133 20th Street, N.W. Suite 300, Washington, DC 20036, USA | Foraging Ecology of Sympatric Asian Otters in a Rice Field/Mangrove Habitat in Peninsular Malaysia |
| 93/8 | 4 Nov. | Mr. Kai Lorenzen Marine Resource Assessment Group Ltd. 8 Princes Gardens, London SW7 1NA United Kingdom | Asian Culture-based Reservoir Fisheries: Population Dynamics, Modeling and Adaptive Management |
| 93/9 | 16 Nov. | ICLARM | Aquaculture Videos: • Fish Culture in Seasonal Ponds and Ditches, Bangladesh • Trading the Silver Seed (Bangladesh) • Aquaculture and the Rural African Farmer, Malawi |

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ANNEX 1

Project Descriptions

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Coastal and Coral Reef Resource Systems Program

Tropical Fish Stock Assessment Project, continuous from July 1979

Cooperating Institutions: Predominantly in-house studies, with informal linkages with various research institutions

Key Personnel: ICLARM - Dr. Daniel Pauly, Mr. Felimon Gayanilo, Jr., Dr. Villy Christensen, Mr. Geronimo Silvestre, Dr. Rainer Froese, Dr. Maria Lourdes Palomares, Ms. Grace Coronado, Mr. Dominador Tioseco, Mr. Edwin de Guzman, Mr. Ely Garnace

Objectives

- 1) To increase our understanding of the dynamics of exploited tropical/subtropical fish communities.
- 1) To develop stock assessment methods which are straightforward and readily applicable to tropical and subtropical stocks.
- 1) To implement and disseminate these methods in the form of widely usable software for research and training.

Results

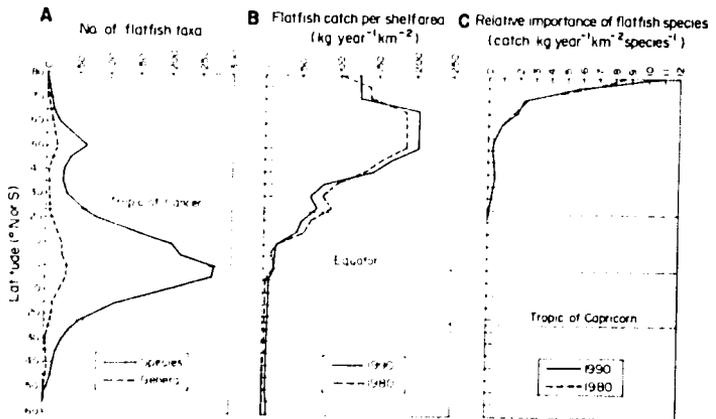
This project has continued to generate the conceptual and methodological advances required by our NARS partners to understand and manage their fisheries resource systems.

In view of the complementarity between the Tropical Fish Stock Assessment Project and the "ICLARM Software Project", a distinct entity from 1986 to 1992, it was decided, in 1993 to subsume the latter under the stock assessment project.

A major advance made in 1993 was a new approach for generating latitudinal transects of biodiversity, presented at an international Flatfish Symposium (see Figure), and now also incorporated as a routine of in FishBase. Other advances included new routines in ECOPATH (p. 57) and in multivariate methods in studying aquaculture systems (p. 84).

The bulk of the work in this project has been preparing the FiSAT software, a set of software tools tying up routines developed in the last decade at ICLARM and at FAO, and which, when released (in 1994), will become the major stock assessment software of our two organizations, for both research and training. The FiSAT documentation, a user's guide and a manual, were also completed, and will be forwarded to FAO for publication in 1994.

It is anticipated that the project will move, in the context of ICLARM's MTP, in the mid-1990s, toward methods for extracting from the results of trawl survey data a maximum of information relevant to management and the maintenance of biodiversity of inshore demersal fish, thus complementing, on tropical shelves, the activity of the ReefBase project (p. 72).



Form of latitudinal transects, showing the relationship between diversity of flatfish (A), their catch (B), and their relative abundance on a per-species basis (C).

Network of Tropical Fisheries Scientists (NTFS), continuous from April 1982

Cooperating Institutions: FAO/DANIDA Training Course in Tropical Fish Stock Assessment

Key Personnel: ICLARM - Dr. Daniel Pauly, *Fishbyte* Editor; Ms. Beth Eleccion, Network Secretary

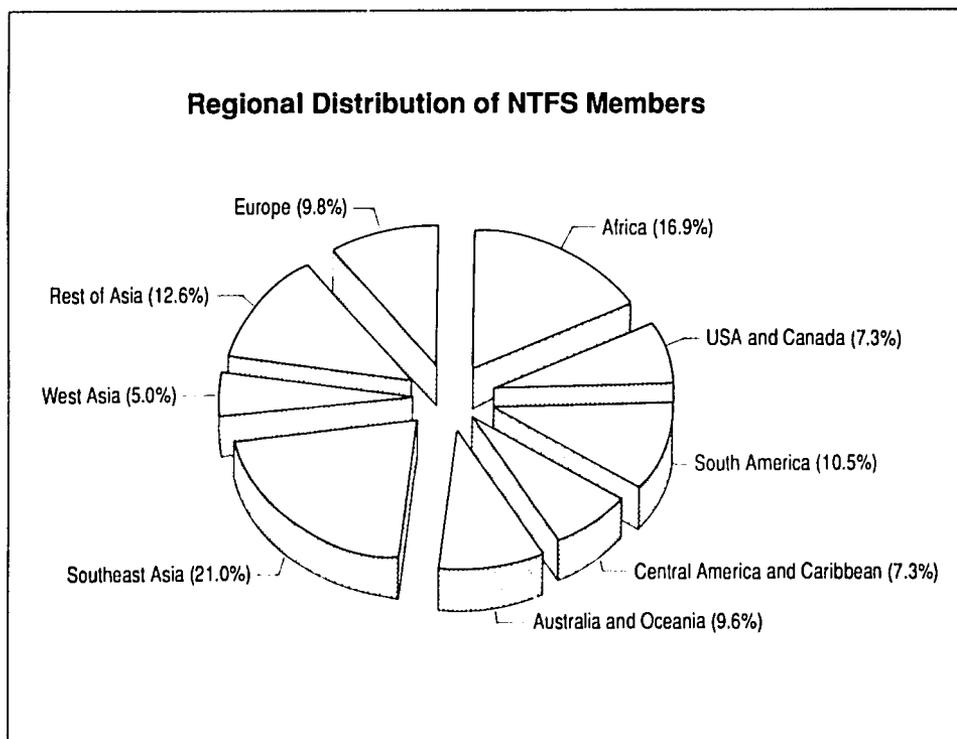
Objectives

- To enhance communication between fisheries scientists working on the assessment, conservation and management of tropical stocks.
- To enhance the output of these scientists by improving access to literature, providing free database searches, distributing manuals and other literature and publishing a regular newsletter.

Results

Total individual membership by the end of 1993 was 1,308 with all members receiving *Naga*, the ICLARM Quarterly. *Fishbyte*, as a section of *Naga* totaled 53 pages in 1993, and included 17 contributions by 30 authors in 18 countries mainly in Asia and Africa, and continued its role as a tool for the dissemination and discussion of methods developed at the center, and/or of other tools for tropical fish stock assessment.

One NTFS member, Mr. Ahmed Darar from Djibouti, spent a GTZ-funded study stage from 19 March to 21 April and wrote a report on fisheries development in his country, to appear in a 1994 issue of *Naga*.



Global Comparisons of Aquatic Ecosystems (ECOPATH)

February 1990 to January 1996

Cooperating Institutions: Center for Tropical Marine Ecology, (Germany) ZMT; International Council for the Exploration of the Sea, (Denmark) ICES; Alfred Wegener Institute for Polar and Marine Research, (Germany) AWI; Department of Fisheries and Oceans, St. John's, (Canada) DFO; also numerous individual researchers in developing and developed countries.

Key Personnel: ICLARM - Dr. Villy Christensen, Dr. Daniel Pauly; AWI - Dr. Astrid Jarre-Teichmann; DFO - Dr. Peter Shelton; ZMT - Dr. Mathias Wolff

Objectives

- 1) To encourage and support ecosystem modelling by researchers in developing countries.
- 2) To conduct comparative studies on the functioning of aquatic ecosystems with special reference to their sustained exploitation and management.

Results

The main activities in 1993 were centered around development of a new version of ECOPATH II and final editing of the volume "Trophic Models of Aquatic Ecosystems" as No. 26 in the ICLARM Conference Proceedings Series, and in which project staff have numerous contributions (see list of publications, p. 49).

The new ECOPATH II is a completely reprogrammed version which will incorporate substantial graphic facilities as well as much better facilities for data handling. The new version is to be released in 1994 on CD-ROM together with FishBase (see p. 59).

"Trophic Models of Aquatic Ecosystems", which is copublished with ICES and DANIDA, includes some 44 peer-reviewed contributions, the majority of which use ECOPATH II to represent trophic interactions in ecosystems. This volume more than doubles the number of published, balanced models of trophic interactions in ecosystems and as such can be seen as a major milestone in ecosystem modeling. One of the new routines incorporated into ECOPATH II in 1993 allows estimating, for any group, the food eaten by all its prey, and by their prey, etc., all the way down the food web. This allows assessing the impact of any group on the overall fabric of an ecosystem, and when the fishery is treated as a predator, the impact of humans on resource systems.

ECOPATH II was distributed at the end of the year to around 350 users split approximately evenly between developing and developed countries. To facilitate adoption of ECOPATH II, four courses and workshops on the use of the software system were conducted in as many countries (see National Research Support, p. 42).

Climate and Eastern Ocean Systems (CEOS), October 1992 to September 1994

Cooperating Institutions: Pacific Fisheries Environmental Group of the National Marine Fisheries Service (NMFS), Monterey, USA; Food and Agriculture Organization of the United Nations (FAO), Rome, Italy; Agence pour le Développement en Coopération (ORSTOM), Paris, France; Universidad Nacional Agraria (UNA), Lima, Peru; Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven, Germany.

Key Personnel: ICLARM - Dr. Daniel Pauly, Dr. Villy Christensen; ORSTOM - Dr. Philippe Cury, Dr. Claude Roy; NMFS - Dr. Roy Mendelsohn; UNA - Dr. Jaime Mendo; FAO - Dr. Andrew Bakun; AWI - Dr. Astrid Jarre-Teichmann, Mr. Wolff Hertlein

Objectives

- 1) CEOS general: To assemble key information and time series on the major eastern ocean boundary (upwelling) ecosystems of the world and to extract, mainly through the comparative method, likely scenarios for future, biological and social consequences of global climate change on upwelling resources.
- 2) ICLARM specific: To describe changes in the four major upwelling ecosystems of the world (Benguela Current, Canary Current, Humboldt Current and California Current) off South and North West Africa and the Americas through ECOPATH II models describing different states of these ecosystems; and to document the ichthyofauna of these upwelling ecosystems through FishBase and through preparation of synopses for the anchovies species important in each of these systems (*Engraulis capensis*, *E. encrasicolus*, *E. ringens* and *E. mordax*).

Results

Several contributions by project collaborators were edited and published through the *FishByte* Section of *Naga*, the ICLARM Quarterly.

Drs. Astrid Jarre-Teichmann and Villy Christensen assembled the elements of a book, to be published in 1994, that will present and compare ECOPATH II models for the four upwelling systems investigated by the CEOS project. The former presented preliminary results at a CalCOFI Conference held in the fall at Lake Arrowhead, California; Dr. Mendo continued to supply the FishBase Project with information on the ichthyofauna of the Peru systems, now covered comprehensively, while FishBase staff continued entry of information for the other three systems.

It is expected that the output of this project will significantly increase our understanding of upwelling systems and of trophic interactions in the resources therein, and thus provide a basis for more benefits to be derived by exploiting these systems.

Development of a Database on Fisheries Resources (FishBase)

October 1988 to end 1994 (also permanent ICLARM core activity)

Cooperating Institutions: Food and Agriculture Organization of the United Nations (FAO), Rome, Italy; California Academy of Sciences (CAS), San Francisco, USA; Zoologisches Institut und Museum (ZIM), Hamburg, Germany; Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven, Germany; Expert Center for Taxonomic Identification (ETI), Amsterdam, The Netherlands; University of the Philippines, Marine Science Institute (UPMSI), Quezon City, Philippines; Institute of Marine Biology and Oceanography (IMBO), Freetown, Sierra Leone; Instituto de Investigaçao Pesqueira (IIP), Maputo, Moçambique; Department of Fisheries, Domasi, Malaŵi; Institute of Aquatic Biology (IAB), Accra, Ghana; Dr. Fridtjof Nansen Project, Institute of Marine Research (NAN-IMR), Bergen, Norway; Ecole Nationale Supérieure Agronomique de Toulouse (ENSAT), Toulouse, France; Muséum National d'Histoire Naturelle (MNHN), Paris, France; Université Blaise Pascal Clermont-Ferrand, Institut des Sciences Biologiques, Hydrobiologie des Eaux Douces (UBPCF), Clermont-Ferrand, France; Musée Royale de l'Afrique Centrale (MRAC), Tervuren, Belgium; Institute of Zoology, Academia Sinica (IZAS), Taipei; State of Hawaii, Department of Land and Natural Resources, Division of Natural Resources (DLNR-DAR), Hawaii; Programa Ecologia, Pesquerías y Oceanografía del Golfo de México (EPOMEX), Campeche, Mexico; Universidad Nacional Mayor La Molina (UNALM), Lima, Peru; CARICOM Fisheries Resources and Management Program, Belize; Ministry of Agriculture, Land and Marine Resources, Fisheries Division (MALMRFD), Trinidad and Tobago; Marine Resources Assessment Group, Ltd. (MRAG), London, UK.

Key Personnel: FAO - Dr. Kent Carpenter, Dr. Devin Bartley, Dr. Toshihiro Matsusato; CAS - Dr. William N. Eschmeyer; ZIM - Prof. Wolfgang Villwock, Ms. Ulrike Sienknecht; ETI - Dr. Peter Schalck; UPMSI - Dr. Ed Gomez, Ms. Emily Capuli (until April 1993); DOF - Mr. B. Mkojo, Mr. Emmanuel Kaunda (until April 1993); IAB - Dr. Martin Odei, Ms. Mamaa Entsua-Mensah; NAN-IMR - Dr. Gabriela Bianchi; ENSAT - Dr. Jacques Moreau; MNHN - Dr. Jean-Claude Hureau; MRAC - Dr. Guy Teugels; UBPCF - Dr. Patricia Reyes-Marchant; IZAS - Dr. Kwang-Tsao Shao; DLNR-DAR - Dr. M. Kimberly Smith; EPOMEX - Dr. Alejandro Yañez-Arancibia, Ms. Christina Bárcenas Barzos; UNALM - Dr. Jaime Mendo (since April 1993); CARICOM - Dr. Peter Flewwelling; MALMRFD - Dr. Sherry Heileman; MRAG - Prof. John Beddington; IMBO - Dr. Michael Vakily; AWI - Dr. Astrid Jarre-Teichmann; ICLARM - Dr. Rainer Froese, Dr. Maria Lourdes D. Palomares, Dr. Daniel Pauly, Ms. Susan Luna, Ms. Crispina Binohlan, Ms. Armi Torres, Ms. Liza Agustin, Ms. Maria Teresa Cruz, Ms. Pascualita Sa-a, Mr. Roberto Cada, Mr. Dominador Tioseco (until July 1993), Mr. Rodolfo Reyes (since August 1993), Ms. Emily Capuli (since October 1993), Ms. Rachel Atanacio (part-time artist since January 1993).

Objectives

- (1) To develop, in cooperation with FAO, other organizations and national institutions, a large biological database on marine and freshwater fishes, containing key information on nomenclature, ecology, population dynamics, aquaculture, genetics, physiology and occurrence.
- (2) To maintain and distribute the database to researchers, teachers, planners and managers, with emphasis on developing-country agencies and institutions.

Results

As of December 1993, FishBase contained nomenclature and distribution by FAO area of more than 8,400 species extracted from more than 6,100 references, representing over one-third of the estimated 24,000 fish species in the world. This includes all fishes used commercially in capture fisheries or aquaculture; all in the IUCN Red List fishes; all dangerous

marine fishes; all freshwater fishes that have been introduced to another country; all sharks; all members of important families such as herrings, mackerels and tunas; and all Micronesian reef fishes, as well as the complete ichthyofauna of numerous landlocked countries, of small island states and of larger sea areas such as the North Atlantic and the Mediterranean.

The first in-depth review of FishBase, performed by a major collaborator, Kent Carpenter of FAO, proved to be very useful and led to important changes in operations aimed at ensuring the quality of the information entered in FishBase. Thus, emphasis now is put on extracting information from *recent* family revisions and country checklists done by taxonomists, both backed by museum samples, while other sources are now used with caution (unless recommended by collaborating experts). Due to the potential usefulness of FishBase as a tool in biodiversity studies, emphasis is also put on completing the country table, thus assuring the reliability of occurrence/distribution maps.

With the help of Dr. Devin Bartley of FAO who developed a multi-lingual questionnaire which will be sent all over the world, an update of the introductions database is on the way.

ICLARM recently signed a Memorandum of Agreement (MOA) with the Muséum National d'Histoire Naturelle, Paris. This will ensure the complete incorporation of their curatorial database (GICIM) into FishBase's occurrence table and thus make the valuable information therein - collected over three centuries and mostly on tropical fishes - available to researchers and managers in the countries where the fish originated.

An MOA was also signed with the Marine Resources Assessment Group, Ltd., London, which acts as a program manager for the British Overseas Development Administration. This collaboration allowed the hiring of a research assistant at ICLARM headquarters to enable the entry of data into FishBase as provided by MRAG and the quick response of FishBase to MRAG's request. This first "buy-in" by a resources assessment group is an early recognition of the potential of FishBase as a tool for fisheries management.

Products available on a 3.5" HD disk include: the FishBase demonstration disk with Manual; a database for entering/contributing/checking occurrence records; a database for entering/contributing/checking common names; and digitized fish pictures as .PCX or .CUT files.

Products available only as hard copy include data collection forms for contributing information, a summary of available information and references used for a particular species (short synopsis), synopsis of all the information in FishBase on a species (full synopsis), list of references used in FishBase by a given author, list of references used for an Order, a Family, Subfamily, Genus or Species, list of references used for a specific topic (e.g. on growth, swimming speed, longevity, etc.), list of all species in a Family (comes with basic information for the Family and all the references used for the species), list of all fishes used in aquaculture in phylogenetic order, list of fishes so far entered in FishBase in phylogenetic order, list of fishes for an FAO statistical area, and list of all fish diseases so far entered in FishBase. Aside from these, printouts of checklists of fishes with basic information on each species and common name (either in English or in the national language) for a given country are also available.

Furthermore, the MAPPER software, which is part of the FishBase package, now allows the display of a variety of maps using occurrence and abundance records. This feature is specially useful in fish biodiversity research. For example, maps of a certain FAO statistical area can be displayed complete with the number of species and families within that location. Maps showing the global occurrence of members of an Order, Family, SubFamily or a Genus can be created.

FishBase's usefulness as a teaching tool was tested during the recently held FAO-DANIDA Training Course on Fish-Stock Assessment and Management in Bogor, Indonesia, as well as at the Fish Recruitment Training Course and the International Workshop on Groupers and Snappers held in late 1993 in Mexico.

Demographic Atlas of African Freshwater Fish Populations

Two years, beginning January 1991

Cooperating Institutions: Ecole Nationale Supérieure Agronomique de Toulouse (ENSAT), and individual researchers in Africa

Key Personnel: ICLARM - Dr. Maria Lourdes Palomares, Dr. Daniel Pauly; ENSAT - Dr. Jacques Moreau

Objectives

- To assemble, analyze and publish previously unpublished length-frequency data collected by African and other scientists.
- To present the results (growth parameters, mortalities and related statistics) in a form enabling their use for fisheries management.

Results

A document titled *Atlas démographique des populations des poissons d'eau douce d'Afrique* was prepared in a format similar to earlier atlases of this type (for the Philippines and Indonesia), published by ICLARM but with the originators of the data sets authoring the section(s) pertaining to "their" populations.

It is anticipated that the growth, mortality and related parameters thus estimated – all of which were also entered in FishBase (see p. 59) – will be used for assessment of the stocks covered, of which a large fraction support important fisheries.

Research Cooperation between IMBO and ICLARM on the Establishment of a Fishery Database for the Development and Management of the National Fisheries off Sierra Leone

April 1991 to March 1993 (Phase I); April 1993 to September 1994 (Phase II)

Cooperating Institutions: Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone (IMBO); Department of Marine Resources (DMR); West-Northwest Artisanal Fisheries and Community Development Programme (WNW AFCOD)

Key Personnel: IMBO - Mr. P.A.T. Showers; DMR - Mr. A.B.C. Jones; WNW AFCOD - Dr. G. Sheves; ICLARM - Dr. J.M. Vakily

Objectives

- To evaluate the present status of the fishery of Sierra Leone and the level of exploitation i.e. both the commercial and small-scale sector.
- To make recommendations on possible fishery management strategies.
- To strengthen IMBO's capabilities to carry out research into the marine resources of Sierra Leone.
- To devise a permanent system of fisheries data collection and assist in the rehabilitation of the statistical unit of the Department of Marine Resources.
- To publish the results of this work and to disseminate them in Sierra Leone, other countries bordering the Gulf of Guinea, and to agencies and institutions with interests in fisheries development, particularly those working in west African countries.
- To improve on the availability of - and the access to - literature in the existing library of the Department of Marine Resources.

Results

In the course of the project, four major database systems were developed for the handling and analysis of fishery data. These were:

Sierra Leone-USSR Fishery Research Cruises. Data from 24 cruises, since 1976. Four dissertations (3 B.Sc., 1 Ph.D.) made use of the database. Analysis showed tremendous fluctuations in the biomass of selected species. A series of routines for standard analysis of the data is being developed and implemented, especially to generate data files for SIERRA, a low-level geographic information system.

Artisanal Fishery Frame Survey. Data from almost 1,400 questionnaires, including a census of fishing crafts, gears, motorization and employment in the artisanal fishery and as such of major importance for the management of the coastal resources. It was found that roughly 5,700 canoes existed in 1990 in the artisanal fishery. Around 15,700 persons derive their main income from fishing, while 2,200 persons are part time.

Industrial Fishery. Data reported by the offshore fishing fleet in the context of the new monitoring and surveillance system introduced in 1990. The database could also support the whole process of issuing and monitoring of licenses. In order to improve the utility of the catch data for management purpose, the project has designed new fishing logs which are now used on board the vessels.

Artisanal Fishery Landing Statistics. Maintained at WNW AFCOD, these data are used to evaluate the performance and the economic returns of the artisanal fishery within the project area.

The data available through the various database systems have been intensively used for research and training (see National Research Support, p. 42).

The Fish Resources of Western Indonesia: a Baseline Study of Biodiversity

One year, beginning January 1993 (extended to June 1994)

Cooperating Institutions: Directorate General of Fisheries (DGF) Jakarta, Indonesia; Marine Fisheries Research Institute (MFRI) Jakarta, Indonesia; Food and Agriculture Organization of the United Nations (FAO), Rome, Italy; and R/V Fridtjof Nansen Project, Marine Fisheries Institute (IMR), Bergen, Norway

Key Personnel: ICLARM - Dr. Daniel Pauly, Ms. Luningning Malumay; MFRI - Mr. Badrudin, Mr. Budihardjo; FAO - Dr. Purwito Martosubroto; IMR - Dr. Gabriella Bianchi; Consultants - Dr. John McManus, Dr. Annadel Cabanban, Dr. Jürgen Saeger

Objectives

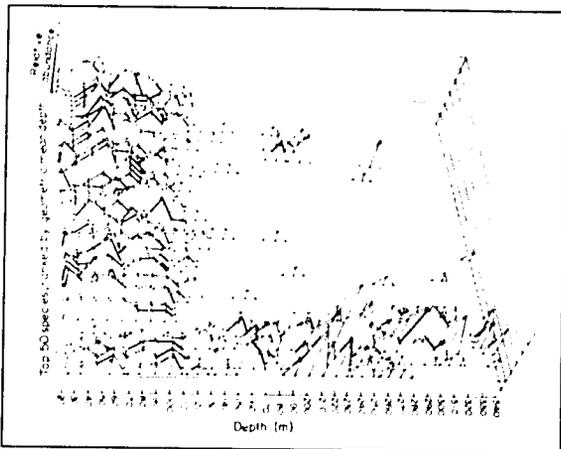
- To assemble, standardize and analyze the detailed data collected during the Indonesian-German JETINDOFISH trawl survey along the Indian Ocean Coast of Indonesia, from early 1979 to late 1981.
- To compare the results of these surveys with those of other trawl surveys conducted in the same period in adjacent areas of western Indonesia.
- To use these analyses to define the status of the coastal fish resources of western Indonesia prior to the onset of demersal fisheries developments, and thus to provide a baseline against which future changes in biodiversity can be evaluated.

Results

The data from the JETINDOFISH survey, supplied by the DGF, and pertaining to 697 fish species from 863 trawl hauls were entered into a database designed by J.M. Vakily in the context of his Sierra Leone-based project (see p. 62), checked for taxonomic accuracy through matching with FishBase records (see p. 59), then transferred to the NAN-SIS format^a, for detailed analysis of abundances by taxon, area and depth.

Community analyses were also performed, enabling identification of distinct communities defined by depth, substrate and other environmental variables.

Data covering the years 1975-1978 from the *Mutiara 4* trawl survey of the Java and southern South China Sea, and emanating from another Indonesian-German fishery development project, were analyzed by Ms. Badrudin and Mr. Budihardjo (MFRI) during a project-funded visit to ICLARM, from 24 May to 24 June 1993. These data will also be used for comparisons with the JETINDOFISH data and with data covering North Sumatran waters, generated during a survey conducted in August 1980 by R/V *Dr. Fridtjof Nansen*.



The two distinct communities emerging from an analysis by Dr. J. McManus of the fish abundances reported in the course of the JETINDOFISH survey.

^aStrømme, T. 1992. Software for fishery survey data logging and analysis. FAO Computerized Information Series (Fisheries). 4, 103 p. Rome.

Bioeconomic Modeling of Capture Fisheries, continuous from 1993

Key Personnel: ICLARM - Dr. Jose Padilla, Ms. Annabelle Cruz-Trinidad, Dr. Daniel Pauly

Objectives:

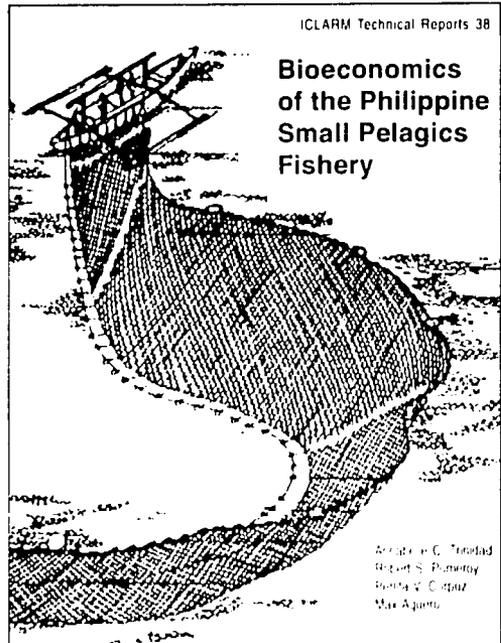
- To add price and cost vectors to resource-orientated analyses of (multispecies tropical small-scale) fisheries, thus enabling "costing" of various management options.
- To contribute to the understanding of the behavior of fishers and thus enabling various (co-)management schemes.

Results

Dr. Jose Padilla completed the concept paper for a comprehensive fisheries bioeconomic model, and much of the software implementing this model.

As this (post-doctoral) research involves considerable methodological development, two papers presenting new methods implemented in the software were written and submitted to primary journals; three other papers were presented at international conferences. Also, Dr. Padilla participated in the conduct of the socioeconomic component of the San Miguel Bay project (see p. 69), mainly to test the abovementioned bioeconomic software, which is expected to be completed in 1994.

Ms. Cruz-Trinidad and Dr. Pomeroy completed a Technical Report, based on field data collected earlier by their coauthors Ms. P. Corpuz and Dr. M. Agüero, on the economics of the Philippine fisheries for small pelagic fishes (anchovies, sardines, mackerels, etc.). The fisheries were found to be grossly overfished; management options are presented that involve community-based interventions to reduce the growth of fishing effort by small-scale fishers, and a revision of policies which sometimes indirectly promote and subsidize the growth of the commercial fisheries.



Cover of a report on the small-scale fisheries of the Philippines, documenting their status, and outlining sectoral and other options for reducing the excessive effort presently applied to this diminishing resource.

Asian Fisheries Social Science Research Network

Phase I, 1983-1985; Phase II, 1985-1988; Phase III, 1989-1993

Cooperating Institutions: INDONESIA - Faculty of Economics, Universitas Diponegoro (UNDIP); Central Research Institute for Fisheries (CRIFI); The Research Group on Agro-Ecosystems (KEPAS), Agency for Agricultural Research and Development; Research Institute for Marine Fisheries (RIMF); MALAYSIA - Faculty of Economics and Administration, Universiti Malaya (UM); Natural Resource Economics Department, Universiti Pertanian Malaysia (UPM); PHILIPPINES - Bureau of Fisheries and Aquatic Resources (BFAR); Freshwater Aquaculture Center, Central Luzon State University (CLSU); Economics Section, Research Division, Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC AQD); Department of Agricultural Economics, College of Economics and Management, University of the Philippines at Los Baños (UPLB); Faculty of Arts and Sciences, University of the Philippines in the Visayas (UPV); THAILAND - Fisheries Economics Research Subdivision, Department of Fisheries (DOF); Department of Agricultural and Resource Economics, Faculty of Economics and Business Administration, Kasetsart University (KU); Coastal Resources Institute, Prince of Songkla University (PSU)

Key Personnel: ICLARM - Dr. Robert S. Pomeroy (Coordinator), Ms. Ma. Angelina A. Agulto

Objectives

- [1] To advance the professional capacities of its members and broaden the base of its membership.
- [1] To support its members in the conduct of research in the social sciences that will generate results of value for the formulation of development policies and management strategies in support of capture fisheries and aquaculture sectors.
- [1] To develop educational programs in the social sciences related to capture fisheries and aquaculture at the graduate and undergraduate levels in AFSSRN member institutions.
- [1] To augment national activities of the AFSSRN with international linkages among its members.
- [1] To promote the use of the AFSSRN research results through effective dissemination.

Results

Activities during the year included:

- approval and conduct of small project development grants for well-designed research proposals for larger funding and collaborative research;
- two national workshops focusing on research priority areas;
- one team leaders' meeting (June 1993);
- participation of team members in international and regional conferences and workshops;
- exchange visits by team members to other member-institutions;
- identification of new member-institutions in Vietnam and Bangladesh; and
- completion of most Phase III research projects.

Research. Of the 15 research projects under Phase III, 13 have been completed. Three additional projects were approved during the extension period. However, funding for these projects only served as "seed money" for the teams to begin research, develop larger projects and to seek other funding.

Membership. The Network has established contacts with a number of additional institutions and hopes to expand its membership in 1994.

AFSSRN-Simon Fraser University Collaborative Agreement. Three Network members, all from Indonesia, availed of the Visiting Scholars' Program under the collaborative agreement.

They are Drs. Mudiantono and Dra. Indah Susilowati of UNDIP and Mr. Budihardjo of CRIFI.

Regional Exchange Visits. The Network sponsored two regional visits by members to other member-institutions: Ms. Susana V. Siar of SEAFDEC AQD visited the Research Institute for Marine Fisheries (RIMF) in Jakarta, Indonesia; and Dr. Miyasto, Vice Dean of Academic Affairs, UNDIP Faculty of Economics, visited officials of Kasetsart University (Thailand) and Universiti Pertanian Malaysia (Malaysia).

Collaboration. In September 1993, the International Agricultural Centre (IAC) in the Netherlands sought the AFSSRN's assistance in the formulation of its project, "Strengthening the Aquaculture Development in the Southern Part of Vietnam." It particularly needed assistance in collecting socioeconomic information on small-scale aquaculture enterprises in Southern Vietnam and in providing inputs in the identification and formulation of strategies and activities for implementation during the project's Phase I. The Network Coordinator participated in fact-finding missions conducted in September, October and November. Other cooperating institutions are the Aquaculture Research Institute II (Vietnam); Faculty of Fisheries, University of Cantho (Vietnam); University of Agriculture and Forestry (Vietnam); and the Fish Culture Research Institute (Hungary). The Network has been identified to assist in the training, curriculum development and collaborative research components of the project.

AFSSRN member-institutions will also become research partners of the ICLARM/North Sea Coastal Fisheries Co-Management Project.

The AFSSRN has also formed active linkages with St. Mary's University (Dr. Anthony Charles); the Coastal Resource Research Network, formerly known as the Mollusc Culture Network (Dr. Gary Newkirk); the Bay of Bengal Programme (Dr. Rathin N. Roy); and the Asian Institute of Technology, Thailand (Drs. Peter Edwards and Harvey DeMaine).

Coastal Fisheries Co-Management: Project Planning Phase

1 October 1993 - 31 March 1994

Cooperating Institutions: North Sea Centre (NSC) Hirtshals, Denmark

Key Personnel: ICLARM - Dr. Robert S. Pomeroy; NSC - Mr. Sten Sverdrup-Jensen

Objectives

- [1] To establish a project management and administrative structure.
- [2] To prepare a project proposal and a workplan.
- [3] To identify national research collaborators.
- [4] To meet project steering committee with the national research collaborators.
- [5] To prepare a co-management literature review.

Results

A Memorandum of Understanding was executed between ICLARM and the North Sea Centre (NSC) to undertake a collaborative coastal fisheries co-management research project. The collaboration between ICLARM and NSC is based on a mutual interest in gaining practical experience in fisheries co-management; to investigate its applicability as a sustainable, equitable and efficient fisheries management strategy; and to develop models for use and adoption by governments, fishing communities, NGOs and others.

At both ICLARM and NSC, project leaders and project staff were appointed. Accounting and administrative procedures have been established at each institution.

The Project proposes to conduct research in several aquatic resource systems in Asia (including the Philippines, Indonesia, Vietnam), Africa (including Mozambique) and the Pacific (Solomon Islands) to determine if fisheries co-management can be a viable management strategy under varying conditions (political, social, cultural, economic, biophysical, technological).

Significant progress has been made in several of the research partner countries in identifying national research collaborators and developing a research agenda and workplan. The project leaders made trips to the Philippines, Vietnam, Indonesia, Mozambique and Zimbabwe to plan project activities.

A research framework for fisheries co-management institutions was developed.

Project research staff at both ICLARM and NSC began a literature review on fisheries co-management. The purpose of the literature review is to document both successes and failures in fisheries co-management and to identify the reasons for these successes and failures. In addition to fisheries, the literature review is documenting and evaluating experiences in other resource systems and sectors such as forestry, irrigation and health to determine applicability for fisheries.

Improved Management of Openwater Fisheries in Bangladesh

three years, beginning July 1991

Cooperating Institutions: Department of Fisheries (DOF), Bangladesh; Fisheries Research Institute (FRI), Bangladesh

Key Personnel: ICLARM - Dr. Mahfuzuddin Ahmed, Dr. Daniel Pauly; DOF - Mr. A.K. Ataur Rahman, Mr. Md. Mokammel Hossain; FRI - Dr. M.A. Mazid

Objectives

- 1) To test alternative mechanisms for management of small-scale fisheries to achieve objectives such as redistributing fisheries benefits in favor of households directly dependent on fishing.
- 2) To assist in the design of experimental approaches for implementation of a new management policy for openwater fisheries in Bangladesh that would emphasize active involvement of fishing communities and NGOs.
- 3) To provide technical assistance and guidance to Bangladesh scientists on methodologies of fisheries research.

Results

The project initiated data collection and completed parts of the analysis for biological and socioeconomic studies in selected sites. The collection and analysis for length-frequency data were conducted by four DOF scientists with the help of a consultant, Dr. Christopher Mathews, and under the general supervision of Dr. Daniel Pauly. Mr. Anisur Rahman, a scientist from FRI conducted with ICLARM staff Ms. Liza Agustin at the Marine Science Institute, University of the Philippines, an electrophoretic analysis of hilsa (*Tenualosa ilisha*), the country's most important fish species. The results suggest the existence of at least two genetically distinct stocks of hilsa in Bangladesh. This result also appears substantiated by detailed analyses of hilsa morphometry conducted by Ms. Carmela Janagap and Dr. R. Froese.

Dr. M. Ahmed supervised the DOF consultants who conducted the benchmark studies and other diagnostic surveys for identifying problems and opportunities of the fishing communities within the project area where DOF and four NGOs such as Bangladesh Rural Advancement Committee (BRAC), Proshika Manobik Unnayan Kendra (MUK), Caritas and Friends in Village Development Bangladesh (FIVDB) are working with the fishing communities. Preparation of manuscripts based on the results of the biological and socioeconomic studies for publication also progressed, although publication funds have not yet been identified. Much technical assistance was also provided during the year. Details are given on p. 42.

Resource and Ecological Assessment for San Miguel Bay, Philippines

April 1992 to August 1993

Key Personnel: ICLARM - Mr. Geronimo T. Silvestre, Dr. Robert Pomeroy (since November 1992), Dr. William Sunderlin, Mr. Cesar Z. Luna, Mr. Herminigildo M. Montalvo, Mr. Len R. Garcés, Mr. Michael Pido (since January 1993), Ms. Madeleine L. Dalusung, Mr. Elviro A. Cinco, Mr. Marcos Jose M. Vega, Ms. Deborah Jean R. Mendoza, Mr. Rene Geraldo G. Ledesma, Ms. Maria Concepcion R. Ricafrente, Mr. Quintin P. Sia III, Ms. Maharlina Luz G. Gorospe, Ms. Gigi B. Calica, Ms. Portia N. Bonilla

Objectives

- To assess the status and exploitation/utilization of the fisheries in San Miguel Bay.
- To evaluate the status and stresses/impacts on critical habitats (i.e., coral reefs, mangroves, seagrass/algal beds) and habitat characteristics (i.e., water quality) of consequence to the "health" of the fisheries resources.
- To assess the socioeconomics of the fisheries and the general socioeconomic/development framework within which it operates.
- To elaborate feasible management options, guidelines and strategies (including feasible investment opportunities for alternative livelihood) that maximize benefits from fisheries resources utilization/exploitation and minimize sectoral conflicts and/or incompatibilities.

Results

San Miguel Bay, a major fishing ground in the southern Philippines, is one of the 12 priority bays of the Fisheries Sector Program currently implemented by the Department of Agriculture of the Republic of the Philippines. ICLARM conducted the Resource and Ecological Assessment of San Miguel Bay Project to provide the scientific basis for the management of the Bay. The Project consisted of five components, one of which, a situational analysis, was completed in 1992. Progress on the other components follows.

Capture Fisheries Assessment. Commercial and artisanal fisheries were monitored for one year. Monthly sampling of some gears were conducted with emphasis on key elements such as total catch and catch per unit effort, species and length composition of the catch, gear design and area and time of operation. Weekly dockside sampling was concentrated in key landing sites. A trawl survey was conducted to complement the monitoring of key landing sites.

The problems reported in the ICLARM studies during the 1980s are still present, with deterioration of trends in some cases. The mean exploitation ratio (E) for commercially important species was estimated at 0.60, which is very high. Likewise, the yield-to-biomass ratio (F) estimated at 6.4 is way above the optimal level. Growth overfishing due to use of small-meshed nets (20 cm) results in about 20% losses. Species changes were observed that are reflective of recruitment and ecosystem overfishing. The present demersal biomass is estimated at 18.5% of levels in the 1940s. Nine papers describing the details of the assessment of capture fisheries are in the final stages of completion.

Ecological and Habitat Assessment. Five tasks were implemented under this component: (1) physical oceanographic studies, (2) water quality baseline studies, (3) assessment of coral reefs, (4) assessment of seagrass and algal beds, and (5) assessment of mangroves.

A technical report on the physical oceanographic studies describes the circulation and dispersion patterns of San Miguel Bay, based on a two-dimensional transport model.

The water quality baseline studies involved the monthly monitoring of temperature, salinity, pH, dissolved oxygen, transparency and suspended solids. Results of this monitoring activity provided insights into the estuarine nature of the Bay. Quarterly monitoring of nutrients and heavy metals (lead, copper and cadmium) were conducted to assess pollution levels. In addition, primary productivity, gross production and respiration were also monitored.

The results indicate that water pollution is not a major problem in the Bay, although fecal coliform levels in the main river emptying into the Bay (Bicol River) were above standards throughout the sampling period, while the copper and cadmium concentrations occasionally exceeded the standards. The detailed results are described in six technical papers.

An average of 50% living coral cover in reef sites was observed. Basic information on seagrass and algal beds was also obtained.

The status of mangroves was assessed using a Geographical Information System (GIS) to overlay a map generated from 1987 SPOT satellite data on topographic maps of the 1950s. Approximately 50% of the mangroves in the 1950s have been harvested or converted. Detailed field assessments of mangroves were also conducted using a transect method. Eight technical papers describe the assessments of coral reefs, seagrass and algal beds and mangroves.

Socioeconomic and Policy Analysis. There were two tasks in this component. The first task focused on the analysis of the socioeconomic facets of the fishery. This task included the following: (1) cost and earnings monitoring, (2) market prices monitoring, (3) landing monitoring, (4) middlemen and processors survey, (5) socioeconomic survey of fishing households, (6) survey of the formal management system and influential stakeholders, (7) survey of fishers' organizations, and (8) research on alternative livelihoods.

The second task involved the analysis of ecological and socioeconomic interrelations. This task combines the findings of the socioeconomic surveys and the ecological/habitat assessments into recommendations for the management of coral reefs and mangroves.

Ten research papers have been produced by this component.

Assessment of Management Implications. This component has two activities: a computerized database and assessment of management implications/options. The database, called "SMB_base", incorporates all data gathered by the various components into a user friendly software package, complete with documentation and a users' guide.

While the project was being conducted, the San Miguel Bay Management Council, a multisectoral group, was created and tasked with managing the Bay's resources. Under the Council, an Interim Planning Committee (IPC) composed of stakeholder representatives was formed to formulate a management plan for the bay. Project team members helped the IPC produce an Integrated Coastal Fisheries Management Plan (ICFMP). A key feature of the planning process was the use of decision analysis by the IPC, under the guidance of project team members, to formulate and assess alternative resource management measures. Thus, the assessment of management implications was done systematically in an analytic framework which involved heavy stakeholder participation. In addition, the results were directly incorporated into a program of action, the ICFMP.

Research activities in coastal fisheries co-management were undertaken in collaboration with the Coastal Fisheries Co-Management Project. The research objective was to evaluate the formal and informal institutional and organizational arrangement for fisheries management in San Miguel Bay. The research results indicated that San Miguel Bay is not a common property regime, but is managed as state property. Limited informal community-based fisheries management strategies exist in the Bay. Institutional restructuring will be needed to address the participation of fishers in management is needed. A San Miguel Bay Management Council has been established to provide a coordinated management strategy which may recognize the common property attributes of the Bay.

Resource and Ecological Assessment for Lagonoy Gulf, Philippines

July 1993 to January 1995

Cooperating Institution: Bicol University College of Fisheries (BUCF)

Key Personnel: ICLARM - Mr. Geronimo T. Silvestre, Mr. Cesar Z. Luna, Mr. Len R. Garcas, Ms. Loida S. Corpus, Mr. Marcos Jose M. Vega, Ms. Rowenc Andrea Santos, Mr. Quintin P. Sia III; BUCF - Mr. Vicior S. Soliman, Mr. Plutomeo M. Nieves, Mr. Scorzeny C. de Jesus, Mr. Marcial R. Jane, Mr. Antonio B. Borro, Ms. Graco B. Brizuela, Ms. Leonor I. Miranda, Ms. Glorie Eva, Mr. Leovigildo Basmayor

Objectives

1. To assess the status and exploitation/utilization of the fishery in Lagonoy Gulf.
2. To evaluate the status and stresses/impacts on critical habitats (i.e., coral reefs, mangroves, seagrass/algal beds) and habitat characteristics (i.e., water quality) of consequence to the "health" of the fishery resources.
3. To elaborate feasible management options, guidelines and strategies that maximize benefits from fishery resources utilization/exploitation and minimize sectoral conflicts and/or incompatibilities.
4. To strengthen BUCF's capabilities on coastal resources management research.

Results

Review of Secondary Information. In November, an outline of a coastal environmental profile was made with individual sections or chapters assigned to key project personnel. Based on the outline, information was collected from government offices, schools and other institutions in November and December. Sections of the coastal profile are presently being drafted using these information sources.

Preliminary Field Activities. Project staff conducted a reconnaissance survey around the Gulf from 29 November to 3 December to gather first-hand information for planning subsequent field activities. The trip was also used to verify a map of coastal habitats prepared by the National Mapping and Resource Information Authority. The map was judged as reliable based on manta tows, bounce dives and ocular surveys. Preliminary water quality surveys and initial surveys of coral reefs, seagrasses, algal beds and mangroves were conducted. Fish landings along the Gulf were also visited to select and establish monitoring stations for the assessment of the Gulf's capture fisheries.

ReefBase - A Global Database of Coral Reef Systems and their Resources

1 October 1993-30 September 1995

Collaborating Institution: World Conservation Monitoring Center (WCMC)

Key Personnel: ICLARM - Dr. John W. McManus, Dr. John L. Munro, Mr. Benjamin M. Vallejo, Jr., Ms. Grace U. Coronado, Ms. Cindy F. Cabote, Ms. Susan Wells, Dr. Rainer Froese; WCMC - Dr. Richard Luxmore, Mr. Mark Spalding

Objectives

- [1] To design a relational database for structured information on coral reefs and their resources that will serve as a computerized encyclopedia for use in reef management, conservation and research.
- [2] To set up a network of coral reef researchers and managers who will contribute to the database.
- [3] To collaborate with other national, regional and international databases and GIS facilities relating to reefs, and provide a means of comparing and interpreting information at the global level.
- [4] To distribute analytical routines and develop new ones that will make full use of the information in the database and ensure appropriate interpretation and synthesis.

Results

The project was initiated with an internationally advertised search for a project leader, beginning in October 1993. The selection was made in November 1993, and the project leader began work immediately. Ms. Susan Wells, the principal compiler of the three-volume work *Coral Reefs of the World*, was hired as a consultant to initiate the design of the database tables. Activities at WCMC began immediately through coordinating discussions with Dr. Rainer Froese (ICLARM FishBase Project Leader). By early December, all efforts were focused on preparing preliminary versions of the data tables for a project initiation workshop in early January 1994. An extensive review of available database software systems led to the selection of the Microsoft Access system.



Geographic Information System for Coastal Area Management and Planning (GISCAMP), September 1991 - January 1994

Cooperating Institutions: National Economic and Development Authority-Region I Office (NRO), San Fernando, La Union, Philippines

Key Personnel: ICLARM - Dr. Chua Thia-Eng, Mr. James N. Paw, Mr. Noel Robles, Ms. Zoraida N. Alojado; NRO - Mr. Leonardo Quito, Jr., Ms. Agnes Grace Cargamento, Mr. Jonathan Guiang

Objectives

To update regional capabilities in coastal area management and planning (CAMP) and to establish an information system for the storage and analysis of spatial and attribute data on the coastal areas for planning and management purposes through the use of Geographic Information Systems (GIS).

Results

Data collection and capture remained the major activities of the project during the first six months of 1993. Ground truthing for the rectification of the 1990 Landsat image, which started in December 1992, was continued in January 1993.

A consultant, Dr. Kam Suan Pheng from Universiti Sains Malaysia, visited the project site and ICLARM on two occasions and reviewed the project's GIS database and application studies which covered nine activities. The nine activities were:

- Impact of upland watershed and lowland land use activities on the coastal zone
- Impact of human settlement development and expansion on the coastal area
- Delineation of fishing zones in the Lingayen Gulf
- Delineation of fry grounds in the Lingayen Gulf
- Identification and assessment of marine park and artificial reef zones
- Identification and assessment of coastal tourism areas
- Identification and assessment of mangrove reforestation areas
- Identification and assessment of areas for aquaculture development
- Zonation scheme for the coastal zone of Lingayen Gulf

GIS analyses began in the second quarter of 1993 and were completed by November, well beyond the project's original ending date in September 1993. Delays in data capture had hampered analyses. Project extension covering the period 1 September 1993 to 31 January 1994 was sought and approved by the International Development Research Centre of Canada. Several activities were rescheduled during the extension period, such as the national workshop and training.

Preliminary results were presented at the National Workshop for GISCAMP organized by the project on 13-15 December 1993 in La Union. The training course on the use of GIS for regional planning in the coastal zone was held in La Union on 19-24 January 1994.

Solomon Islands Aquaculture and Resource Enhancement in Coral Reef Ecosystems, Continuous

Cooperating Institutions: Fisheries Division, Government of Solomon Islands (GSI); Australian Institute of Marine Science (AIMS); numerous South Pacific and Asian institutions.

Key Personnel: GSI - Mr. Hugo Tafea, Mr. Gideon Tiroba; ICLARM - Dr. John L. Munro, Dr. Johann Bell, Mr. Mark Gervis, Mr. Idris Lane, Mr. Cletus Oengpepa, Mr. Kim Friedman, Mr. Christian Ramofafia, Mr. Ferral Lasi, Ms. Stephanie Pallay, Mr. Stephan Soule, Mr. Robert Jimmy, Mr. Patrick Timmy

Objectives:

The objectives of ICLARM's Coastal Aquaculture Centre (CAC) in the Solomon Islands and of its single project are to:

- (1) develop village-based farming systems for economically important coral reef organisms;
- (2) investigate the potential for fisheries enhancement systems in coral reef environments; and
- (3) disseminate results, systems and information on a regional basis for the economic and social benefit of coastal villagers.

Results

In 1993, considerable progress has been made towards the goals of the Centre. In particular, the scale of village giant clam farms was expanded, lucrative markets for giant clams were developed, and new research projects on pearl oysters and sea cucumbers were started.

Giant Clam Farming Systems

Broodstock. A new development in broodstock management this year has been the use of small, individual concrete pads to provide a secure substratum for each *T. crocea* and *T. maxima*. A depression in the pad allows the clam to "bury" itself and provides protection to the byssal area from predators. The pads holding the clams are placed in open wire trays on trestles 0.5 m above the substratum within their discrete areas.

During 1993, all giant clam broodstock were retagged on both valves. Dymo tape was used for the smaller species and aluminium tags for the larger ones. All tags were attached with epoxy glue. To facilitate retrieval of any given individual, the tagged clams have been arranged within their discrete areas according to tag number. "Clambase", ICLARM's database for giant clams, was also modified to allow for complete records on the origin, growth and spawning history of each broodstock clam, and the performance of their progeny.

Spawning and Hatchery Production. All species of giant clam except *T. gigas* (for which broodstock were decimated in 1992) were induced to spawn in 1993. A total of nine cohorts were reared successfully from these species. Most of the successful spawnings occurred around the new or full moon. Spawnings were induced by heat stress, application of frozen "egg-water" and, if needed, intragonadal injection of the neuro-transmitter, Serotonin (5, hydroxytryamine). The spawnings involved 4-12 parents and produced a highly variable number of fertilized eggs, ranging from 12 to 130×10^6 .

Formal comparisons between larval rearing under static and flow-through conditions were begun. *T. squamosa* survived better in the static system than in the flow-through tanks in indoor and outdoor tanks. Comparisons between static and flow-through hatchery systems will be made for all species of giant clams in 1994. The planned expansion of the number

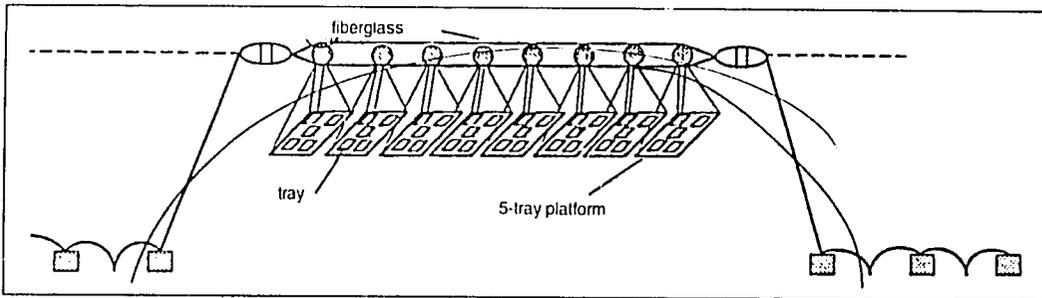
of 700-l hatchery tanks from 6 to 12 in 1994 will make these experiments more powerful.

Land-Based Nursery. A total of 13 cohorts passed through the land-based nursery in 1993. The number of cohorts for each species were: *H. hippopus*, five; *T. maxima*, three, *T. squamosa*, two; *T. gigas*, one; *T. derasa*, one and *T. crocea*, one. In total, 269,881 clams were harvested from the land-based nursery for distribution to the ocean nursery at the CAC, the field station at Nusa Tupe, and the village grow-out trials or South Pacific Aquaculture Limited (SPAL) (see below). The mean growth rate for all species in the land-based nursery was 2.2 mm per month, and ranged from a low of 0.95 mm/month for *T. gigas* to 2.97 mm/month for *T. derasa*.

In June, the CAC approached SPAL, located 7 km away, to test the suitability of their five vacant outdoor prawn nursery tanks for rearing juvenile clams. The need to use these tanks arose because the ocean nurseries at the CAC and Nusa Tupe could not accommodate all the seed clams ready to harvest from the land-based nursery at that time. The nursery tanks at SPAL are made of cement and each one has a capacity of 46,000 l. They proved excellent for rearing both metamorphosed larvae and seed clams.

Ocean Nursery. The capacity of the floating ocean nursery system was increased by the addition of two longlines. Each longline is capable of holding forty 0.5-m² trays. The longline system was subjected to a cyclone in early 1993, and performed well. The longline system is about 30% cheaper than the previous method of supporting trays in the ocean nursery using floats made of PVC pipes.

Fifteen cohorts of giant clams were held in the ocean nursery during 1993; five cohorts of *H. hippopus*, and *T. maxima*, two cohorts of *T. squamosa* and *T. crocea* and one of *T. derasa*. In total, 231,356 juvenile clams were placed in the ocean nursery. Of these, more than 82,000 were harvested at a size of 25-35 mm during the year for use in growth trials at village sites and at Nusa Tupe. This represents a 110% increase in production compared to 1992, when 39,000 clams were produced. The increased production was due to the wider variety of species induced to spawn and the increased capacity provided by the new longlines.



Longline system used in floating ocean nursery.

Nusa Tupe Field Station. In 1993, the Nusa Tupe field station continued to provide a base for culturing a selection of the fastest growing individuals of each cohort for future use as F1 broodstock, for keeping clams used in morphometric studies, for growing-out clams to supply developing markets, for supplying clams to village trials in the Western Province, and for running field experiments. The clams kept at Nusa Tupe were held in approximately 200 cages and in three enclosures.

Biological Control of Predators. Ranellid gastropods in the genus *Cymatium* are major predators of juvenile clams and can decimate captive stocks in a short period of time unless they are removed regularly. Research at the CAC in previous years demonstrated that cone shells (*Conus* spp.) were predators of, and therefore possible low-cost biological control agents of *Cymatium* spp.

This hypothesis was pursued in earnest in 1993 in a field experiment at Nusa Tupe. The results confirmed that cone shells were effective at reducing the number of *Cymatium* spp. in a cage. However, there was considerable mortality in all treatments and there were

no significant differences in the number of clams surviving in cages with and without cone shells after five months. It is now evident that clam farmers cannot rely on using cone shells alone to prevent mortality of juvenile clams in cages: other routine husbandry procedures must also be followed to guard against other sources of mortality, and to remove those *Cymatium* spp. missed by the cone shells.

Village Grow-out Trials. There were two types of village trials in 1993; continuation of trials established prior to 1993, and a new round of village trials commenced in September. Twenty-six villages were involved in the first category of trials. There was a significant difference in the growth and survival of clams that were, or were not, removed from the cages for cleaning. Survival at sites where clams were removed for cleaning every three months was greater (54%) than at sites where clams were not removed for cleaning (22%). By contrast, growth was significantly lower at sites where clams were removed for cleaning (3.66 mm/month) than at those sites where clams were not removed (4.85 mm/month). The other result was a trend for faster growth at the sites with greater current speeds.

Using the current price for *T. gigas* paid to CAC by importers of aquarium animals in the USA, village growers would have netted US\$70 per cage during the average 10-month grow-out period. If survival had been 60%, which should be possible with more recent husbandry methods, earnings would have been around US\$235 per cage.

The new round of trials started in September differs from the previous trials in three ways: far greater numbers of clams at each village, a wider variety of species, and aimed at producing small live clams for the developing aquarium and sashimi markets. The trials involve 16 villages spread across 500 km of Solomon Islands, between Marau and Gizo. The trials have already resulted in development of a "settlement" ring, inserted in each cage. The ring is constructed of a strip of 0.5 cm galvanized wire mesh. The ring is placed so that it fits neatly within the perimeter of the cage and prevents the clams from crawling through the larger mesh of the cage during the 5 days that it should take them to attach to the cement base. The results showed that the rings were more effective if left for one month before removal. Further work on this problem is ongoing.

Marketing of Giant Clams. Considerable effort was put into developing markets for giant clams in 1993. Small shipments of 120-150 mm *T. gigas* were sent to Singapore to test the live-clam trade. Feedback was positive, but large shipments of bigger animals were preferred. A shipment to Taiwan was unsuccessful, as the 36-hour journey was too long; all the clams died. Initial shipments to Los Angeles (30 hours) were also unsuccessful. The clams in these shipments were packed in wet cloth in oxygen-filled bags. Smaller shipments of five species were then made to Los Angeles to compare methods of packing. Results suggest that packing in water gives best survival.

Prices are attractive but assessing the commercial viability of village-based giant clam farming will depend mainly on evaluating mean costs of producing the seed clams from a hatchery, and mean survival of each species in the village. The marketing will require additional facilities, e.g., a packing shed, holding raceways, and additional staff. These facilities will be funded by proceeds from the sale of the stock of production clams held by the CAC.

Pearl Oyster Farming

Reasonable quantities of both the blacklip pearl oyster (*Pinctada margaritifera*) and goldlip pearl oyster (*P. maxima*) have been harvested from many areas within Solomon Islands on a regular basis. In view of the success of the blacklip pearl industry in Tahiti and Cook Islands, ACIAR, ICLARM, and the Solomon Islands Fisheries Division are collaborating to determine whether it is possible to establish blacklip pearl oyster farms in other types of coral reef habitats in the Pacific, e.g. the more open lagoon complexes of Solomon Islands.

To answer the question whether there are sufficient wild spats of the blacklip pearl oyster in the open lagoon complexes of Solomon Islands to set up a viable industry, spatial and temporal variations in abundance of blacklip spat over a wide area of Solomon Islands are being measured by collecting spat from three sites in each of five main areas using large numbers of spat collecting bags.

Surveys of the five areas to choose suitable sites for the installation of longlines were made in October and November in conjunction with Provincial Fisheries Officers and local villagers. Materials for building the spat collectors were delivered in November and December, and construction was complete by the end of December. Installation of the longlines is scheduled for January 1994.

Sea Cucumbers (Bêche-de-mer)

As sea cucumbers are fished heavily throughout the Indo-Pacific, there is concern that current levels of harvest may not be sustainable. One way of managing fisheries for these animals in tropical areas for sustained high yields is to enhance stocks by liberating hatchery-reared juveniles, as is currently done for one temperate species of sea cucumbers in Japan.

In 1993, the CAC received a grant from the Australia and Pacific Science Foundation for the initial research on cultivation and fishery enhancement of tropical sea cucumbers. During the year, progress was made in three areas of research related to this subject: documenting the extent and status of the fishery for bêche-de-mer in Solomon Islands, assessing growth of one species of sea cucumber in captivity and experimenting with the larval rearing of another species.

The fishery in Solomon Islands harvests 22 species; the most valuable species are white teatfish (*Holothuria fuscogilva*) and prickly redfish (*Thelonata ananas*). There are no regulations on the exploitation of sea cucumbers in the Solomon Islands. However, the community at Ontong Java, which supplies much of the white teatfish, has a self-imposed management system whereby sea cucumbers are only harvested every second year.

In the absence of data on abundance, growth and mortality, the status of the fishery has to be inferred from the level of exports. Decreased landings, and the increased dependence on species of lower value, indicate that overharvesting may have occurred in recent years in many areas of Solomon Islands. Improved records on the source, species composition and size frequency of the catch will provide a better guide to the need for management.

Growth in Captivity. Surf redfish (*Actinopyga mauritiana*) is a common sea cucumber in the intertidal and shallow sublittoral areas of coral reefs in Solomon Islands. It is easy to collect at low tide, and of moderate value when processed as bêche-de-mer. In August 1993, an experiment was set up in concrete tanks to examine the effect of stocking density on growth and survival of juvenile surf redfish caught from the wild.

The experiment indicated that at densities of one individual per 0.125 m², juvenile surf redfish are capable of averaging a five-fold increase in weight in three months, but that growth is retarded at high densities. The results are encouraging: most previous attempts to rear sea cucumbers in tanks using individuals caught from the wild have recorded decreases in body weight.

Spawning and Larval Rearing. Attempts to induce spawning were made around the full moon in early December. This period coincides with predictable times of mass spawning of many invertebrates on the Great Barrier Reef, including several species of sea cucumber.

Spawning was induced by raising water temperature in the broodstock tanks 3°C above ambient. The animals were then transferred repeatedly for periods of 30 minutes between the heated tank and a tank containing ambient water. After two or three such transfers, male and female white teatfish and lollyfish (*Holothuria atra*), and male elephant trunkfish (*H. axiologu*) shed gametes. Unfortunately, the male and female white teatfish did not spawn on the same days so no fertilized eggs were obtained.

There was synchronous spawning of four female and five male lollyfish, resulting in production of 9.7×10^6 fertilized eggs. There was good survival of larvae up to metamorphosis to the doliolaria stage beginning on day 20. By day 30, all had died, possibly due to deficiencies in nutrition.

Inland Aquatic Resource Systems Program

Network of Tropical Aquaculture Scientists (NTAS), continuous from July 1987

Key Personnel: ICLARM - Ms. Mary Ann P. Bimbao (Network Secretary), Dr. Roger Pullin (*Aquabyte* Editor)

Objectives

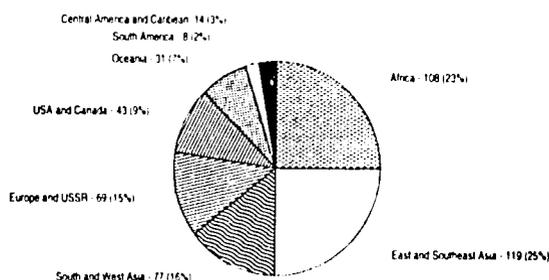
1. To enhance communication among aquaculture scientists working in the tropics, especially in genetics, integrated agriculture-aquaculture farming systems and coastal aquaculture of tropical molluscs.
2. To facilitate increased output by these scientists by assisting in information and database searches, research methods, data analysis and interpretation, and publishing research findings of members in the *Aquabyte* section of *Naga, the ICLARM Quarterly*.

Results

Recognizing the need for NTAS to reexamine itself after five years of operation, a questionnaire was sent out to 579 members in April 1992. The general objective was to solicit members' views on the NTAS and on how to improve its services. The specific objectives were to: compile a list of still active and interested members who wish to continue their membership; reclassify members' fields of research interests; ascertain the extent of communications among members as a result of their NTAS membership and receipt of *Aquabyte*; and identify ways to improve the services of the NTAS and *Aquabyte* to members.

The response to the questionnaire was good: 421 (73%) responded, 418 of whom indicated their desire to continue membership. A new classification of members' fields of research interests, based on 105 descriptors, was obtained. Half of the members' research interests were in biology and ecology; 21% in inland aquatic systems; 13% in methods and tools; 10% in coastal and coral reef systems; and 6% in social science. Many members suggested that *Aquabyte* should include more articles on breakthroughs in aquaculture research and development; expand its scope of subjects; and increase the number of articles, pages per issue and issues per year. Many felt that members should send in more articles on their research work and contribute more to *Aquabyte*. Moreover, it was suggested that NTAS should organize conferences/workshops among members. More details are in the article "The Network of Tropical Aquaculture Scientists (NTAS): Past, Present and Future" published in *Naga, the ICLARM Q.* 16(2-3)21-23 (1993).

The first full NTAS directory was published and distributed to members this year. This directory lists members with their addresses and contact numbers. Members are indexed by institution, by country, and by minor and major fields of research interests.



Regional distribution of NTAS members: 469 members in 79 countries

Asia-Africa Cooperation to Develop Aquaculture Technology

continuous from 1988

Key Personnel: ICLARM - Dr. Roger Pullin, Ms. Catherine Lhomme Binudin

Objectives

- [1] To examine the scope for application of Asian aquaculture principles and practices in Africa.
- [1] To prepare and distribute information relevant to African aquaculture development, especially for francophone African countries.
- [1] To foster interregional cooperation between Africa and Asia for the benefit of aquaculture research and development.

Results

Activities to date have concentrated on helping researchers in francophone Africa, including members of the Network of Tropical Aquaculture Scientists. In 1993, Ms. Catherine Lhomme Binudin, a French national, continued a translation program to assist francophone scientists from western Africa. This is largely an information service and also helps researchers to prepare their results for publication. Ms. Binudin also continued to assist with the preparation of the proceedings of the Third International Symposium on Tilapia in Aquaculture (ISTA III), held in Abidjan, Côte d'Ivoire in November 1991. The proceedings of ISTA III are being edited by French, Ivorian and ICLARM editors and will be copublished in French and English by ICLARM and CIRAD/ORSTOM.

Under this project, a study on the translation activities in other CG centers and major international organizations was conducted and Ms. Binudin attended an international conference on translation in Malaysia. A project to use machine translation at ICLARM was started towards the end of the year.

This year assistance was also extended in the preparation of the French version of FishBase (p. 59) and documentation of several collaborative projects between ICLARM and Sénégal.

Genetic Improvement of Farmed Tilapias (GIFT)-Phase II

1988 to 1991; Phase II, 1993-1997

Cooperating Institutions: The National Freshwater Fisheries Technology Research Center of the Philippine Bureau of Fisheries and Aquatic Resources (NFFTRC/ BFAR); the Freshwater Aquaculture Center of the Central Luzon State University (FAC/CLSU); the Research Outreach Stations of the Philippine Department of Agriculture (ROS/DA); the Philippine Bureau of Agricultural Statistics (BAS); the Institute of Aquaculture Research of Norway (AKVAFORSK) through the Norwegian Center for International Agricultural Development (NORAGRIC/NORAD)

Key Personnel: NFFTRC/BFAR - Mr. Melchor Tayamen, Mr. Ruben Reyes, Mr. Marlon Reyes, Ms. Jodecel Danting, Ms. Edna Dionisio, Ms. Felicisima Longalong, Ms. Teresita Gonzales, Ms. Lilibeth Afan, Mr. Mar Danting; BFAR - a. Freshwater Demonstration Farm, Sto. Domingo, Bay, Laguna - Mr. Orlando Comia; b. Freshwater Fish Farm, San Mateo, Isabela - Mr. Hermogenes Tambalque III; c. La Trinidad Fish Farm, Benguet - Mr. Jesus Astrero; FAC/CLSU - Mr. Ruben Sevilleja, Ms. Remedios Bolivar, Mr. Antonio V. Circa; ROS/DA - a. Region I (Ilocos) - Mr. Rogelio Signey, Mr. Nestor Domenden, Mr. Roy Gonzales, Mr. Vicente Tayamen; b. Region II (Cagayan Valley) - Mr. Gumersindo Lasam, Mr. Hermogenes Tambalque, Mr. Rodolfo Caasi; c. Region III (Central Luzon) - Mr. Renato Bulay, Mr. Wilfredo M. Cruz; d. Region IV (Southern Tagalog) - Mr. Jose Garrido Jr., Mr. Orlando Z. Comia; e. Region V (Bicol) - Ms. Fe Laysa, Mr. Dennis del Socorro, Mr. Rodolfo Villezar; f. CAR (Cordillera Autonomous Region) - Mr. Faustino Maslan, Mr. Jesus M. Astrero; BAS - Dr. Romeo Recide, Ms. Erlinda Ramos, Mr. Juan Miralles; AKVAFORSK - Dr. Trygve Gjedrem, Dr. Hans Bentsen, Dr. Terje Refstie; ICLARM - Dr. Ambekar E. Eknath, Dr. Roger S.V. Pullin, Ms. Belen O. Acosta, Ms. Marietta P. de Vera, Ms. Ravelina R. Velasco, Ms. Carmela Janagap, Mr. Hernando Bolivar, Mr. Gaspar Bimbao, Mr. Divino Rosales, Ms. Ma. Josephine France Rius

Objectives

- (1) To develop improved breeds of tilapia and provide those fish breeds to national testing programs and thence to fish farmers.
- (1) To strengthen national institutions in aquaculture genetics research.
- (1) To establish a mechanism for international exchange and evaluation of improved breeds and research methods.

Results

Selection and Estimation of Genetic Gains. The project's second generation selection experiment to estimate response to selection, genotype by environment interactions between growth performance in ponds, cages, brackishwater and cold water environments; and to test-release genetically improved fish in a wide variety of farming environments initiated in September 1992, was completed in May 1993. A total of 24,500 fingerlings were individually tagged and communally reared for 120 days in six different environments. Replicates of each family were also identified during tagging to analyze the effects of replicates when families were reared separately in cages until tagging.

Due to mass mortality in some ponds and low survival rates in others, the planned analysis of genotype by environment interaction between growth performance in ponds, cages, brackishwater and cold temperature could not be accomplished. However, the on-station earthen ponds provided sufficient data for the estimation of heritability and response to selection.

Heritability estimates for growth performance were similar to those obtained during the previous selection experiment: 0.4 and 0.3, based on sire and dam components, respectively.

Response to selection (based on the growth performance of offspring of selected individuals and those from average breeders from previous generation in earthen ponds) was 14%. When measured on the same units as the first generation selection, this 14% increase would be equal to about 17% increase in growth performance. The accumulated increase in growth performance relative to the base population (i.e., after only two generations of selection) is about 40%.

The comparison between the performance of offspring of selected individuals and the commercial 'Israel' strain was interesting. During the first generation selection experiment, the mean superiority of GIFT fish was about 60% for growth and survival. During generation 2, it was only 20%. This may indicate that offspring from random breeders from the Israel strain are too variable in their performance to serve as a scientific control.

Third generation selection experiments are ongoing. Also an experiment is underway to determine whether communal stocking of control groups (with the selected groups) has any effect on their growth performance and thereby the estimated response to selection.

On-Farm Trials. On-farm trials for comparative growth evaluation of GIFT and the commercial Israel strain were conducted in four provinces located in three regions of Luzon. Across all farms, the GIFT strain was on the average 40% faster growing than the Israel strain.

Growth Performance of Improved Breeds in Ricefields. Experiments on fingerlings of three strains (GIFT, Israel and Sénégal) showed that the GIFT strain had the highest survival (based on % fish recovered) followed by Israel and Sénégal strains. In both separate and communal rearing, there was no significant difference between growth of GIFT and Sénégal strains. In all treatments, the Israeli strain registered poor growth performance.

Genetic Variation for Age at First Spawning. The objective of this experiment is to determine the variation in age at first spawning and to develop techniques for measuring this trait.

A total of 1,000 fingerlings were individually tagged and stocked in two 500-m² earthen ponds in May. Approximately 90 days after stocking, the ponds were drained to determine the condition of all females. Females were scored (0 or 1; based on their spawning condition) and stocked again in the same ponds for subsequent observations. Data analysis is in progress.

Cryopreservation of Tilapia Spermatozoa. A compact cryopreservation unit was established in consultation with Dr. K. Rana of the Institute of Aquaculture, University of Stirling. Cryopreservation of spermatozoa from founder stocks collected from Africa is in progress.

Estimation of Economic Benefits of Improved Breeds. On-farm experiments have so far indicated that it is possible to achieve significantly higher production and income from tilapia farms by shifting to improved breeds developed in the project. To analyze systematically the potential social and economic benefits of using improved breeds, the project initiated a socioeconomic survey of tilapia farming in cooperation with BAS. The survey will be administered in three phases: a) national production and fish farmers' census survey; b) tilapia production economics survey prior to the distribution of improved breeds; and c) production economics survey after distribution of improved breeds.

The first phase of the survey was completed in January 1993. Data are now being edited for analysis. Preparation and pretesting of questionnaires for the phase 2 and phase 3 of the survey are now nearly complete.

Dissemination of Germplasm and Improved Breeds. Dissemination of germplasm assembled in the GIFT project and the improved breeds will be through INGA, which was formally established in July 1993 (see below). Codes of practice for international transfers and quarantine protocols were discussed during an FAO/ICLARM expert consultation from 11 to 13 November 1993.

International Network on Genetics in Aquaculture (INGA). One of the major objectives of the GIFT project (objective 3) has been successfully accomplished with the formal establishment of the INGA in July 1993. The INGA was established following extensive consultations with the national program leaders during UNDP/DGIP-sponsored missions to 10 countries in Africa and Asia from January to July 1993 led by Dr. D.V. Seshu and

during the Network Planning Workshop in July 1993. The 11 founding member countries of INGA are: Bangladesh, China, India, Indonesia, the Philippines, Thailand and Vietnam (Asia); Côte d'Ivoire, Egypt, Ghana and Malawi (Africa). ICLARM coordinates the network. Dr. Seshu has been serving as the INGA Coordinator since September 1993.

The INGA Steering Committee has been formed in accordance with the principles and guidelines established during the Network Planning Workshop. The Steering Committee consists of 12 members (one representative each from the 11 member-countries plus one ICLARM representative). The INGA coordinator serves as the Executive Secretary of the Steering Committee. The first meeting of the Steering Committee will be held in 18-21 May 1994 in Bangkok, Thailand.

Database Management. Designing of data input formats, compilation of routine SAS application programs into a user-friendly software using the Screen Control Language of SAS under its AF module, and development of a complete information system to integrate data handling and processing (a stand-alone GIFTSYS application) were initiated and are now in various stages of completion.

Construction of Dedicated Research Facilities. Selection of a site in the CLSU campus and design of facilities have been completed. Construction will start in March 1994.

Project Reviews. The Project was reviewed by the External Advisory Panel (EAP) and also during the annual Tripartite Review (TPR) in November 1993, both convened by the UNDP/DGIP. The EAP was extremely impressed with the progress of the project and the achievements so far. The EAP has commended the commitment and dedication of the project leader and the staff from collaborating institutions. The constructive criticism and suggestions by the EAP has been extremely useful in prioritization of activities, project organization to enhance productivity, and development of a well-structured workplan for 1994.

Research on the Tilapia Genetic Resources of Ghana for Their Future Conservation and Management in Aquaculture and Fisheries

Planning phase, January - June 1991; project phase, July 1991 - June 1994

Cooperating Institutions: The Institute of Aquatic Biology (IAB) in Accra, Ghana; the Zoological Institute and Museum of the University of Hamburg (ZIM/UH)

Key Personnel: IAB - Dr. Eddie Kofi Abban; ZIM/UH - Dr. Sabine Oberst, Prof. Wolfgang Villwock, Prof. Lothar Renwranz; ICLARM - Dr. Ambekar Eknath, Dr. Roger Pullin

Objectives

- [1] To determine the status of the tilapia genetic resources of Ghana with a view to future conservation of their biodiversity and their management.
- [2] To document the genetic characteristics of tilapia populations in Ghana.
- [3] To demonstrate the use of appropriate methods for such documentation in tropical developing countries.
- [4] To analyze and interpret all the information gained so as to formulate guidelines for the management of fish genetic resources in Ghana and a national breeding program to develop inland aquaculture and to publish these in a form appropriate for use by policymakers, scientists and extension organizations.
- [5] To strengthen the capabilities of IAB and Ghanaian scientists and administrators in fish genetic resources research and management.
- [6] To disseminate results as widely as possible both within Ghana, by means of workshops and written reports, and by publications for wider use by parties concerned with the management of African freshwater fish genetic resources.

Results

During the year, sampling of tilapia populations in principal river basins in Ghana was completed. Species identified were *Oreochromis niloticus*; *Sarotherodon galilaeus galilaeus*, *S.g. multifasciatus*, *S. melanotheron*; *Tilapia busumana*, *T. dageti*, *T. discolor*, *T. guineensis* and *T. zillii*. *O. niloticus* and *S.g. galilaeus* were generally widespread in the Volta system. *S.g. multifasciatus* was found only in Lake Bosomtwi, just as *T. dageti* was restricted to a few portions of the Volta system. *T. busumana* and *T. discolor* were found in Lake Bosomtwi and in the Western coastal rivers (Pra, Ankobra, Tano). *T. guineensis* and *S. melanotheron* were widely distributed in the lower reaches of the coastal rivers. *T. zillii* was found to be widely distributed in all parts of all rivers.

Consistent, unambiguous morphological identification of species could not be achieved. However, by the application of different biochemical and immunological techniques, various genetic markers for all species were identified. Principal among these techniques were starch and polyacrylamide gel electrophoresis as well as isoelectrofocusing. Proteins subjected to electrophoretic analysis were general muscle proteins, parvalbumins and plasma proteins. Band patterns and estimated molecular weights of parvalbumins and plasma, and allele mobilities of general muscle proteins provided most species markers.

Laboratory training of IAB technical staff was consolidated and extended to cover all techniques applied.

RESTORE (formerly FARMBASE), June 1991 - May 1994

Cooperating Institutions: International Institute of Rural Reconstruction (IIRR)

Key Personnel: IIRR - Mr. Nestor Roderno, Mr. Carlos Basilio, Mr. Scott Killough, Dr. Julian Gonsalves; ICLARM - Dr. Clive Lightfoot, Dr. Mark Prein, Mr. Jens Peter Tang Dalsgaard, Ms. Mary Ann Bimbao, Ms. Teresita Lopez, Mr. Farlyz Villanueva, Ms. Grace Coronado

Objectives

To improve the way farmers manage their land and water resources through integration of aquaculture and agriculture.

To develop participatory research procedures for farmers to integrate aquaculture into their farming systems.

To develop participatory research methods for enhancing farmers' natural resource management skills.

To develop an analytical framework, including customized software, for monitoring the impact of integration on households, assess the sustainability of integrated farming systems and provide direct feedback to farmers.

Results

The development of rapid appraisal and farmer participatory procedures for modeling community and farm level natural resource types were continued at the field sites in Cavite, south of Manila. The number of sites increased from two (Pook Paliparan and Kanutuhan) to include a third in Niugan, Dasmariñas municipality. Seven new farmer-cooperators joined the project, increasing the total number to 21. During the latter half of the year, the level of research in Pook Paliparan dropped steadily. Faced with the prospect of surrendering land for industrial and resettlement purposes, the farmers scaled down their agricultural activities and started turning their attention towards alternative sources of income.

The data collected in farming system monitoring transects and bioresource flow models were encoded, entered and analyzed using RESTORE software (Research Tools for Natural Resource Systems Monitoring and Evaluation) which facilitates performance analysis across farming systems and natural resource types. Before and after assessments highlight the benefits that may be derived from diversification and integration through introduction of aquaculture components (e.g., ponds and rice-fish culture) into rice-based farming systems.

Linkages with other graphics software developed in-house facilitate the generation of computerized flow models, transects, performance indicators and time series graphs. Print-outs of models and graphs are useful both for giving feedback to and discussing results with farmers as well as for presenting results to wider audiences.

Investigations are also being conducted into the ecology of integrated farming systems. Using ECOPATH II, a software developed in-house for aquatic ecosystem modeling, description, and analysis, insights into the ecological performance of integrated agriculture-aquaculture systems can be generated. A tentative typology of farming systems, classified along a scale of increasing sustainability, was developed and analysis of various systems types has now begun. Criteria for selection of indices and indicators of sustainability include the ease with which such indicators can be appreciated by both researchers and farmers.

A book was published presenting the background and applications of multivariate statistical methods to aquaculture systems (ICLARM Stud. Rev. 20). Many of the examples use data from integrated aquaculture. The methods used are multiple regression, path analysis, canonical correlation, factor analysis and ANOVA. These can provide additional insights into the growth, production and mortality of cultured fish, compared to conventional approaches to data analysis (e.g., t-test, correlations, linear regressions). Throughout the book, data on tilapia are used, as these are an important group for aquaculture expansion in developing countries.

Integrated Rice-Fish Research, January 1993 - 31 December 1993

Cooperating Institutions: The International Rice Research Institute (IRRI) and its Asian Rice Farming Systems Network (ARFSN); the Freshwater Aquaculture Center of Central Luzon State University (FAC/CLSU), Philippines, Goettingen University, Germany

Key Personnel: IRRI - Dr. V.R. Carangal, Mr. M. Halwart; FAC/CLSU - Ms. Arsenia G. Cagauan, Mr. Ruben C. Sevilleja; ICLARM - Dr. Clive Lightfoot, Dr. Roger Pullin, Mr. Jens Peter Tang Dalsgaard, Ms. Mary Ann Bimbao, Ms. Gesa Horstkotte, Dr. Catalino R. dela Cruz (Consultant)

Objectives

1. To elucidate the feeding ecology and integrated pest management (IPM) aspects of culturing fish in ricefields, including the effects of fish on rice growth.
To develop bioeconomic models of rice-fish systems and to apply these in appropriate Asian countries.

Results

Ricefield Ecology. Additional information, both positive and negative, on the effects of Nile tilapia (*Oreochromis niloticus*) and common carp (*Cyprinus carpio*) on soil fertility and in controlling weeds were obtained from three related experiments. The studies did not show increased rice yield as obtained in previous results.

The abundance of weeds (predominantly grasses and sedges) was 57% lower in plots with fish than in plots without fish. In two trials, the concentration of suspended solids was consistently 42% higher in plots with common carp than in plots without fish. The reduction in oligochaete worm populations in plots with fish was confirmed further. This time, oligochaetes in plots with fish were reduced 50-85% compared to plots without fish. Higher reduction occurred in plots stocked with larger fish (16-17 g) than with smaller fish (5.4-7.4 g).

Gross photosynthesis at the early stage of rice growth (30 days from transplanting) tended to be higher in the presence of fish than in their absence. However, conflicting results were obtained on the effects of fish on soil parameters (e.g., bulk density, pH, total nitrogen and phosphorus).

Rice-Fish Systems Modeling, Methodology Development. Bioresource flow models depicted the extent of available farm resources, prevailing farming systems, the material flows within and interactions among the different farm enterprises, and the respective sizes of rice and rice-fish enterprises. Through the linear programming (LP) technique, the influence of household characteristics on the choice of rice-fish systems was demonstrated. The LP also examined if the system adopted by each farmer was the best option considering individual resource levels (land, labor and capital). Land appeared not to be a constraint among the 15 farmers who participated in this exercise.

The LP analyzed the individual household data of 15 rice-fish farmers in relation to their choices of rice-fish systems (RFS). Although only six groups of rice-fish systems were identified, within each system differences in technology adoption were apparent. Thus, the system practised by each farmer was considered an option. With one farmer practising two systems, data on 16 RFS options were generated through farmer participation. These options were used further in developing arrays of rice-fish options for different farm sizes as a basis in reallocating the areas for rice monoculture and rice-fish culture, and for large-scale dissemination.

The Economics of Integrating Fish into Rice-Based Farming Systems in Asia

July 1992 - September 1995

Cooperating Institutions: Göttingen University (GU), Germany; International Rice Research Institute (IRRI); Antique Integrated Area Development (ANIAD) Foundation, Inc.

Key Personnel: GU - Gesa Horstkotte, Prof. Dr. Hermann Waibel; ICLARM - Dr. Clive Lightfoot; IRRI - Dr. Mahabub Hossain

Objectives

1. To assess the profitability of rice-fish culture in irrigated lowlands for small-scale farmers.
2. To evaluate the potential of fish culture as a vehicle for the introduction of environmentally sound crop technologies.
3. To investigate the impact of Integrated Pest Management on farmers' perceptions of aquatic life.

Results

The current status of research on Aquatic Life Management (ALM) and Integrated Pest Management (IPM) was reviewed and assessed through literature studies and visits to former and current project sites for both rice-fish culture and IPM in the Philippines. Secondary data on ALM and IPM as well as on general rice farming practices in the Philippines were collected from various sources.

Of the once numerous cooperators in the nationwide rice-fish culture program, only 15 could be found in the province of Nueva Ecija. A monitoring system was established with 7 rice-fish farmers in that province to assess weekly activities, labor utilization, input use and food consumption of these farmers. This should give an indication of the profitability of the rice-fish enterprise, its linkages with the whole farming system and the contribution of fish to better nutrition. In Antique province, 15 farmers practicing IPM were monitored following the same criteria, to study the possibility of introducing rice-fish culture there.

Field studies using such methods of farming systems research as semi-structured interviews, key-informant interviews, ecosystem drawings, farm maps and wealth ranking were performed to understand existing farming systems.

A survey of 229 farmers was conducted in Antique Province. This survey evaluates the impact of the IPM training by comparing farmers who were trained with untrained farmers. Topics included general farming practices, pest management, knowledge of the ricefield ecosystem, and perceptions of aquatic life.

The conceptual framework used for exploring complementarities between ALM and IPM is described in a two-dimensional diagram where the optimal path consists of a combination of the two technologies. Results of the survey will be used to develop scales for IPM and ALM. Ranking farmers along these scales will show whether such a relationship exists.

Agricultural Research Project II (Supplement)

May 1989 - June 1993

Cooperating Institutions: Bangladesh Agricultural Research Council (BARC); Fisheries Research Institute (FRI)

Key Personnel: BARC - Dr. A.K.M. Nuruzzaman; FRI - Dr. M.A. Mazid; ICLARM - Dr. Modadugu V. Gupta, Dr. Clive Lightfoot, Dr. Roger S.V. Pullin, Ms. Mary Ann Bimbao

Objectives

The Government of Bangladesh (GOB) is implementing the USAID-funded Agricultural Research Project II (Supplement) for strengthening its National Agricultural Research System to increase domestic food supply, small farm incomes and rural employment. ICLARM is assisting the planning and implementation of the aquaculture research, training and extension.

The objectives of the project with regard to the aquaculture component are:

- (i) To assist the FRI in planning and implementation of aquaculture research.
- (ii) To recommend specific research ideas/technologies that could be incorporated in farming systems research.
- (iii) To provide technical guidance for farming systems research incorporating aquaculture.
- (iv) To assist extension agencies, including nongovernmental organizations (NGOs), in disseminating results to farmers and fishers.

Results

Implementation of the project resulted in evolution of low-cost, sustainable aquaculture technologies. The project provided assistance to national research organizations in (i) aquaculture research planning; (ii) implementation of on-station and farmer participatory on-farm research programs; (iii) development of institutional linkages between government research and development organizations and NGOs; (iv) development of a mechanism for feedback to research from the field; (v) human resources development through on-the-job training to scientists and organizations of in-country and overseas training programs and study tours; and (vi) publication of training and extension manuals. Progress achieved during the implementation period of the project is detailed below.

On-Station Research. Assistance was provided to FRI in implementation of 11 on-station aquaculture research programs in the fields of fish reproduction and hatchery management, nursery pond management and different low-cost integrated fish production systems. These studies resulted in development of nursery management practices wherein survival of fry has been increased to over 75% as compared to 25 to 30% obtained by farmers under traditional practices.

Farmer Participatory Research. Experiments to increase fish production from under- or unutilized ponds and ditches resulted in development of management practices for culture of Nile tilapia and silver barb either in monoculture or in mixed culture. The technologies developed found wide acceptance and are being implemented by different development agencies in the country and over 25,000 farmers have already benefitted, of whom over 40% are women.

Studies on integrating fish culture in farmers' rice fields showed increased rice yields and net profits. Many farmers have adopted the practice.

Assistance was provided to FRI, Bangladesh Agricultural Research Institute (BARI), Bangladesh Jute Research Institute (BJRI) and Bangladesh Sugarcane Research Institute (SRTI) in incorporating aquaculture as a farming activity through farming systems approach. In Tangail, a low-lying floodprone area, farmers were not culturing fish due to risk of losing fish. The research has shown the feasibility of post-flood stocking and pre-flood harvesting

of fish. The farmers are impressed with the yield they are getting, up to 5 t/ha and are culturing fish even in those ponds which get flooded, by erecting a fence around the pond using jute sticks, which are subsequently used as fuel.

Technology Transfer and Feedback to Research. The government's extension department is understaffed and is not in a position to serve all the needs of farmers. On the other hand, a large number of NGOs with grassroots-level workers are involved in fisheries extension, but lack technical skills. The project for the first time in Bangladesh developed close linkages between the government research and development organizations and the NGOs, both in on-farm research, technology dissemination and feedback to research. Collaborative programs were developed through which over 1,200 farmers increased their incomes by an average of 65% through improved aquaculture practices. The program also provides feedback to research of the performance and changes needed in technologies to suit different agroclimatic and aquaecosystems, and problems that need to be addressed by further research. The model developed by the project is being followed by other research organizations. Substantial training was conducted by the project also (Table 2, p. 45).

Socioeconomic Impact of a Fish Culture Extension Program on the Farming Systems of Bangladesh, June 1990 - June 1994

Cooperating Institution: Bangladesh Agricultural Research Council (BARC); Department of Fisheries (DOF), Bangladesh; Fisheries Research Institute (FRI), Bangladesh

Key Personnel: BARC - Dr. A.K.M. Nuruzzaman; DOF - Mr. A.K. Ataur Rahman; FRI - Dr. M.A. Mazid; ICLARM - Dr. Mahfuzuddin Ahmed, Mr. M.A. Rab, Ms. Mary Ann P. Bimbao, Dr. Modadugu V. Gupta, Dr. Clive Lightfoot, Dr. Roger S.V. Pullin

Objectives

The main objective of this project is to assess the socioeconomic impact of extending fish culture (aquaculture) techniques to rural households and communities.

Results

The project team continued to collect and analyze information on pond management including data on input, output, sales and consumption of the fish farmers in the target area (Kapasia thana) and control area (Sreepur thana) in Gazipur district. In addition, an end-project household socioeconomic survey was conducted. Project-assisted extension and training support were continued and expanded to cover more waterbodies such as ponds, ditches, ricefields and small depression areas (beels) with activities ranging from nursery, hatchery and growout operations. The project was able to initiate aquaculture directly in 33.10 ha of ponds and ditches, 43.62 ha of beels and 3.60 ha of ricefields.

Pond Aquaculture Adoption. Three aquaculture technologies (polyculture of carps [rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*), mirror carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*) and bighead carp (*Aristichthys nobilis*)], monoculture of Nile tilapia (*Oreochromis niloticus*) and monoculture of silver barb (*Puntius gonionotus*), which relied mainly on on-farm resources, by-products and wastes of the existing agricultural enterprises of the rural households, were extended to the farmers in Kapasia thana.

A year after the extension program, aquaculture operations became regular practices and new fish species were stocked. Stocking densities, species ratio and composition were followed, though not strictly, as some cooperator farmers stocked other species besides those recommended by the technologies. The number of users and application rates of feeds (rice bran) and fertilizers (organic [chicken and poultry manure, grass, termites] and inorganic [urea, TSP]) increased, although the rates were still below the technology levels. Average annual fish production was 2,196 kg ha⁻¹ which is 3.22 times higher than the pre-project benchmark production level.

Compared to the pre-extension period, a greater proportion (58%) of the fish harvest was sold, particularly carps (78%) and silver barb (65%). For Nile tilapia, bulk (67%) of the harvest was consumed by the operating households.

Extension Services. Most of the components of the extension program pursued in 1992 were continued during the year (see National Research Support, p 42).

The Project extension activities expanded to cover more cooperator farmers in the target thana. The Project also assisted nursery pond operators in order to ensure timely stocking into the ponds of cooperator farmers for the 1993-94 fish growing cycle. Almost 64% of the total fingerling requirements were supplied by the project-assisted nursery operators. Integrated poultry-fish farming was also extended to six of the cooperator farmers.

The Project extension staff continued to assist in post-stocking management of the cooperator farmers. Record keeping books were distributed to 105 selected cooperator farmers to keep detailed records of aquaculture operations for 1993-94. The rest of the cooperator farmers were provided with record keeping cards to document basic data on aquaculture operations. Training and extension activities are summarized in Table 3, p. 45.

Sustainable Aquaculture Development for Poverty Alleviation and Improved Nutrition in Bangladesh, June 1993 - May 1995

Cooperating Institutions: Bangladesh Agricultural Research Council (BARC); Fisheries Research Institute (FRI), Bangladesh

Key Personnel: BARC - Dr. A.K.M. Nuruzzaman; FRI - Dr. M.A. Mazid; ICLARM - Dr. Modadugu V. Gupta, Dr. Clive Lightfoot, Dr. Roger S.V. Pullin, Ms. Mary Ann P. Bimbao

Objectives

The main objective of this project, a followup to the Agricultural Research Project II (Supplement), May 1989-1993, and also funded by the USAID, is to assist the Bangladesh national research institutions in development and dissemination of sustainable, low external input aquaculture practices that integrate with other farming activities.

Results

Polyculture of silver barb (*Puntius gonionotus*), tilapia (*Oreochromis niloticus*), silver carp (*Hypophthalmichthys molitrix*) and mirror carp (*Cyprinus carpio*) in seasonal ponds resulted in fish production as high as 3.4 t ha⁻¹ in six months rearing, using duckweed collected from ricefields and rice bran as supplementary feed. Studies to control fry population in Nile tilapia culture with predatory species *Wallago attu* and *Channa striata* showed promising results compared to tilapia monoculture: tilapia yields increased by 12% and table-size (over 80 g) tilapia harvests increased by 34%.

Integrated Rice-Fish Farming. Twenty-eight rice-fish plots (1,200-8,000 m²) with a fish refuge of 20-160 m², were stocked with fingerlings of either silver barb or mirror carp during *aman* (rainfed) season. After 57-94 days rearing in ricefields, fish production amounted to 102-258 kg ha⁻¹, with an average of 208 kg ha⁻¹. Farmers harvested and shared the fish according to their ricefield areas. Rice yields from plots with fish averaged 3,318 kg ha⁻¹, and 3,228 kg ha⁻¹ from fields without fish.

Studies were undertaken in six plots at the Central Extension Resources Development Institute (CERDI) in collaboration with an integrated Pest Management (IPM) Program, to assess the effect of integrated rice-fish farming on pest management, rice yields and economics. All plots (two control, two with IPM and two with fish) were infested with case worm (*Nymphula depunctali*), yellow stem borer (*Scirpophaga incertulas*), rice bug (*Leptocoris acuta*) and green leaf hopper (*Nephotettix nigropictus*). While control plots were sprayed with Diazinon-60EC, no pesticide was used in IPM and integrated rice-fish plots. At harvest, rice production amounted to 3,103, 3,184 and 3,697 kg ha⁻¹ from control, IPM and integrated plots respectively, showing integration as a way of increasing production and income without pesticides.

Involvement of Women in Aquaculture. One hundred women were trained in fish culture in seasonal ponds and ditches, using on-farm resources. Of these, 52 were undertaking fish culture with very low production, while others indicated lack of fish culture knowledge as constraint for not yet taking up aquaculture.

Development of Institutional Linkages between NGOs and Government Organizations. A one-day workshop entitled "Strategies for Aquaculture Development Through NGOs" was organized, with 55 participants from nongovernment and government organizations. The workshop stressed the need for closer linkages between government research and development organizations and the NGOs for identification of problems that need to be resolved through research and speedier dissemination of research results.

Research for the Future Development of Aquaculture in Ghana

June 1991 to May 1993, extended until May 1994

Cooperating Institutions: Institute of Aquatic Biology (IAB), CSIR, Ghana; Ghana Rural Reconstruction Movement (GhRRM), Ghana; International Institute for Rural Reconstruction (IIRR), Philippines; Institute of Renewable Natural Resources (IRNR), University of Science and Technology, Ghana

Key Personnel: IAB - Mr. Joseph Ofori, Mr. Ambrose Asamoah; GhRRM - Mr. David Y. Owusu, Mr. Alex Baah; IRNR - Mr. Alfred Dassah, Mr. Francis Ulzen-Appiah, Mr. Henry Bulley, Ms. Beatrice Fiawatsror; IIRR - Dr. Isaac Bekalo, Dr. Julian Gonsalves, Mr. Scott Killough; ICLARM - Dr. Mark Prein, Dr. Clive Lightfoot, Dr. Roger Pullin, Ms. Grace Coronado

Objectives

- To make firm recommendations for future aquaculture development in Ghana, especially for those species and systems appropriate to small-scale farmers.
- To provide guidelines for similar work in other countries, i.e., a comprehensive integrated approach to aquaculture development.
- To develop microcomputer software for use in such activities.
- To train Ghanaian personnel in these methods and approaches.
- To publish the results of this work and to disseminate these widely in Ghana, other developing countries and to agencies and institutions with interests in aquaculture development, particularly those working for African development.

Results

The project is based on an analytical framework with a focus on smallholder farmers. This research framework is new in that it gives much consideration to existing information from previous studies, government statistics, and available knowledge, combined with farmer-participatory research, on-station experiments, and in-country rapid appraisals of farming systems in the different agroecological zones of Ghana. The framework also adopts a resource system approach, in which the unit of investigation is the indigenous natural resource.

A study of the past initiatives for aquaculture development revealed that practically none have been successful, due to top-down approaches without consideration of existing socioeconomic and biotechnical constraints. The most appropriate areas for aquaculture development in Ghana are located in the southern half of the country, where annual rainfall exceeds evaporation, and farming practices allow the integration of a pond into their activities. Limitations were identified through rapid rural appraisal techniques as to soil quality and farmer access to lowland areas where ponds can be sited next to streams.

Surveys outlined the socioeconomic characteristics and related gender issues on resource-poor farm households. Constraints of cash, labor and land availability, as well as cultural traditions were studied based on secondary information. No direct limitations to fish culture were identified. The high preference of Ghanaians for fish as the main source of animal protein in their diet (approximately 70%) is underlined by a theoretical per-caput fish consumption of 23 kg·year⁻¹ as of 1992. Fish size is of minor importance to the rural consumers.

Farmer participatory on-farm experiments with a group of farmers in Mampong Valley, Akuapem, were successful, indicating that farmers understand the benefits of integration, nutrient recycling, and enterprise diversification. Farmers themselves decided on design and extent of integration with fishponds and vegetables. In financial terms, the benefits of these systems came only to a minor extent from the fish produced. The major returns came from the vegetables grown on dikes and adjacent beds which were made possible with fertile

water from the ponds. A direct benefit came in the form of 40-50 kg of fresh fish per year for the farmer's family from a small pond.

Trials with rice-fish culture in irrigation schemes in the northern arid zone of Ghana, which were initiated by the project, were successful and aroused farmer interest.

The project cooperated successfully with a local NGO, the Ghana Rural Reconstruction Movement (GhRRM), based in Mampong Valley, Akuapem. The main advantages of the cooperation were the grassroots contact maintained with the farmers and the knowledge of the particular characteristics of the area.

The prevailing human ecological context factors in Ghana were described, outlining the degraded state of the environment (deforestation, erosion, soil nutrient depletion), the high rate of population increase ($2.6\% \cdot \text{year}^{-1}$), and the extent of malnutrition.

The potential impact of integrated agriculture-aquaculture systems on sustainable farming practices in Ghana was outlined, based on results of the research conducted with a set of farmer-adopters in the Mampong Valley. Benefits were shown in terms of production, economics, and in terms of sustainability indices computed from data collected from the monitoring of farmer experiments, as analyzed with computer software developed at ICLARM. It was estimated that the adoption of integration on a wider basis in Ghana has potential for improvement of food supply and farm income. It was shown that, given the existing human ecological context factors in Ghana, changes in agricultural practices are of highest importance, if the growing population is to be fed from the continuously degraded land in the future. Integrated agriculture-aquaculture systems offer a viable means to counteract this threat.

In the course of the project, two important subjects of future research were identified. These are necessary in order to provide more precise information on which to base future recommendations for an integrated agriculture-aquaculture development strategy for Ghana: (a) research on the nutritional demand of farm households in Ghana to assess the areas of highest impact, and (b) farmer-participatory research of the formulation of guidelines for cost-effective methods for rapid spread of integrated agriculture-aquaculture among smallholder farmers in Ghana.

A workshop was held in Accra from 13 to 15 March 1993, presenting the results obtained so far by the project. The workshop was attended by Ghanaian and international scientists, fisheries officers, and by policymakers for research and development in Ghana. Results of farmer-participatory research work were demonstrated on a field trip to Mampong where workshop participants had the opportunity to interview farmers and see the different levels of adoption.

Aquaculture Development in Africa: Learning from the Past and Implementing Research Results on Small-Scale Farms

Planning phase, November 1985-April 1986; Startup phase, May 1986-October 1986; Main Project, November 1986-October 1991; Current Extension to October 1994.

Cooperating Institutions: Malaŵi Fisheries Department (FD), Malaŵi Department of Research and Environmental Affairs (DREA), University of Malaŵi (UM), Malaŵi-German Fisheries and Aquaculture Development Project (MAGFAD), Central and Northern Regions Fish Farming Project (CNRFFP), Aquaculture for Local Community Development (ALCOM/FAO), Swedish Agency for Research Cooperation with Developing Countries (SAREC), University of Hawaii (UH).

Key Personnel: FD - Mr. Boniface Mkoko, Mr. Sloans Chimatiro, Mr. Emmanuel Kaunda, Mr. Tony Mahango, Mr. Kennedy Katambalika; DREA - Mr. Orton Msiska; UM - Dr. Sosten Chiotha, Dr. Emmanuel Fabiano, Dr. Elenemo Khonga; MAGFAD - Dr. Thomas Gloerfelt-Tarp, Mr. Achim Janke, Ms. Olivia Liwewe; CNRFFP - Mr. Alan Brooks, Mr. Alfred Maluwa; ALCOM - Mr. Boyd Haight, Ms. Sevaly Sen, Ms. Monique Maes; SAREC - Mr. Niklas Mattson; UH - Mr. Mark Amechi; ICLARM - Dr. Randall Brummett, Dr. Reg Noble, Mr. Daniel Jamu, Mr. Fredson Chikafumbwa, Ms. Emma Kambewa, Ms. Chipo Jamu, Dr. Roger Pullin, Dr. Clive Lightfoot, Dr. Eric Worby, Mr. Jens Peter Tang Daalsgard

Objectives

- To develop, through collaborative research conducted at Malaŵi's National Aquaculture Center (NAC) with African biological and social scientists, aquaculture technologies appropriate to the prevailing conditions in rural Africa.
- To strengthen aquaculture research, training and extension through information exchange and research collaboration with African institutions.
- To assess the constraints to, potential for, and impact of, low-input integrated aquaculture by conducting on-farm, farmer-participatory research and development.

Results

New technologies continue to be developed at the Malaŵi National Aquaculture Center (NAC) for use by African smallholding foodfish and fingerling producers. In collaboration with the Malaŵi Fisheries Department, several indigenous barbs that are popular foodfish are being tested as potential polyculture species with the locally well-established *Oreochromis shiranus*. This research was suggested by the farmers themselves. Biological studies on the food habits of *Barbus trimaculatus* and *B. paludinosus* have shown that the former concentrates on phytoplankton and diatoms, while the latter shows a strong preference for microcrustaceans. Although final results are not yet in, *B. paludinosus* appears to be performing better in polyculture than *B. trimaculatus*, presumably because the *B. trimaculatus* is competing directly for food with another phytoplanktivore, *O. shiranus*, while the zooplanktivorous *B. paludinosus* is complementing *O. shiranus* by taking advantage of previously unused zooplankton and reducing microcrustacean grazing on phytoplankton. On the other hand, *B. trimaculatus* is much easier to handle and transport than the extremely fragile *B. paludinosus*. Management recommendations for smallholders are now being formulated.

Understanding the trophic and nutrient dynamics of small pond ecosystems is essential to making good management decisions. Food habit studies on the indigenous *O. shiranus* and *Tilapia rendalli* revealed significant ontogenetic shifts in food preference for both species. As with other oreochromines, *O. shiranus* switches from being highly omnivorous to primarily phytoplanktivorous during the juvenile to adult transition. Interestingly, this food transition appears to occur at a much smaller size in ponds (<2 cm) than in the wild (10-15 cm), paralleling the earlier sexual maturation observed in ponds. *T. rendalli* is also quite

omnivorous as a juvenile, only adopting the diet of macrophytes widely reported for it at a size of about 15 cm. The significance of these findings for the stocking and management of low-input ponds is being evaluated.

Trophic dynamics were also addressed through collaborative research with the University of Malaŵi, University of Hawaii and SAREC. Students from these institutions worked to assay the natural food resources in low-input ponds and relate them to management. This dataset will also be used in the development of protocols for introducing new indigenous fish species into low-input aquaculture. This work will continue into the new year with an expanded list of collaborators.

Another part of the project's work on the ecological functioning of small fishponds was research on nutrient cycles. Various combinations of locally available material (*Leucaena* spp., maize bran, waste vegetables and napier grass) were tested in fish growth trials and the cycling of nitrogen and dry matter monitored and quantified. Data from this study will be used by one of the project's research associates in a Rockefeller-financed PhD program on modeling of nutrient dynamics in integrated systems at the University of California, Davis.

Linking the nutrient dynamics and on-farm research activities was a continuation of research aimed at the development of biotechnical methods for the integration of aquaculture into existing farming systems. As a direct result of project activities, integrated rice-fish farming is now a widely adopted practice in Zomba District, Malaŵi. In 1993, two cycles of rice-fish research/demonstration were conducted at the NAC. In addition to improving fish yields, farmer-led research this year has brought rice yields in integrated systems from the previous 1.5 t·ha⁻¹ up to almost 4 t·ha⁻¹ (the Government of Malaŵi's target) and has overcome the problems associated with otter predation, but environmental constraints continue to limit the further expansion of this technology. Wet season flooding and associated fish escape tend to reduce the fish harvest, while the concentration of rice among relatively few farmers in the dry season also concentrates the rice birds and reduces rice harvest.

The constraints to, and potential of, the use of integrated aquaculture as a rural development tool were extensively studied. Exhaustive input, management and socioeconomic data were collected from eight cooperative farmers. It was learned that the introduction of a small pond into the existing farming system, if done in partnership with the farmers, can lead to very significant improvements in overall farm productivity, efficiency and profitability. The results of this research are being formulated for use by rural development planners and extension agents.

As a result of the above work, new methods for conducting on-farm experimentation were devised. A new computer software application developed by the project (PondSim) takes data collected on-farm and from the laboratory and uses them to help researchers formulate management strategies which simulate, on the experiment station, actual conditions on the farm. This adds a new dimension to small pond aquaculture research by substantially improving the usability by smallholders of station-generated technology.

Several other research projects which will be completed in 1994 were started. New aquaculture options for smallholders who have access only to rainwater for pond filling are being devised in station-controlled on-farm study with four farmers using the methodology just described. In collaboration with Fisheries Department technicians, new approaches to the problems faced by would-be tilapia fingerling producers are also being addressed. Stocking rates and sex-ratios of *O. shiranus*, and different *T. rendalli* fingerling harvesting intervals are being compared in order to make management recommendations to farmers with undrainable brood ponds, no holding facilities and no nets. Complementing research on genetic drift in small ponds are being carried out by researchers at the University of Malaŵi. ICIARM commenced a multiple-year study of the effects of traditional pond management strategies on fish growth, fecundity and catchability.

The project also undertook much national strengthening (see p. 42).

ANNEX 2

ICLARM Staff

OFFICE OF THE DIRECTOR GENERAL

| | |
|-----------------------------|-----------------------------------|
| Kenneth T. MacKay, PhD | Director General (until 22 April) |
| Laurence D. Stifel, PhD | Director General (since 8 July) |
| Josephine Z. Hernandez, BS | Executive Assistant |
| Aurea T. Dimaunahan, AB | Clerk/Typist |
| Milagros D. Inquig, AB | Clerk/Typist |
| Sten Sverdrup-Jensen, MS | Consultant (MTP Preparation) |
| Ma. Concesa C. Gayanilo, BS | Secretary |

COASTAL & CORAL REEF RESOURCE SYSTEMS PROGRAM

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|-------------------------|---------------------|
| John L. Munro, PhD | Director |
| Jose E. Padilla, PhD | Postdoctoral Fellow |
| Miriam C. Balgos, MS | Research Associate |
| Geraldine A. Gilera, AB | Secretary |

Tropical Fish Stock Assessment

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| Annabelle C. Trinidad, MA | Research Associate |
| Eliseo H. Garnace, BS | Programmer |
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Multispecies Modeling

| | |
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Development of a Database on Fisheries Resources (FISHBASE)

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| Jalme Mendoza, PhD | Consultant |
| Maria Lourdes D. Palomares, PhD | Postdoctoral Fellow |
| Liza Q. Agustin, MS | Research Assistant |
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| Armi G. Torres, BS | Research Assistant |
| Rachel C. Atanacio | Artist |
| Roberto N. Cada | Artist |
| Ma. Teresa G. Cruz, BS | Secretary |

**Aquaculture and Resource Enhancement
in Coral Reef Ecosystems, Solomon Islands**

| | |
|--------------------------------------|--|
| Johann D. Bell, PhD | Senior Scientist/Officer-in-Charge (since 27 March) |
| John L. Munro, PhD | Director (until 1 April) |
| Patricia Munro, PhD | Affiliate Research Scientist |
| Mark Gervis, MSc | Manager |
| Idris Lane, MSc | Assistant Manager |
| Cletus Oenggepa, BSc | Assistant Manager |
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| Veronica Wickham | Administrative Supervisor |
| Stephanie Pallay, BBus (Comm.) | Administrative Assistant |
| Rüdiger Röttgers, B.Sc | Affiliate Scientific Assistant |
| Alexandra Holland, BSc | Scientific Assistant |
| Stephan Soule, BSc | Affiliate Scientific Assistant |
| Kimberlee Forbes, BSc | Scientific Assistant |
| Robert A. Jimmy, A. Dip. | Research Assistant |
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| Gideon A. Tiroba, A. Dip. | Affiliate Research Assistant, GSI |
| Francis D. Tofuakalo, D. Trop. Fish. | Affiliate Research Assistant, GSI |
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| Martin Uikaria | Research Aide |
| Dick Tavake | Senior Artisan |
| John Suli | Foreman/Caretaker |
| Benson Kalea | Foreman/Caretaker |
| Maxwell Sau | Senior Technical Aide |
| Andrew Peli | Senior Technical Aide |
| Joseph Boraule | Technical Aide |
| Alfred Lau | Technical Aide |
| Henry Rota | Technical Aide |
| Paul Mercy | Technical Aide |
| Joseph Olisia | Technical Aide |
| Roland Jimmy | Technical Aide |
| Mason Tauku | Technical Aide |
| Thomas Teltoi | Technical Aide |
| Rimon Teun | Trainee Technical Aide |
| Moana Pelu | Administrative Aide |
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**Socioeconomic Valuation of Coastal
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The Fish Resources of Western Indonesia: a Baseline Study of Biodiversity

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Resource and Ecological Assessment of San Miguel Bay, Philippines

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Research Cooperation between IMBO and ICLARM on the Establishment of a Fishery Database for the Development and Management of the National Fisheries off Sierra Leone

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Aquaculture Development in Africa: Learning from the Past and Implementing Research Results on Small-Scale Farms, Malaŵi

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Socioeconomic Impact of a Fish Culture Extension Program on the Farming Systems of Bangladesh

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