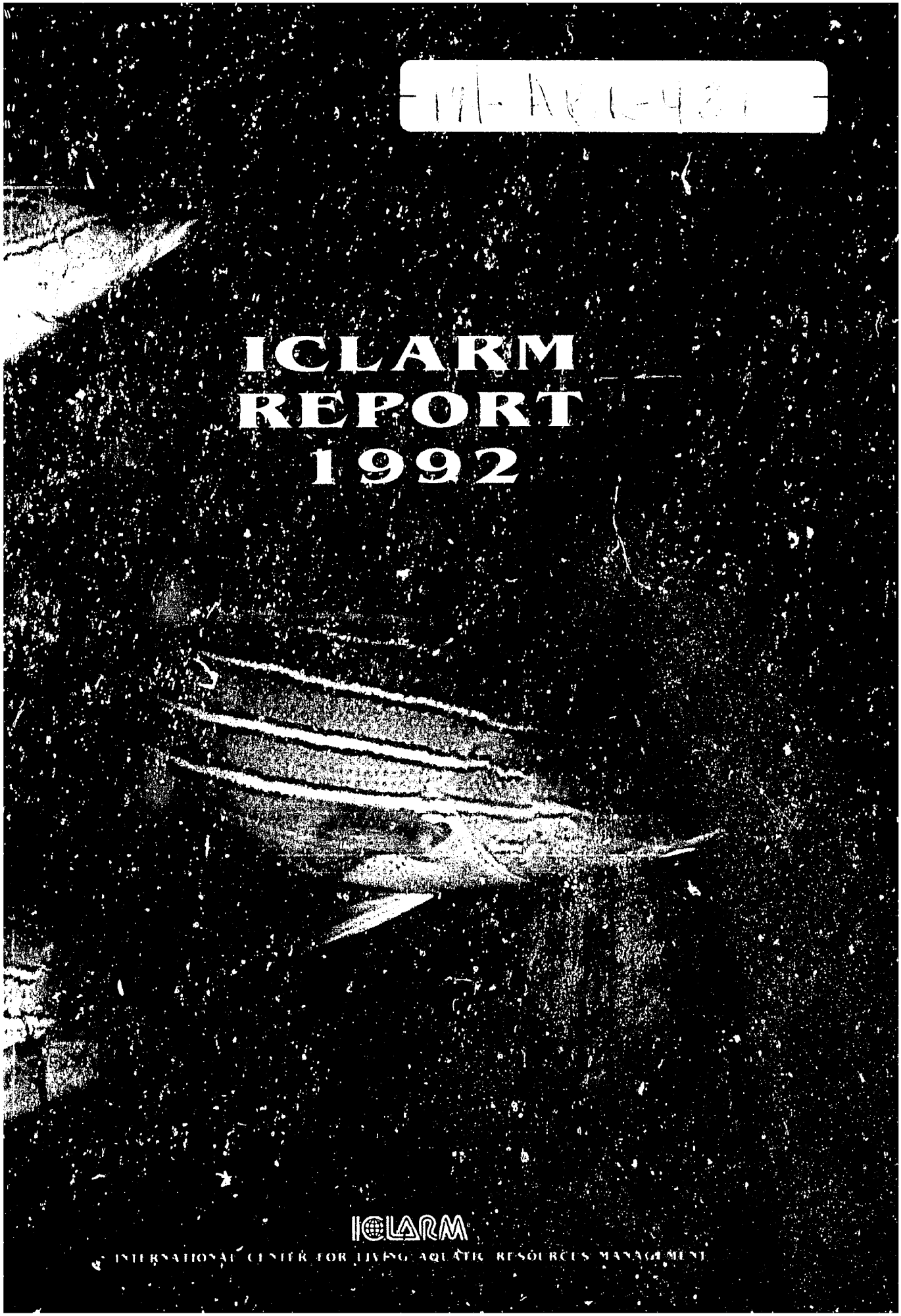
ICLARM REPORT 1992



ICLARM
INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

ICLARM REPORT 1992

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INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

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Foreword

A momentous year for ICLARM, 1992 saw an external program and management review by the Consultative Group on International Agricultural Research (CGIAR) in January, completion of the Center's strategic planning in March, admission into the CGIAR system in May and subsequent development of a Mid-Term Plan for the years 1994-1998. The mid-term planning work was still occupying staff time at the end of the year.

That so much research and related activities were nevertheless carried out as reported herein is a tribute to the dedication of staff at all levels to ICLARM and its social purpose, a feature of the Center well recognized by the external review team.

The concentration on planning, particularly for 1994-1998, has made 1992 the beginning of a transitional period for the Center. The report herein reflects this transitional nature by departing from the traditional focus on project activities. Instead it describes some of the research themes, their background and how they fit together towards aquatic resources management.

As this report of ICLARM's activities during 1992 was being prepared for publication, we were very pleased and fortunate to be able to announce that Dr. Meryl Williams, outstanding Australian scientist, was appointed Director General of the Center, effective April 1994.

We believe that ICLARM, in its new role as a CGIAR center and with a new dynamic leader, is well placed to fulfill its international mandate in aquatic resources research.

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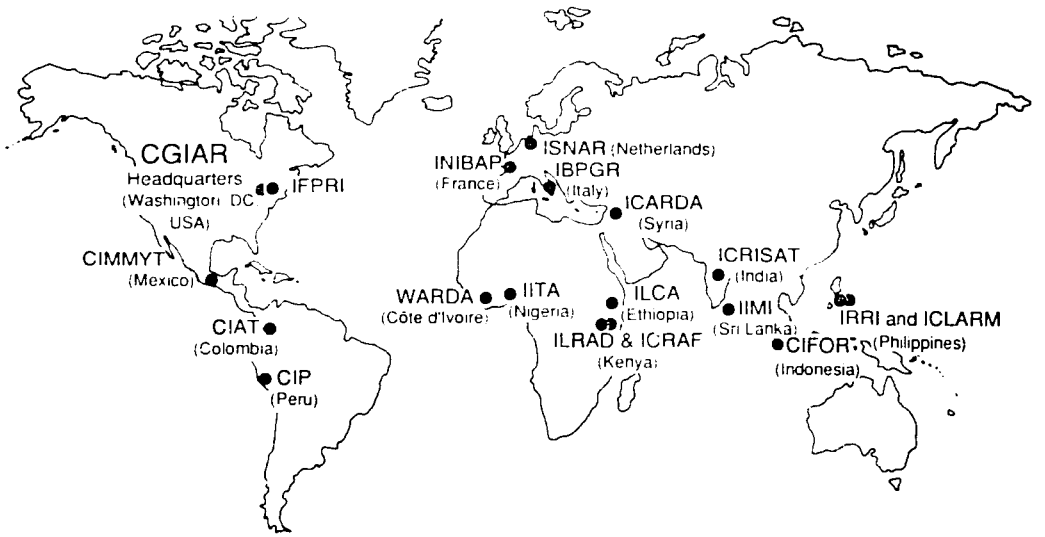
Details of Board membership and committees are on p. 30-34.

*Retiring Board members
**New Board members
***Resigning to join the Technical Advisory Committee of the CGIAR

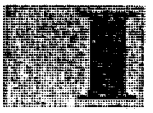
The Consultative Group on International Agricultural Research (CGIAR) is an informal association of 41 public and private sector donors that supports a network of 18 international agricultural research centers. The group was established in 1971.

Consultative Group on International Agricultural Research (CGIAR) Centers



CIAT - Centro Internacional de Agricultura Tropical
CIMMYT - Centro Internacional de Mejoramiento de Maiz y Trigo
CIFOR - Center for International Forestry Research
CIP - Centro Internacional de la Papa
IBPGR - International Board for Plant Genetic Resources
ICARDA - International Center for Agricultural Research in the Dry Areas
ICLARM - International Center for Living Aquatic Resources Management
ICRAF - International Council for Research in Agroforestry
ICRISAT - International Crops Research Institute for the Semi-Arid Tropics
IFPRI - International Food Policy Research Institute
IIMI - International Irrigation Management Institute
IITA - International Institute of Tropical Agriculture
ILCA - International Livestock Center for Africa
ILRAD - International Laboratory for Research on Animal Diseases
INIBAP - International Network for the Improvement of Banana and Plantain
IRRI - International Rice Research Institute
ISNAR - International Service for National Agricultural Research
WARDA - West Africa Rice Development Association

ICLARM'S STRATEGY FOR INTERNATIONAL RESEARCH ON LIVING AQUATIC RESOURCES MANAGEMENT



n 1992, ICLARM published a Strategic Plan for its future international, strategic fisheries research. The Plan was developed at the request of the Consultative Group on International Agricultural Research (CGIAR - see opposite page) which had invited ICLARM to join the Group conditional upon developing a Plan acceptable to the Group.

One outcome of the Plan was a redefining of ICLARM's goal and objectives from the broad "Statement of Purpose" shown in previous Reports, to the following:

Goal

Improved production and management of fisheries resources for sustainable benefits of present and future generations of low-income users in developing countries.

Objectives

Through international research and related activities, and in partnership with NARS (National Aquatic Research Systems), to:

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

Below is a summary of the Plan and its development.

Rationale

Aquatic resources are important for livelihood and consumption. Fish, including finfish, crustaceans, molluscs and seaweeds, are the fifth most important agricultural commodity. Developing countries catch and produce 52 million tonnes annually, over half of the world production. At least 50 million persons are involved in small-scale fisheries.

There have been substantial increases in fisheries catches (35%) and aquaculture (100%) in the past decade. This, however, is misleading as it reflects exploitation of new stocks, heavy fishing pressure on previously fished stocks and a large increase in aquaculture in one country, China. A close examination reveals that most developing-country fisheries have levelled off or are declining. Their sustainability is threatened by overfishing, destructive fishing practices and land-based pollution. In aquaculture, major increases have occurred nowhere other than in China. In spite of these issues, there has been only limited international research effort directed to aquatic resources.

That there is a need for concerted research effort directed to aquatic resources for the benefit of low-income producers and consumers in developing countries was recognized as early as 1971 by the CGIAR but it was not until 1990 that they endorsed the recommendation by the Group's Technical Advisory Committee (TAC) to include fisheries research and invited ICLARM to develop a strategic plan as part of the process of ICLARM joining the CGIAR.

Process

The planning process involved all ICLARM professional staff, the ICLARM Board, and some 150 managers and scientists from other institutions.

ICLARM planning was facilitated by recent studies by the TAC, the International Development Research Centre (IDRC) and the Study of International Fisheries Research Needs for Developing Countries (SIFR). The SIFR reports were particularly useful as they included the findings of several task forces and missions to various regions of the developing world.

A resource system approach was developed to assist in setting priorities for research. Seven resource systems which reflect the aquatic habitats and the people who rely on the resource have been used. They are similar in concept to agroecological zones used in agriculture. The freshwater systems are ponds (including ricefields); reservoirs and lakes; and streams, rivers and floodplains; and in the marine systems, estuaries and lagoons; coral reefs; soft-bottom shelves; and upwelling area shelves.

The analysis showed that future gains in capture fisheries are possible, especially in coral reefs, upwelling areas and reservoirs. In coastal fisheries, a major concern will be sustaining them at present levels in the face of pollution and competing coastal resource users. Gains are also possible in aquaculture and enhanced fisheries in ponds, lakes and reservoirs.

Indications are that even without intersectoral conflict, the rate of increase in fish supply will not keep up with projected demand. The supply gap will be further challenged by those factors outside the sector: human population growth, domestic and industrial pollution, competing demands for the same resources, erosion and siltation from unsustainable agricultural and forestry practices, and the overriding but unknown consequence of global climate change. While difficult to predict, the

impact of these changes will be to reduce potential growth in fisheries resulting in an increased supply gap.

To decrease the supply gap will require concentrated strategic research. The research must help improve the management and sustainability of current fisheries and establish the biological and social basis for increased aquaculture and enhanced fisheries potential.

The research must focus on the interaction between populations of fish and humans. In addition, the guiding principles must be concern for gender, equity, sustainability, participation of users and a systems approach.

Thus, the priority for research in each resource system was derived by taking into account not only potential for gain but also "modifiers" as used recently by TAC - threats to sustainability and equity. Priorities were assessed on a regional basis.

Research Priorities

The seven emerging priority issues for ICLARM's international research using these criteria are:

- Sustainability of coastal fisheries systems
- Improved management of coral reef fisheries
- Improved fish productivity through genetics and husbandry
- Removal of socioeconomic and environmental constraints to aquaculture growth
- Development of farming systems
- Assessing and developing the potential for enhanced fisheries
- Strengthening of national research systems

Asia is to receive the highest priority for research and related activities, followed by SubSaharan Africa, Latin America/Caribbean and West Asia/North Africa.

Using the activity types of TAC, the types of research activities and their proportions to address the priority research issues above were determined to be:

Resource conservation and management	35%
Fish productivity	25%
Social sciences	20%
Institution building	20%

An assessment of the priority for each research type in the various resource systems concluded that the research will focus in ponds, estuaries and lagoons, and coral reefs.

Programs

The focus on resource systems provided the basis for research programs. There will be three research programs:

- Inland Aquatic Resource Systems (focusing on ponds)

- Coastal Resource Systems (focusing on estuaries, lagoons)
- Coral Reef Resource Systems (focusing on coral reefs)

This program structure allows a high degree of integration, with common themes and methodology underlying clear discrete thrusts to respond to the seven international research issues noted above.

A fourth program, National Research Support, will provide a strong institutional building role for ICLARM. Closely linked to the research programs, it will often rely on their output for NARS strengthening activities.

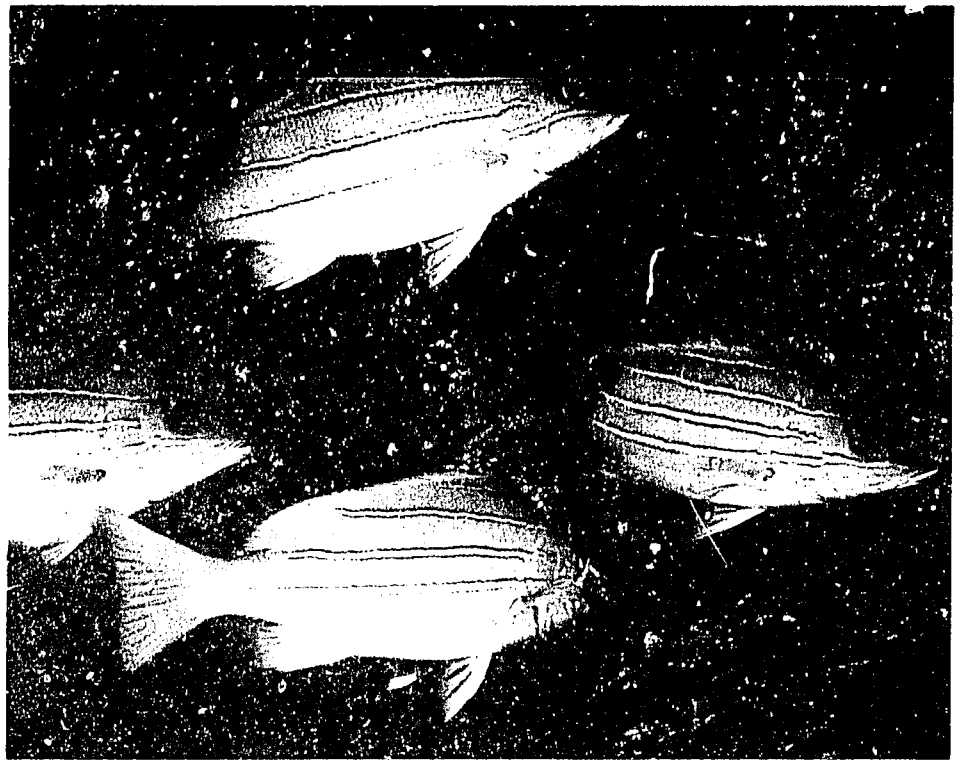
The Inland Aquatic Resource Systems Program will direct its research activities towards the adoption of sustainable inland aquaculture by resource-poor small-scale producers in three thrusts: improved fish productivity through genetic gain and better husbandry; development of integrated agriculture-aquaculture farming systems; and removal of socioeconomic and environmental constraints to aquaculture development.

The Coastal Resource Systems Program has a clear focus on the sustainability of coastal aquatic resource use. The Program aims to improve the biological, socioeconomic and institutional management mechanisms for sustainable use of coastal resource systems, involving both intra- and intersectoral issues. The Program will accomplish this by: understanding the dynamics of the resources; developing management strategies for the resources; and seeking to integrate management strategies into generalizable management options and policy recommendations compatible with sustainable coastal resource use.

The Coral Reef Resource Systems Program will focus on the sustainable utilization of the reef resources for the benefit of the adjacent coastal communities. This will be accomplished by addressing thrusts in: developing aquaculture and enhanced fisheries systems for coastal communities; understanding the interaction between people and the reef resources; and developing sustainable fisheries management systems suitable for coastal communities.

The National Research Support Program is designed to strengthen NARS through: information (publications, workshops, conferences); training (focusing on researchers); and assisting in priority setting of NARS research policy and research management.

The impact from these research and related activities on fisheries will be: improved fisheries management leading to sustainable increases in fisheries catches; increased aquaculture and enhanced fisheries production; and stronger national programs able to continue the research efforts for the benefit of low-income producers and consumers in developing countries.



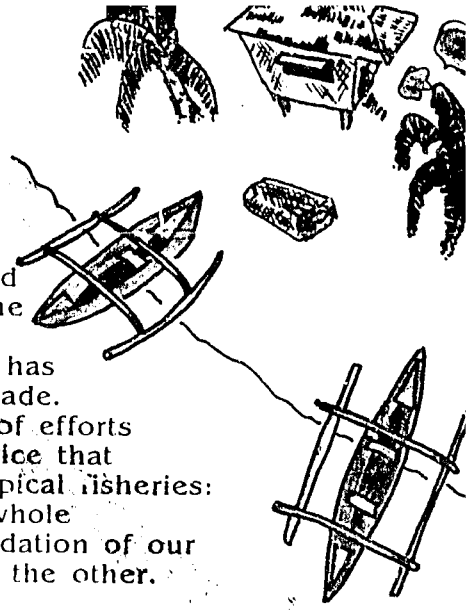
FROM FISHERIES TO AQUATIC RESOURCES

ICLARM's research covers a broad spectrum of topics on aquatic and coastal resources. Most deal with aspects of managing the resources, through first understanding their dynamics, especially by models; through breeding programs and improved farming systems for cultured species; and through understanding the social, economic and institutional context of aquatic resource use.

For administrative purposes, the work is presently divided into three research programs - Coastal Area Management, Capture Fisheries Management, and Aquaculture - with a supporting Information Program.

As noted above in the summary of ICLARM's Strategic Plan, the Center's future research will focus on several aquatic resource systems and the program names will reflect those resource systems.

For this transitional report, we highlight aspects of the Center's research under rather different categories, which reflect common questions about ICLARM's role and features that have not been emphasized in our previous program-based reports.



Towards An Understanding of Tropical Fisheries

Underpinning any decision on aquatic resources management is the need for knowledge of the sustainable yields the resources can provide. In the tropics, the numbers do not come easily and ICLARM has been addressing this issue for over a decade.

In 1992, there was a continuation of efforts on two fronts to improve the level of advice that biologists can provide to managers of tropical fisheries: a broadening of perspective to embrace whole ecosystems on the one hand, and consolidation of our knowledge of individual fish resources on the other.

The Aquatic Numbers Game

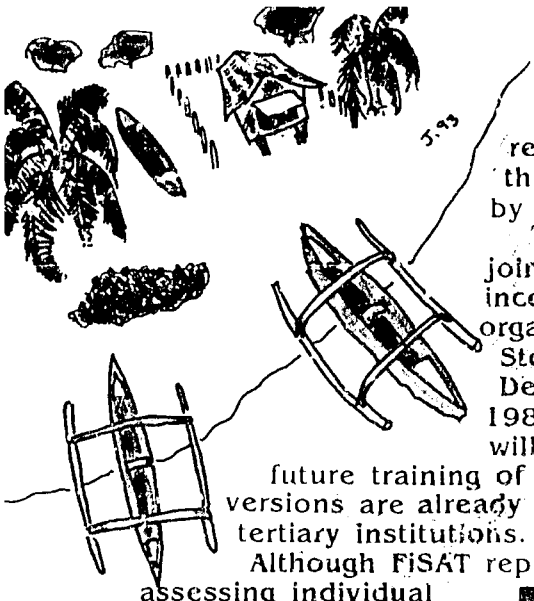
You have a large estate with thousands of livestock scattered over the land. How many or what weight of produce can you obtain each year without gradually depleting the stock? To find out, one simply needs to know their birth, growth and mortality rates, easily determined by observation.

Now imagine making the calculations when you cannot see the animals on the estate. That is the situation for fisheries scientists. They can only see relatively minute samples of the stocks after they are caught - by traps and nets that are size selective. The samples are thus not very representative at all.

In the tropics, where ICLARM's research is centered, there are a few other complications. While our large estate in temperate areas would contain only a handful of important species, in the tropics there is a whole zoo! For example, hundreds of species make up a tropical trawl fishery. And one cannot easily tell the age of tropical fish, unlike their temperate counterparts.

ICLARM has pioneered methods to deal with this problem by using size (length) rather than age of fish as a basis of estimations. The manuals and software that have resulted from the research are used in many countries, both tropical and temperate. For the

Tropical trawl fisheries involve hundreds of species.



relatively short-lived fish of the tropics, the methods give information required by our hypothetical estate owner.

The culmination of this work is a joint FAO-ICLARM set of software incorporating routines from both organizations, called FiSAT: FAO-ICLARM Stock Assessment Tools (p. 79). Development of this software began in 1989 and continued through 1992. It will be used by FAO and ICLARM in all future training of scientists in stock assessment. Early versions are already being used by students in several tertiary institutions.

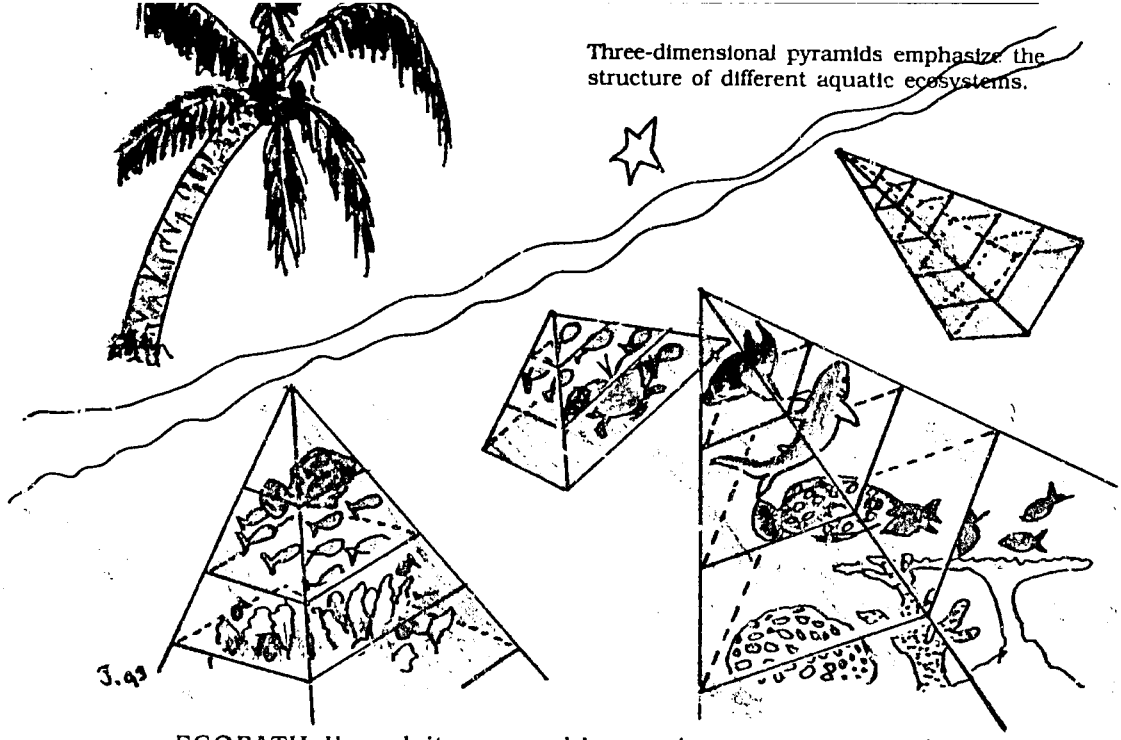
Although FiSAT represents the state-of-the-art in assessing individual tropical fish stocks, it does not (in its present form) tell us about the effects of fishing the stocks of one species on the stocks of all the other species nor the effects of concurrently fishing all species, but at different rates in multispecies, multigear tropical fisheries. More needs to be known about the ecosystem "framework" within which fisheries operate. New knowledge of ecosystems is coming from ICLARM's modeling research described below.

Pyramids of Aquatic Life

A fresh way of viewing ecosystems - as quantifiable three-dimensional pyramids of life - is a minor but significant outcome of ICLARM's ongoing investigations into the bases of fish production. The pyramids are simple representations of aquatic food webs.

These model pyramids can be altered to allow scientists to see the result of changes in the food web. What would happen to a coastal ecosystem if all the anchovies were caught? Is it more productive to catch all the fish that eat the anchovies or to catch the species that eat those fish? And on a coral reef, how much of the herbivorous fish should be left to make sure there is enough food for the prized groupers to eat (before they are harvested)?

A model which we have been developing since 1986, called ECOPATH II (p. 80), allows such questions to be answered - if there is enough information to construct the pyramids. The model also helps identify needed information and thus useful research directions.



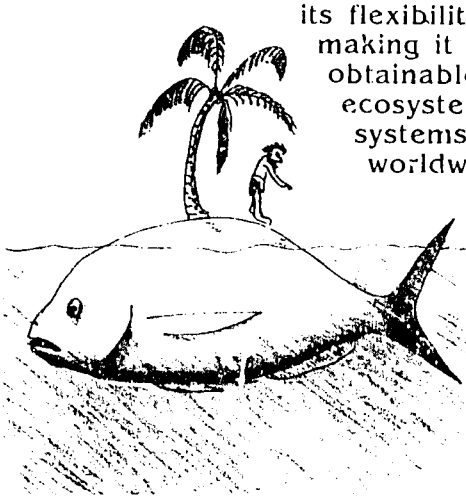
Three-dimensional pyramids emphasize the structure of different aquatic ecosystems.

ECOPATH II and its pyramids are by no means whimsical toys. To understand their significance, it should be realized that in recent years, fisheries scientists have increasingly realized that predictions of yields and advice on management, based on species by species assessments and assuming constant predation rates, are not very accurate. The scientists' attention was focused on only one predator - humans. But humans are actually minor predators in aquatic ecosystems. Predation by other organisms in the aquatic milieu wipes out most individuals of most species before they can reach a size of interest to fishers.

In the North Sea, huge international research efforts were made in the 1980s to get a better idea of the true predation rates amongst the important fisheries species.

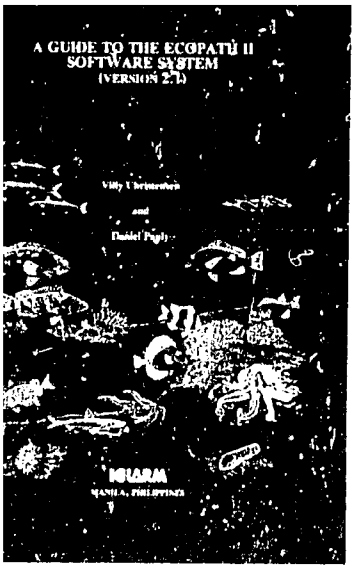
In the tropics, such large research projects are rare and, as mentioned, the fisheries (and the fisheries scientists) deal with hundreds of species, unlike the few species in temperate water fisheries.

The precursor of ECOPATH II was initially developed for application to a Hawaiian coral reef area by Dr. J.J. Polovina of the US National Marine Fisheries Service. This model could be used to quantify the energy flows (predation primarily) in ecosystems in the relatively data-poor, species-rich tropics. ECOPATH was then further developed at ICLARM to increase its flexibility and computational power as well as making it more user friendly. It uses easily obtainable data, yet is also applicable to describe ecosystems in temperate waters and in farming systems, ponds, rivers, lakes and oceans worldwide.

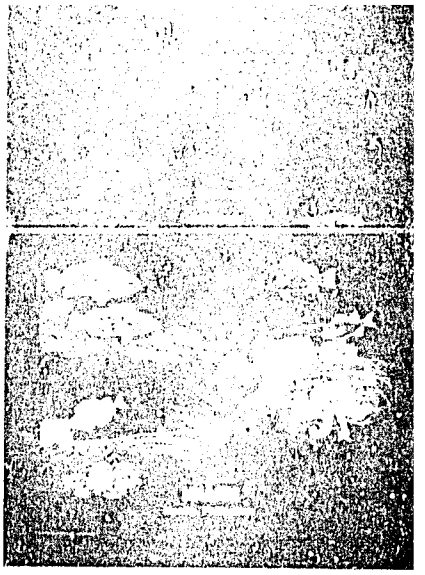


In 1992, a new version (2.1) of ECOPATH II was released to some 200 pilot users, and French and Spanish versions of the manual were released.

"No fish is an island" is the motto of the ECOPATH work.

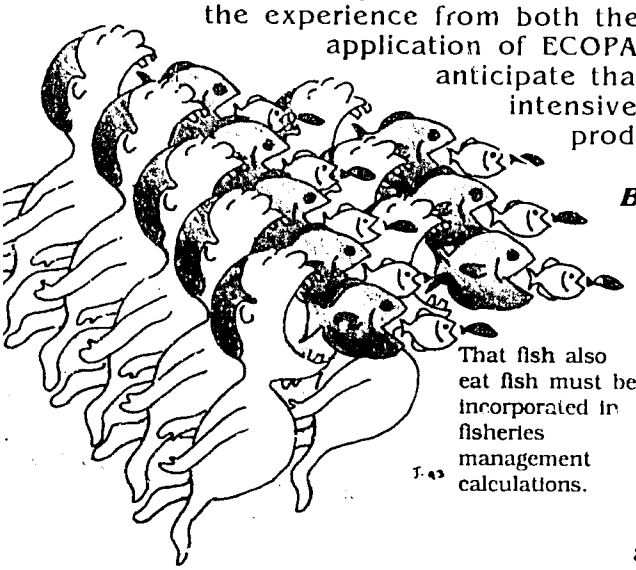


ECOPATH II models of the four major upwelling systems of the world's oceans are being made as part of ICLARM's contribution to an international study on "Climate and Eastern Ocean Systems" (p. 81). The study is intended to determine the potential effects of global climate change on the living resources of these upwelling systems which support some of the world's richest fisheries.



Filling the Fisheries Management Tool Box

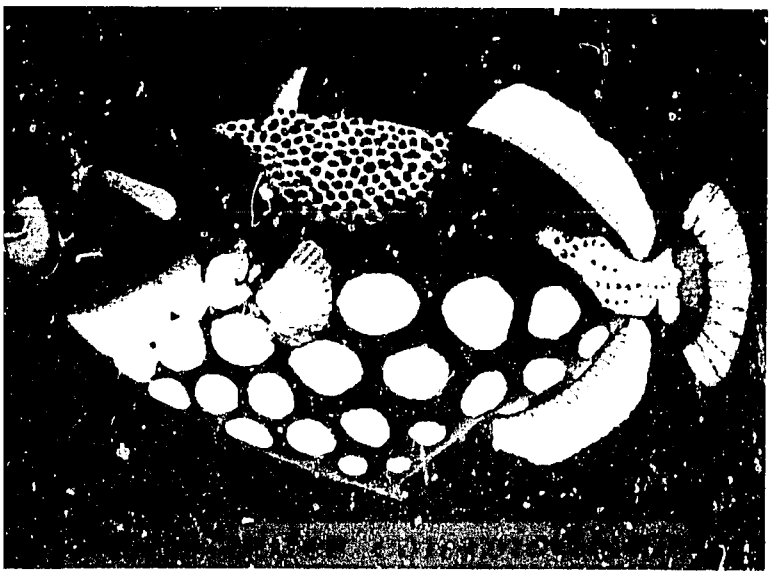
Neither FiSAT nor ECOPATH II is sufficient to provide all the answers needed by decisionmakers for sustainable fisheries management. However, both can provide vital inputs into a new way of managing fish stocks. It is now generally accepted that it is necessary to incorporate interactions between the fish stocks in management: fish eat fish. In consequence, development of a suitable methodology for tropical fisheries is to be a priority research area for ICLARM in the future. Focus in the initial stages is on "tropicalization" of an approach called multispecies virtual population analysis (MSVPA). This is a data-intensive method presently used for assessment in several northern temperate systems. Using the methodology, it is possible to answer questions of the type: "what will happen if we increase the number of gill nets in this bay?," or "what consequences will it have on total catches and catch composition if we ban the use of fish corrals?" To answer such questions a dynamic model is needed. By incorporating the experience from both the development and application of ECOPATH II and the MSVPA, we anticipate that a robust, not too data-intensive methodology can be produced.



That fish also eat fish must be incorporated in fisheries management calculations.

Biological Software

Apart from the above, the electronic encyclopedia of fish, FishBase (p. 86), will become an essential component in future management. Under development by ICLARM, FAO and cooperating institutions and individuals, FishBase



FishBase provides color images of the species covered.

already contains information on all fishes used commercially. This database provides a wide range of information to different people. For example, for university teachers and students in ichthyology, FishBase contains a checklist of the fishes in their country together with biological information on these species; for taxonomists, it contains the latest revisions of all genera and higher taxa of recent fishes; for research directors and funding agencies, it shows existing knowledge for each species and research gaps; for conservationists, it lists all threatened species for a given country as contained in the IUCN Red Book; for zoologists, it contains information on reproduction, morphology, brain size, eye pigments, etc.; for ecologists, it lists preferred habitats, environmental tolerance, prey and predators, food consumption, etc.; for aquaculturists, it provides information on gene traits and on culture experiments; for the fishing industry, it contains proximate analyses and recommendations for processing; for sport fishers, it lists the occurrence of game fishes by country. Researchers on indigenous knowledge will find more than 24,000 common names (to date) of fishes together with the language/culture in which they are used and with comments on their etymology; librarians can provide their customers with up-to-date species synopses as printouts from FishBase.

Another software tool for managers under development

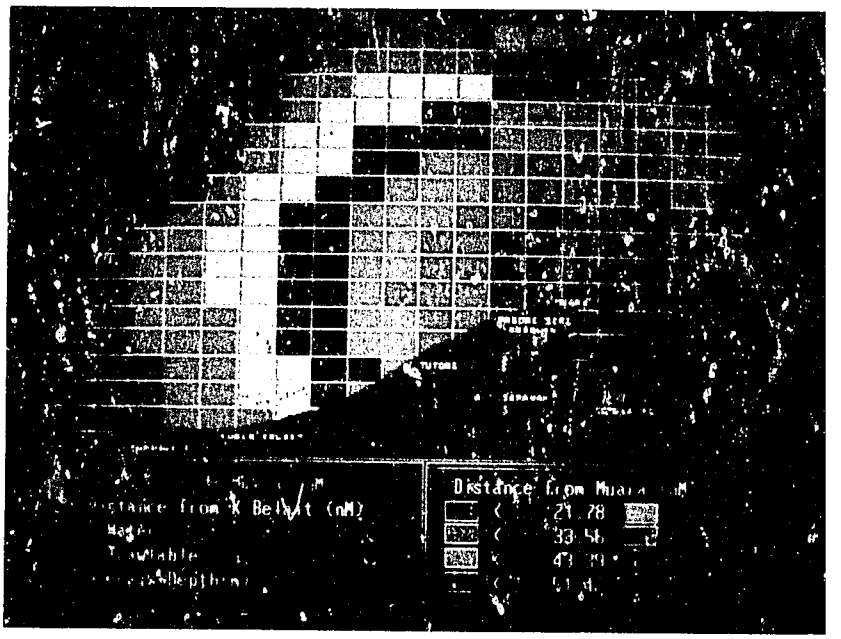
A cartoon expression of FishBase's capacity to assemble information on fish.

by ICLARM and collaborating institutions in Sierra Leone (p. 82) is called FiDAS - Fishery Data Acquisition System - a generic software for computer-assisted handling of fisheries data for management analysis. The program includes a GIS component (see below). It is part of a two-year project to establish a database for the management of Sierra Leone fisheries. As in other ICLARM projects, the goal is to produce a methodology widely useful in tropical developing countries. In 1992, data were entered from Soviet fishing fleet activities, from a survey of small-scale fisheries, and from daily landings along the north coast of Sierra Leone. An important feature of FiDAS is its ability to exchange data with FishBase.

Of direct management use is a generic low-level geographic information system (LL-GIS) created at ICLARM to use data from software like FiSAT and to express them spatially. Currently under development are applications for management decisionmaking related to marine fisheries in Brunei Darussalam (B:RUN) (p. 79) and Peru (SIGMAP), while the software has also been incorporated in FiDAS. The GIS routines enable researchers or managers to investigate the state of fish stocks in particular areas (5 nautical miles square in Brunei Darussalam, for example) of their marine waters.

The B:RUN software also includes an economics module allowing managers to see the profitability of fishing in different parts of the Brunei Darussalam exclusive economic zone, after entering a number of parameters related to a proposed expansion of the fishing fleet.

The LL-GIS is being further developed in MAPPER, which can create/edit maps and overlays; includes a plotting routine to draw a map and overlay data files of different types; and includes routines for calculating perimeters and areas, and for zooming, printing, saving and redrawing displayed maps. MAPPER, which will be available in 1993, will provide fisheries researchers and managers with a cheap, user-friendly GIS.



A view of B:RUN. B:RUN provides stock assessments and economic analyses for decisionmaking.

Socioeconomic Research

To many involved in the fisheries sector, and certainly to the managers and politicians whose decisions impact on resource systems, fisheries scientists talk sense only when they talk about the economic value of fisheries, potential or realized.

Conversely, the complexities of the economic aspects of fisheries make it difficult to evaluate what fishers do in their attempt to maximize their incomes, i.e., the difference between their gross returns and their fishing costs.

However, bringing at least a minimum of economic realism into stock assessments is rather straightforward. When performing stock assessments, one can express expected yield in terms of dollars per year rather than weight per year, by multiplying biomasses with size-specific prices. Prices usually increase with fish size and graphs of economic yields versus effort are more peaked than those using biological yields only (which tend to be more flat topped in the tropics). Such analyses also eliminate from consideration absurd solutions such as "maximum yields" associated with extremely high levels of effort with a catch composition dominated by very small fish sizes.

Additionally, attempts should be made to estimate fishing costs using space-structured approaches (e.g., as a function of distance from the coast), which can be done by monitoring a few representative units from a fishing fleet, under some agreement guaranteeing confidentiality. This allows managers to assess whether a fishery is generating a positive rent (profits above all costs) or whether the rent is dissipated by excessive effort, a diagnosis of obvious importance.

A software package to perform such analyses routinely is being developed and it will complement FiSAT, which supports simple bioeconomic analyses. These two programs will thus complement the approach of coastal resource valuation, which links the fisheries sector with other coastal activities (see p. 78).

We recently devised a theoretical framework that will capture fishers' knowledge and perceptions of their environmental resource base using coastal transects, which will enable researchers to match "local" knowledge with rigorous frameworks, enabling quantification of processes and comparisons among sites (see p. 27).

This should enable social scientists involved in fisheries research to go beyond the purely descriptive approaches conventionally used, and in which imported classifications may be forced onto a reluctant body of observations.

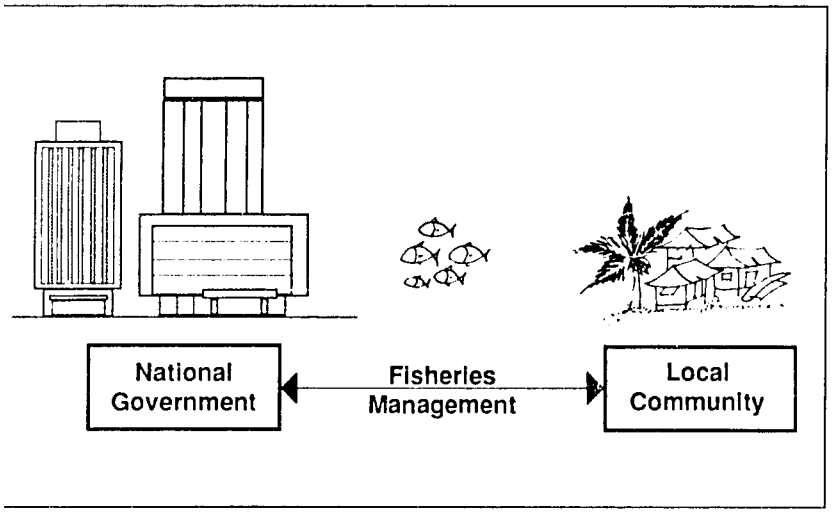
Finally, the issue of the usefulness of "unidirectional" management, as implied in the discussion above, must be raised.

Governments and states the world over have shown themselves unable to "manage" natural resources all by themselves, however large the bureaucracy that is deployed. Rather, without the involvement of local users' groups and other stakeholders, all that governments and states can do is

increase the alienation of the local communities from their resources base, and thus directly or indirectly foster their nonsustainable use and ultimate destruction.

Overcoming this involves drawing communities into the management process, leading to the term "co-management", the international research aspects of which will be investigated at ICLARM in coming years. At the national level, ICLARM is working with several institutions in Bangladesh on alternative management mechanisms for inland fisheries (p. 84). A co-management program is being implemented in a number of sites.

In Bangladesh, ICLARM is also working with the government to examine the socioeconomic impact of aquaculture extension work (p. 101). The study began with a baseline survey in 1991. The extension work is ongoing and new fish farmers are being monitored. In order to assess such socioeconomic impact, the goal is to develop a practical tool which will be useful not only in Bangladesh but also in other developing countries.



Co-management: shared authority for fisheries management between community and government. A partnership of capacities and interests of fishing communities with the capability of national governments to provide legislation, institutions and assistance.

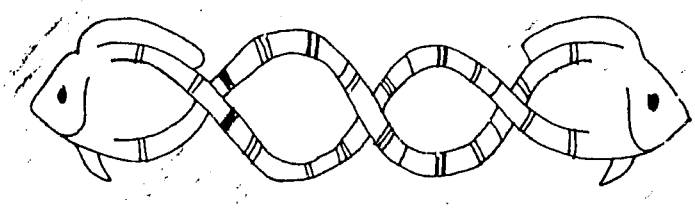
Many new entrants to aquaculture in Bangladesh are women. Their produce contributes to household nutrition and income.

Tropical Fish Husbandry: From Art to Science

Imagine the state of agriculture several centuries ago, before livestock had pedigrees and their productivity was low. That is more or less the state of tropical aquaculture.

The benefits of genetic improvement in livestock have been tremendous, leading, for example, to several-fold increases in carcass weights, milk yields and egg production.

Aquatic livestock was left behind with few exceptions, such as common carp, trout and recently, salmon.



Tilapia Breeding

ICLARM began genetic characterization of one important group of tropical food fish, the tilapia, in the mid-1980s. Together with the Marine Science Institute of the University of the Philippines, we documented the deleterious effects of starting aquaculture with a narrow genetic base, as is the case in most countries because the fish were introduced in very low numbers, and of uncontrolled interbreeding.

In 1988, work began with three Philippine institutions, the Freshwater Aquaculture Center of the Central Luzon State University, the National Freshwater Fisheries Technology Research Center of the Bureau of Fisheries and Aquatic Resources and the Marine Science Institute of the University of the Philippines, on genetic improvement of the tilapias by bringing carefully quarantined stocks of Nile tilapia, the species commonly used in the Philippines and elsewhere for aquaculture, from several sources in Africa to the research facilities of our counterparts (p. 91).

The idea was to improve Nile tilapia strains using the classic livestock breeding approach, recently successfully used in Norway on Atlantic salmon. Thus, we also teamed up with AKVAFORSK, the research group that developed faster-growing salmon.

Tilapia breeding trial: a typical experiment involves tagging some 25,000 tiny fish.

After characterizing and assessing the growth rates of wild tilapias from Egypt, Ghana, Kenya and Sénégal, along with locally available strains which were introduced at different times from Israel, Singapore, Taiwan and Thailand, a new synthetic strain was produced by crossing all combinations of the eight strains and selecting from the purebred and crossbred offspring the 25 best performing families.

The year 1990 saw the beginning of growth trials of the synthetic strain in various farming environments in the Philippines. During 1991, the first major results were achieved. The synthetic strains grew about 40% faster in all environments than the strain normally used in Philippine fish farms. This before selective breeding had even begun.

In 1992, the selection work began in earnest. Two generations were reared to estimate the magnitude of genetic gain. Results were outstanding: a 23% response to selection, with selected fish growing up to 75% faster than some of the strains originally collected and with better survival.

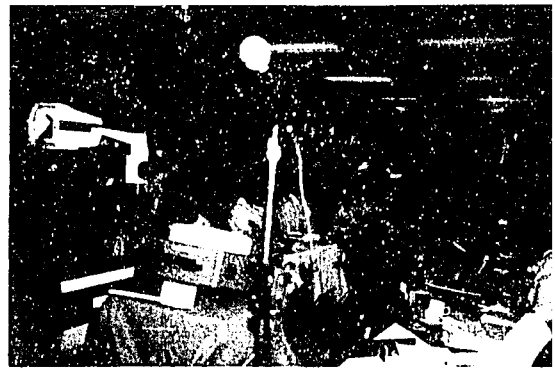
In on-farm trials, ranging from backyard ponds to ricefields, selected fish grew on average 60% faster and with 50% better survival than the strain most commonly farmed in the Philippines.

The work involved in the study is prodigious. Whereas a livestock breeder may be working with dozens or hundreds of animals, researchers in tilapia breeding are dealing with many thousands of tiny fish, each of which has to be identified - by tagging. A typical experiment involves 500 cages and the careful tagging of 25,000 individual juvenile fish. Data collection and processing is a demanding exercise.

Nevertheless, in 1992 the research team also transferred additional Nile tilapia germplasm from Africa to enlarge the 'gene pool'; undertook a major training workshop on quantitative genetics; and began planning for an international collaborative research network to develop national breeding programs on tilapias and other species. In addition, international experts were brought together to discuss and make recommendations on the various concerns associated with the international transfer of fish germplasm and its use.

The new strain of Nile tilapia being developed by the project will be made available to farmers in the Philippines through a national breeding program beginning in 1993.

he "GIFT" Nile tilapia (upper) with a commercial strain of
ie same age (below).



The participants in a round table discussion during the meeting on International Concerns in the Use of Aquatic Germplasm in June 1992.

Giant Clam Genetics

At ICLARM's Coastal Aquaculture Centre in the Solomon Islands, production of thousands of baby clams through the spawning of a single giant clam is a routine task. Researchers have observed that there is a large size variation in the baby clams. There would seem to be scope for a genetics/breeding program to maximize the growth potential of the clams. Consequently, some attention was given to genetic characterization of the Center's giant clam broodstock during 1991.

In 1992, ICLARM held an international workshop to review the potential application of genetic improvement of clams (p. 119). The workshop produced guidelines for clam hatchery managers on sound genetic practices and for transfers of clam germplasm. The major outcome was the creation of a consortium of represented institutions for the re-establishment of giant clam stocks in those areas of the Pacific Ocean where they have been extinguished, in a manner which conforms to sound genetic principles. Funding is being sought to implement the plan.

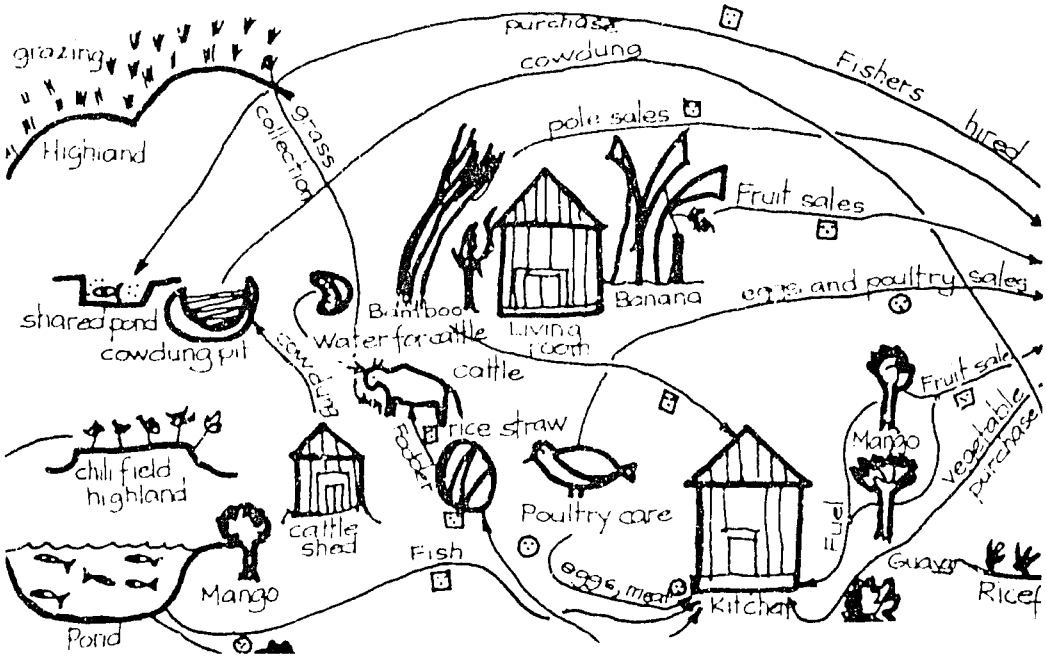
Checking juvenile clams at the Coastal Aquaculture Centre—variation in size gives scope for selective breeding. Photo by Michael Mckoy.

Teaching Scientists to Learn from Farmers

A few years ago, a wind of change began to blow across ICLARM's efforts to bring fish into the farming scene. Our earlier work was technology focused - optimizing manure and farm waste levels in farm ponds.

Farmers will have the last say in what they produce, of course, but only recently have their ideas become incorporated into formal research. "Farmer-participatory research" is the term for this phenomenon and ICLARM is pioneering it from the aquatic perspective.

Sorting farming activities into processes rather than unrelated events, into resource flows rather than crop cycles, is the first point of contact between farmer and researcher in this scheme, in which farmers are encouraged to describe the interconnections of their activities. Then the farmers suggest other connections, other possibly better ways of channeling their farm resources. Since farmers cannot risk innovations beyond their means which may or may not prove to be an improvement, the researchers are, in effect, given the opportunity to investigate farmers' suggestions to improve productivity.



The other aspect is sustainability of farming systems. New systems must not only improve productivity, they must also be sustainable. It is necessary for development agencies to recognize the complexity of the problem of sustainability and recognize that this will not be achieved by any particular set of technologies.

Converting farmers' data on sustainability into a form amenable for comparative analysis and quantification has been one focus of this work at ICLARM, in partnership with the International Institute of Rural Reconstruction (IIRR).

A software, tentatively called FARMBASE (to be renamed RESTORE, Research Tools for Natural Resource Systems Monitoring and Evaluation) which links qualitative and quantitative data in ways that provide measures of farm sustainability - diversity (number of plant/animal species used); number of recycling events; capacity (biomass of all produce over the year); and net income - is under development (p. 94).

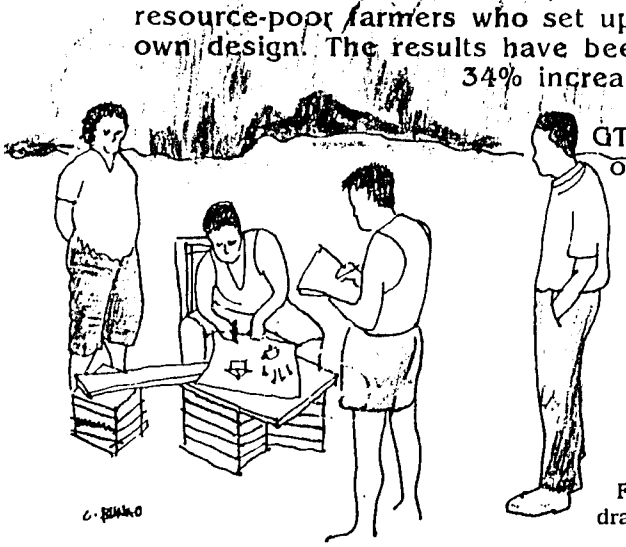
Using these tools, ICLARM and IIRR researchers have employed monitoring and recall data to show clearly the benefits to farmers' income of increasing the diversity, recycling and capacity of farm operations.

In the field, joint experiments this year by ICLARM, the International Rice Research Institute (IRRI) and the Freshwater Aquaculture Center of Central Luzon State University (Philippines) have demonstrated how even a simple increase in diversity can improve a farm system: the addition of fish in ricefields (p. 96). Fish actually improved the rice crop by nearly 10%, reduced weeds by up to two-thirds; and improved the quality of surface soil.

Farmers are also being helped to improve their management and experimenting skills through group sessions which are helping rice farmers to diversify by using their water resources for fish and other crops.

Farmer-participatory research is a feature of the Center's ongoing work in Ghana to investigate the potential for future aquaculture development there (p. 105). In cooperation with national institutions and the Ghana Rural Reconstruction Movement (affiliated to IIRR), research was instituted with resource-poor farmers who set up integrated farms of their own design. The results have been encouraging - an average of 34% increase in farm production.

In Malawi, where ICLARM and GTZ are working with a number of national institutions and international projects, farmer participation is also being used to find new species for African aquaculture and new integrated farming systems that might have broad usefulness in rural Africa (p. 108).



Farmer-researcher interaction in Ghana: a drawing session on resource flow diagrams.

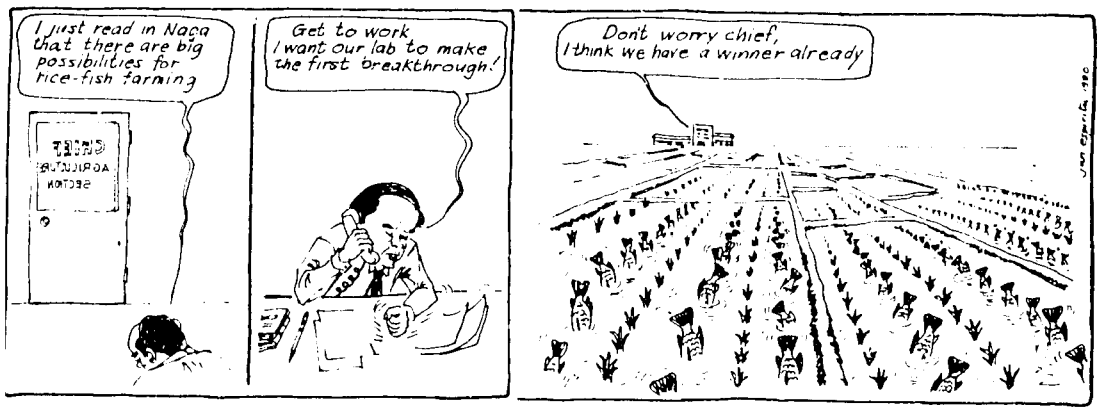
A Malawian smallholder farmer is interviewed by an ICLARM technical assistant and discusses how on-farm resource can interact to improve overall productivity.

There were also encouraging on-station research results: readily available on-farm materials were found to enhance fish production and tree-crop-fish systems were found to be advantageous.

This year, there has been increasing adoption of rice-fish and vegetable-fish integration in Malawi as a result of these collaborative efforts. Participation of larger groups of farmers is planned in cooperation with other institutions.

The Center is helping Bangladesh NGOs and the Bangladesh government's Agricultural Research Project in planning and implementing aquaculture research (p. 98). Farmer participation is a strong element of the research. Bangladesh farmers, like those in the Philippines, are finding that rice yields are higher from fields with fish; fish provide additional income; and there are fewer weeds and pests in the presence of fish.

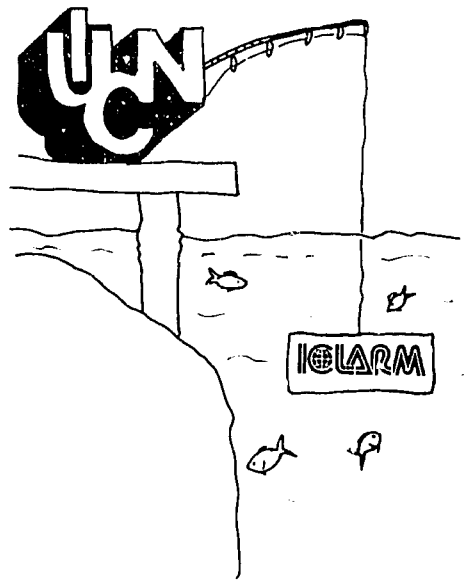
Motivational session for farmer participation in on-farm research in Bangladesh.



Despite this lighthearted view by Pongase which appeared in *Naga, the ICLARM Quarterly*, rice-fish farming is proving to increase rice yields and to result in fewer weeds and pests.

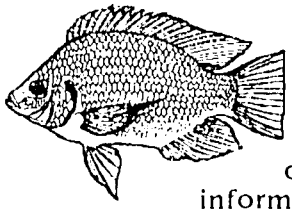
Conservation of Biodiversity

Implicit in ICLARM's Strategic Plan is the need to maintain biodiversity, both to ensure the broadest gene pool from which to draw broodstock and to retain the "balance of nature."

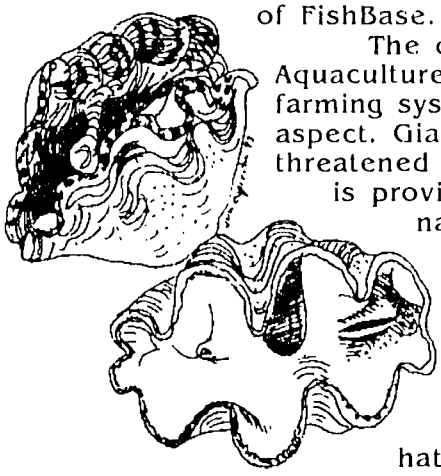


The Center is a member of the World Conservation Union (IUCN) and assists the Union on issues related to aquatic resources, focusing on the need for both *in-situ* and *ex-situ* conservation of germplasm.

During 1992, the ongoing development by ICLARM, FAO and other organizations and individuals, of FishBase (p. 86), the electronic encyclopedia of fish, included entries for key features of fish germplasm, giving also occurrence records and status; for example, all threatened species in the IUCN Red Book are included. In these respects, the database is similar to that of the International Rice Research Institute for rice and to the activities of the International Board for Plant Genetic Resources.



In the field, a project is under way with the Institute of Aquatic Biology of Ghana and Zoological Institute and Museum of the University of Hamburg to document the tilapia genetic resources of Ghana (p. 106). The results will be useful for both aquaculture and conservation. Following publication, the information will be documented in the genetics tables of FishBase.



The ongoing research at ICLARM's Coastal Aquaculture Centre (CAC) to develop giant clam farming systems (p. 115) includes a biodiversity aspect. Giant clams have become extinct or threatened in parts of the Indo-Pacific and the CAC is providing postlarval clams to collaborating national agencies for reestablishing stock in such areas. As noted above, a consortium of institutions has been formed to ensure that re-establishment of giant clam stocks is done using sound genetic principles. The CAC will contribute to breeding programs aimed at maximizing the genetic diversity of hatchery-reared clams.

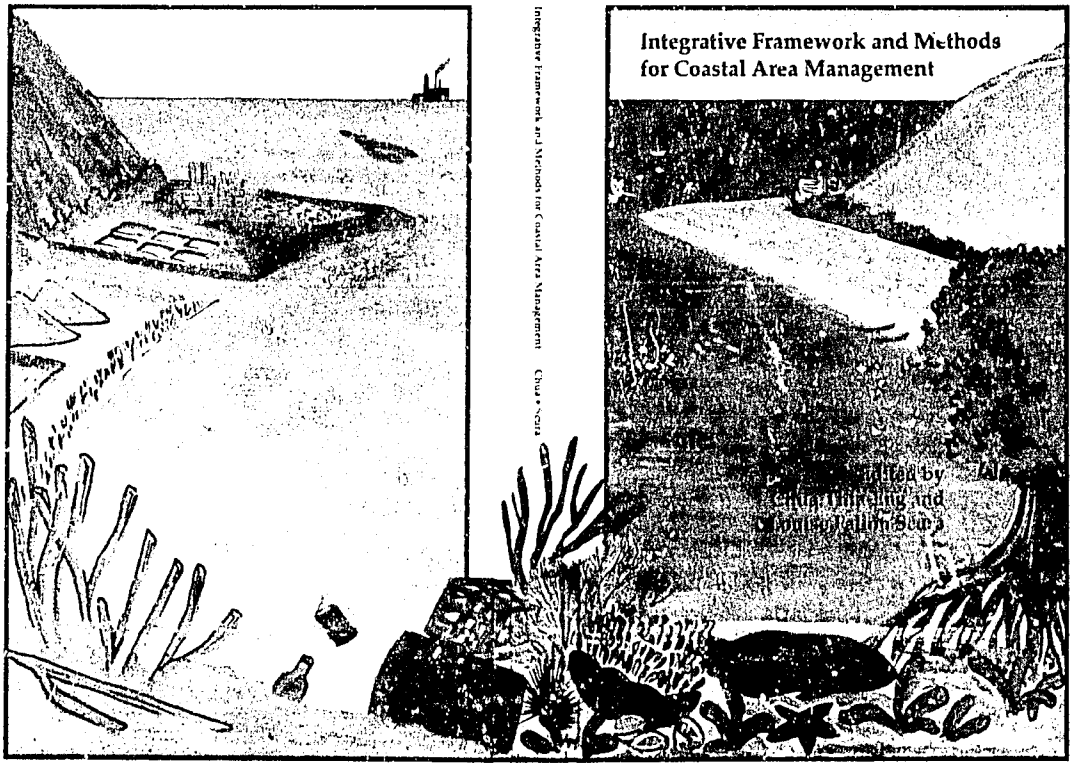
Intersectoral Issues

While our understanding of tropical fisheries is improving and the level of advice available to fisheries managers is being vastly improved as a result of recent research by ICLARM and its collaborators, the advice may be worthless if demands from other sectors, such as mining, forestry, urban development, tourism, etc., conflict with fisheries management goals!

Coastal Management

This year marked the completion of the ASEAN/US Coastal Resources Management Project (CRMP) (p. 66), coordinated by ICLARM, which, over a seven-year period, has worked towards preparation of management plans for pilot coastal areas in the six ASEAN nations - Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore and Thailand. Publications of those plans and a regional workshop on lessons learned during the course of the project on integrated coastal zone management were highlights of the final year.

The CRMP tackled the various issues in other sectors that compete with fisheries along coasts. Multidisciplinary national teams investigated biophysical and environmental aspects, social and economic aspects, institutional and organizational aspects, and opportunities for management interventions.



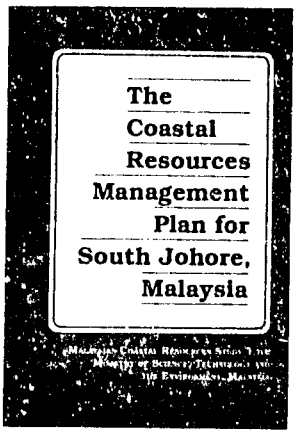
A picture is better than a thousand words. Cover of the book from the final regional workshop of the CRMP. Artwork by Rachel Atanacio.

Most of the site plans have been integrated partly or fully into national or local development plans, and the project has in addition made policymakers in ASEAN more aware of coastal management issues as well as creating a pool of trained personnel in the relevant government departments of ASEAN countries.

The final regional workshop, on "Integrative Framework and Methods for Coastal Area Management" in April 1992, included a review by ICLARM project staff entitled "Lessons for Integrated Coastal Zone Management: The ASEAN Experience." The review drew heavily on the workshop discussions and documented the various process-related, development state-related, and institutional setting-related lessons from the projects activities. The review described key areas for future research in coastal area management (see Box 1).

ICLARM's work in coastal management during 1992 also included (i) assistance to a regional office of the Philippine National Economic and Development Authority on the use of geographic information systems, in this case a commercial system, SPANS (p. 68); and (ii) a resource and ecological assessment of San Miguel Bay, Philippines for the National Fisheries Sector Program (p. 70). ICLARM is undertaking the latter work because the Center carried out a collaborative multidisciplinary study of the Bay's fisheries in 1981. It is hoped that valuable lessons of broad applicability will result from the combined data.

One research area identified in CRMP - valuation of benefits and costs of sectoral activities (see Box 1) - was the subject of ICLARM research collaboration with the UN Economic Commission for Latin America and the Caribbean (p. 78). This project, on socioeconomic valuation of coastal resources of southwestern Latin America, ended this year with the draft of a software tool to assign relative values to different coastal resources and to evaluate, through a linear programming approach, various options for their utilization and management. Further development of this software, OPUS, is continuing at ICLARM. It will assist coastal managers worldwide in assessing coastal management priorities.



Coastal Aquaculture

For some years, ICLARM's Coastal Aquaculture Centre (CAC) in the Solomon Islands has been engaged in developing farming systems for giant clams (p. 115). Concurrently, the CAC has investigated how giant clam farming can fit into traditional marine tenure and social systems in the Indo-Pacific.

In 1992, a joint study of the rural context of giant clam farming in the Solomon Islands was carried out with the Centre for Development Studies of the University of Bergen. The study dealt with customary marine tenure and its role

Box 1: Coastal Management

Key research areas for Coastal Area Management, identified in the ICLARM review "Lessons for integrated coastal zone management: the ASEAN experience" by L.F. Scura, T.E. Chua, M.D. Pido and J.N. Paw, p. 1-70. *In* T.E. Chua and L.F. Scura (eds.) Integrative framework and methods for coastal area management. ICLARM Conf. Proc. 37, 169 p. (1992)

The ASEAN/US CRMP experience suggests that research should be directed at the following areas.

Understanding Interactions in Coastal Resource Systems

- Understanding the ecological functions of critical aquatic resources, habitats or ecosystems (e.g., coral reefs, mangroves, marshes/wetlands).
- Identification of trends in supply and demand for goods and services derived from coastal resources and habitats, and social and economic factors influencing these.
- Interpretations of implications for management of carrying capacity or assimilative capacity of aquatic habitats or systems.
- Identification and documentation of critical threshold levels and indices for management.

Identification and Prioritization of Management Issues

- Identification, physical quantification, and evaluation of tradeoffs and trends of impacts in coastal areas.
- Identification of a general typology relating occurrence of specific management issues with biophysical, socioeconomic and institutional and organizational factors.
- Valuation of social and environmental benefits and costs of sectoral activities.
- Identification of management priorities through evaluation of the sustainable level of output, adverse impacts, and associated net benefits and costs.

Identification and Evaluation of Management Strategies and Actions

- Identification and evaluation of appropriate policies and management strategies to mitigate negative impacts and maximize human welfare benefits.
- Identification of general guiding principles with respect to appropriate management action elements including (1) market-based incentives, (2) regulations, (3) direct public involvement or investment and (4) institutional and organizational arrangements.

Development of Methodologies and Tools

- Evaluation, integration and packaging of appropriate, cost-effective methodologies and techniques to facilitate the inventory of resource distribution, utilization and impacts within the coastal resource system.
- Evaluation, integration and packaging of appropriate, cost-effective methods and techniques for the evaluation of benefits and costs of coastal activities and management interventions.

Villagers building ocean nursery cages for juvenile giant clams in the Solomon Islands.

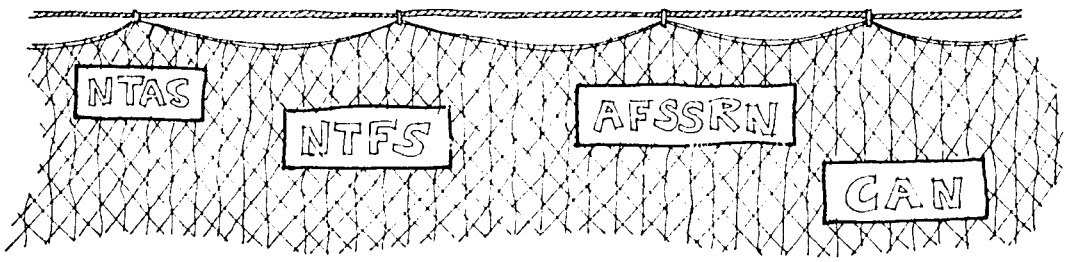
as a framework for coastal aquaculture management. Results will be published in 1993.

During the year, 20 cohorts of giant clams belonging to six species were successfully reared. Experimental work focused on improving land-based and floating nurseries (p. 117.). Village farm trials are under way in 32 sites in the Solomon Islands. Studies indicated that economic viability of village-based farms is primarily determined by survival rates in the ocean nursery phase (p. 119). A collaborative predation study (p. 121) has resulted in suggestions for improved farming methods. Other resources that might be managed (p. 119) or farmed (p. 120) within the rural context of coral reef communities were also investigated.

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



ICLARM maintains four networks. Two, the Network of Tropical Fisheries Scientists (NTFS, p. 77) and the Network of Tropical Aquaculture Scientists (NTAS, p. 89) exist to foster the development and professionalism of individual aquatic scientists in tropical developing countries. Members receive a

newsletter (*Fishbyte* and *Aquabyte*, respectively, which were incorporated into ICLARM's quarterly magazine *Naga* in 1992), to which they contribute articles and news. Other benefits include literature searches and copies of articles.

The Asian Fisheries Social Science Research Network (AFSSRN, p. 71) also seeks to advance the professional capacities of its members as well as to support their research and develop relevant educational programs. There are 13 national member institutions and the main activities are research projects undertaken by national teams. Phase III of the Network ended in 1992. A proposal for Phase IV focuses on collaborative research and training. The Network's newsletter is also incorporated in *Naga*.

Finally, the Coastal Aquaculture Network (CAN, p. 120) differs from the other networks in that it consists only of collaborative research groups which exist to work on specific topics. Training of group members is also a feature of the Network, and a separate newsletter is produced.

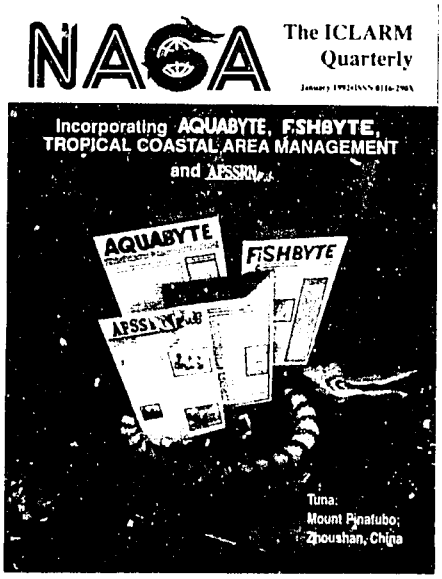
As mentioned above, ICLARM is helping form an International Network on Genetics in Aquaculture which will commence in 1993.

A researcher interviews an oyster farmer during a survey for the AFSSRN project *Socioeconomic study of oyster and mussel farming in Western Visayas, Philippines.*

Publications

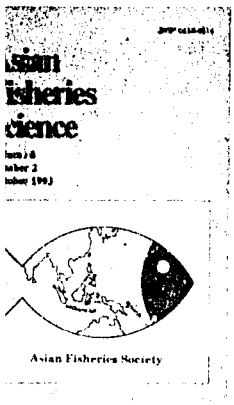
The decision of ICLARM's founders to publish the Center's findings through its own technical series and newsletters has proven to be a major advantage in enabling ICLARM's research results to be widely distributed and cited.

Presently some 500-600 copies of most titles are sold or provided free in the first year of publication. There are 1,000-1,500 copies produced of each title.



Highlights in 1992 were the production of the revised ICLARM Strategic Plan and the merging of all four newsletters produced at ICLARM headquarters *(Aquabyte, Asian Fisheries Social Science Research Network News, Fishbyte and Tropical Coastal Area Management Newsletter)* into *Naga, the ICLARM Quarterly.*

Publications in 1992 in the ICLARM Technical Series included the 457-page conference proceedings "Rice-Fish Research and Development in Asia," three technical reports, the French version of the ECOPATH II software manual, and the summary report of the Bellagio conference on environment and aquaculture in developing countries. Also published were the 1991 Annual Report, four issues of the merged *Naga* and five issues of the *ICLARM Newsbriefs*.



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 137,000. Total *Naga* distribution since its first issue in July 1978 is 187,600; *Naga* recipients in 1992 totalled 3,800 per issue.

ICLARM hosts the Asian Fisheries Society secretariat and handles its editorial and publishing functions. As a free service to the Asian Fisheries Society, the Program prepared three issues of the society's journal *Asian Fisheries Science* in 1992.

Contributions. The number of items published or in press by ICLARM staff and in the Center's technical series during 1992 was 87. The total number of contributed items since ICLARM's first output in 1975 is now 874.

Library

The Ian R. Smith Memorial Library and Documentation Center added 42 new serial titles and 961 new volumes of books and monographs in 1992.

Library holdings since 1987 are all computerized, facilitating searching by the 2,583 users during the year. Over 600 retrospective literature searches were conducted on the CD-ROM version of Aquatic Sciences and Fisheries Abstracts.

A fully indexed annual book catalogue was prepared and distributed to selected libraries. The current awareness service produced by the library for the Information Department in *Naga, the ICLARM Quarterly* comprised 1,024 entries in 1992. The database is computerized back to the first issue of *Naga's* predecessor, the *ICLARM Newsletter*, in 1978 and is also regularly used by library visitors.

During the year, the library's in-house bibliographic databases grew by 2,204 items and now contain a total of 19,700 references.

The ICLARM Library and its bibliographic database of 19,700 references were used by more than 2,500 visitors in 1992.

Translations

Translations of relevant publications between French and English is a major aspect of ICLARM's Asia-francophone Africa cooperation project (p. 90). In 1993, a survey is planned on the extent of translation policies and activities in a cross section of organizations, including the CGIAR, to help develop a translation policy for the Center.

Future Research: A Resource Systems Basis

ICLARM's Strategic Plan, summarized on p. 1-4, is based on research in resource systems - comprising the various aquatic habitats and the people who exploit their resources.

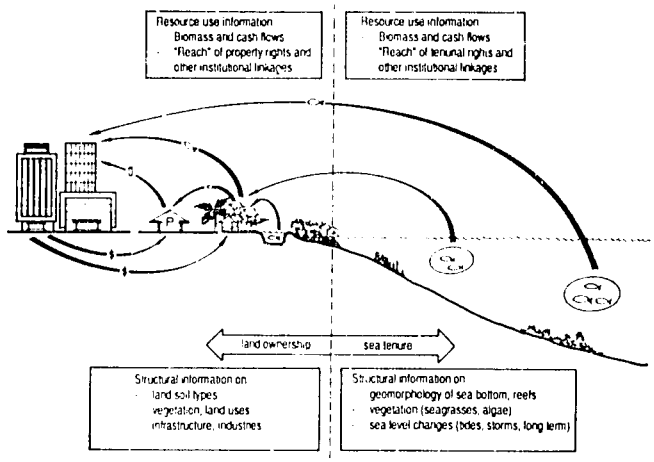
Thus, from an understanding of tropical fisheries, ICLARM will move towards helping understand resource systems in their entirety. The systems chosen for priority strategic research, inland (focusing on ponds and rice floodwaters), coastal and coral reef, are most important in tropical developing countries. There are at present or planned for the near future, many national, regional and international initiatives to manage these resource systems. However, very few are addressing the research issues other than those specific to particular sites or particular disciplines. ICLARM's main strategic roles will be (i) to provide managers and researchers of these resource systems worldwide with a common set of management tools; and (ii) to provide a conceptual framework for integrating and comparing the results of research conducted by different disciplinary groups.

On the question of a conceptual framework, some progress has already been made on a rudimentary framework for analyzing and comparing coastal resource systems. Staff from the Aquaculture and Capture Fisheries Management Programs have developed a concept called "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.

Box 2 demonstrates the concept. It will be developed in part though linkages to existing ICLARM software, including ECOPATH II, FARMBASE (RESTORE), FishBase, FiSAT and low-level GIS programs. Bioeconomic modeling will also be incorporated. This complex of activities is illustrated in Box 3.

The transition to working on a resource systems basis, in which all Asia-Pacific research programs will be directed from ICLARM headquarters, led to the closure of the South Pacific Office (SPO) in 1992. The Coastal Aquaculture Centre near Honiara, located in Solomon Islands, which was administered by the SPO, will continue to be a major focus of ICLARM's research on coral reef environments, primarily in aquaculture and fisheries enhancement.

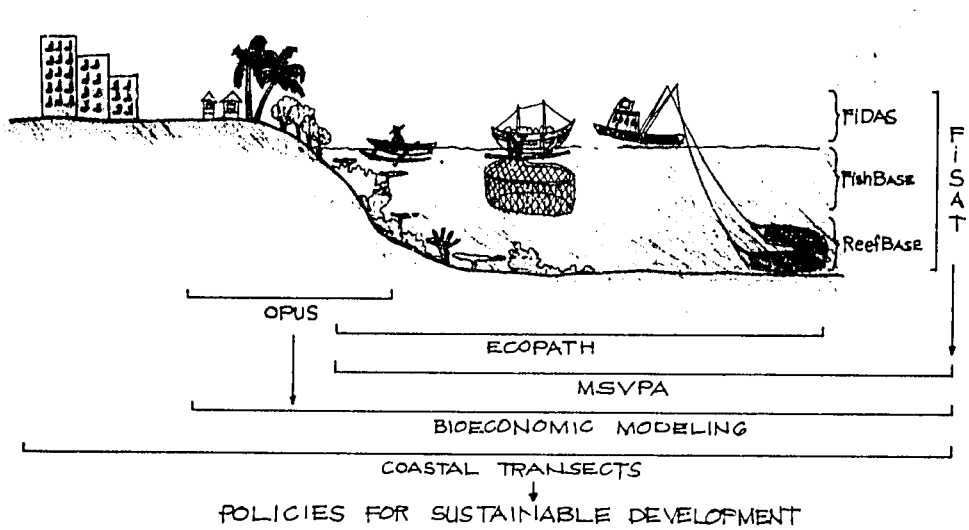


Box 2: Coastal Transects. A hypothetical coastal cross section illustrating biomass and cash flows between small-scale fishers (huts behind the coastal mangroves), processors/intermediaries (hut marked "P") and a nearby city. The arrows may be quantified and other data on land and aquatic resource and ownership patterns added.

An international workshop on "Management of Coral Reef Resource Systems" was held at the Australian Institute of Marine Science, Townsville, on March 1992, to make recommendations both to ICLARM and the Australian Government on future research needs.

ICLARM's Medium-Term Planning work, which continued throughout the latter half of the year, has involved many persons, both within and outside the Center, as well as a number of meetings with experts in various fields; a planning committee of Center staff undertook the major role of writing and coordinating. The Plan will be presented to the CGIAR's Technical Advisory Committee early in 1993.

Based on progress to date, ICLARM believes that its Medium-Term Plan, based on an ecosystem approach, will reflect urgent needs in international strategic research in aquatic resource management.



Box 3: ICLARM Software. Diagrammatic representation of the application of ICLARM software to aquatic resource management. The goal is to provide the best possible advice for creating and continuously improving policies for sustainable development.

ADMINISTRATION AND FINANCE

ast year's report discussed how events and circumstances in specific periods of an organization's history can permanently and very significantly change the character of that organization. The report identified several such periods in ICLARM's history and heralded 1991 as the beginning of another such period for ICLARM as its Strategic Plan was developed and completed.

This period of transition and change which began in 1991 continued into 1992. The events that increased the pace of change in 1992 were the external review of ICLARM, ICLARM's formal admission into the Consultative Group for International Agricultural Research (CGIAR) and the start-up of medium-term planning activities.

In January 1992, an external panel composed of experts from various disciplines completed and presented to the ICLARM Board of Trustees and management, programs and strategies. This panel of reviewers was commissioned by the CGIAR to conduct an independent and thorough appraisal of ICLARM and all of its activities. The panel was also requested by the CGIAR to assess ICLARM's suitability as a potential member of the CGIAR system.

The external panel's report identified ICLARM's strengths and weaknesses as an international research institution. The report also detailed a set of actions that needed to be taken by ICLARM's trustees, management and staff in order to overcome its identified weaknesses and improve its institutional effectiveness. Among the panel's major recommendations concerning management were the following:

- action to change its legal status to that of an international institution;
- approval and implementation of an improved set of human resource management policies and practices;
- achievement of a better balance between restricted and unrestricted funding of its programs and projects;
- improved financial management in terms of planning and control;
- improved integration and coordination of its programs;
- more systematic program planning, monitoring and evaluation; and
- increased understanding of national agencies (or NARS) as primary clients and to build stronger linkages with them.

These recommendations were accepted by ICLARM's Board and management who then established an intensive plan

to address these recommendations and achieve the intended results within the three-year period before the next external review. The Center's positive response to the external review paved the way for ICLARM's formal admission in May 1992 as the eighteenth Center in the CGIAR.

Among the first requirements imposed by the CGIAR on its newest member was the preparation of a Medium-Term Plan covering the period 1994-1998. The preparation of this plan was begun in earnest in July with the assistance of Dr. Sten Sverdrup-Jensen whose services were provided to ICLARM by Denmark.

The development of the Center's Medium-Term Plan revisited many of the issues discussed during the preparation of the Strategic Plan. The shorter time frame of the plan and the recognition of resource constraints renewed the discussions on Center priorities and client needs. ICLARM had to deal with the many pressing demands for the services of the Center in spite of very limited budgets. Numerous internal iterations were required before some degree of consensus began to be apparent.

While all this was going on, management began to address key areas identified in the report of the external review panel. The salary administration system was reviewed in depth through a series of job evaluation exercises participated in by ICLARM staff. This new system was reviewed and approved by the Board of Trustees in June 1992 and implemented immediately.

ICLARM also began to change its financial management and reporting systems and to align these with those of the CGIAR. A lot of work was put into restructuring the Center's Chart of Accounts and Codes to allow for accurate and fast data capture and reporting. Reporting formats were also developed with the objective of making the reports more useful to the users of financial information.

Due to the major changes being undertaken throughout the entire Center, the fact that the Center registered a growth of over 35% (in terms of expenses) in 1992 escaped the notice of most staff. The effects of this steep growth, however, were felt in the form of severe cash flow difficulties and processing delays as the administrative support systems were overloaded because of increased transactions. Management effort for 1993 will be the continuing development of systems to handle a larger center.

Governance

Board Membership

The final terms of Dr. Martin Bilio, Ms. Hannah King and Dr. Keishi Amano, all having served as Trustees since 1986, expired at the end of the 1992 Annual Board of Trustees Meeting. At the same meeting, Dr. E.A. Huisman also announced his decision to resign from the ICLARM Board as a result of his acceptance of the invitation to be a member of CGIAR's Technical Advisory Committee (TAC).

Elected as new trustees to their first three-year term were the following:

a) Dr. Nyle Brady: Currently a consultant to the United Nations Development Programme (UNDP). Formerly a Director General of the International Rice Research Institute (IRRI) from 1973 to 1981 and Senior Assistant Administrator for Science and Technology, USAID.

b) Dr. Masaru Fujiya: Senior Advisor and Consultant of the Overseas Fishery Cooperation Foundation (Tokyo), formerly Director General of the National Research Institute of Fisheries Science (Tokyo) and of the Japan Sea Regional Fisheries Research Institute (Niigata).

c) Dr. Jacqueline McGlade: Currently Professor and Institute Director at the Forschungszentrum Jülich, Germany; and Programme Director of Project Prospero, University of Cambridge, UK.

d) Ms. Britha Mikkelsen: Currently Education and Training Planner and Sociologist to COWIconsult, Consulting Engineers and Planners AIS, Denmark; and formerly Course Planner and Lecturer in Third World Studies under Technical University, Copenhagen, Denmark.

During the year, the newly-elected President of the Philippines, Fidel V. Ramos, appointed Mr. Roberto Sebastian to replace Mr. Senen Bacani as Secretary of the Department of Agriculture. As a result of this appointment, Mr. Sebastian assumed the ex-officio position reserved on ICLARM's Board of Trustees for the most senior Philippine government official in charge of fisheries.

Elected at the 1992 meeting to serve a final three-year term to end in 1995 was Dr. Zimani Kadzamira.

The full Board membership for the Annual Meeting 1992 follows:

1. Dr. Dayton L. Alverson: Owner/President of Natural Resources Consultants, Inc., Seattle (1980 to present).
2. Dr. Keishi Amano: Tokai Regional Fisheries Research Laboratory (1950-1975); Tokyo University of Fisheries-Professor (1975-1979), President (1979-1985). ICLARM Board Member since 1985.
3. Dr. Agustin Ayala-Castañares: Institute of Marine Science and Limnology, National Autonomous University of Mexico (UNAM) - Senior Researcher (1973 to present). ICLARM Board Member since 1989.
4. Dr. Martin Bilio: Deutsche Gesellschaft für Technische Zusammenarbeit (Germany Agency for Technical Cooperation) - Head, Fisheries and Aquaculture (1982 to present). ICLARM Board Member since 1986.
5. Dr. Barry K. Filshie: Officer-In-Charge, Commonwealth Scientific and Industrial Research Organisation (CSIRO), International Relations Centre, Australia (1983 to present).
6. Dr. Edgardo D. Gomez: University of the Philippines - Director, Marine Science Institute (1975 to present). ICLARM Board Member since 1989.
7. Dr. E.A. Huisman: Department of Fish Culture and Fisheries. The Netherlands - Head. Elected ICLARM Board Member in 1989.

8. Dr. Zimani David Kadzamira: Chancellor College, University of Malawi - Principal (1981 to present). Elected ICLARM Board Member in 1989.
9. Ms. Hannah R. King: Commonwealth Secretariat (London) - Fisheries Officer, Food Production and Rural Development Division. ICLARM Board Member since 1986.
10. Dr. Peter A. Larkin: University of British Columbia - Vice President, Research (1986 to present), Professor, Resource Ecology and Department of Zoology (1969 to present). ICLARM Board Member since 1989.
11. Dr. Kenneth T. MacKay: ICLARM - Director General.
12. Dr. David Adolph Philipp Muller: South Pacific Forum Fisheries Agency - Director (1981 to present). ICLARM Board Member since 1989.
13. Dr. Cornelia Nauen: Senior Fisheries Cooperation Officer, Commission of the European Communities (1990 to present).
14. Mr. Roberto Sebastian: Minister, Philippine Department of Agriculture (1992).

1992 Board Meetings

In 1992, the Center's Board of Trustees held the following meetings:

- Special Board of Trustees Meeting, 27 to 31 January 1992 (to receive, discuss and respond to the report of the External Review Panel on the External Program and Management Review of ICLARM)
- 17th Annual Meeting of the Board fo Trustees, 8 to 12 June 1992
- Program Committee Meeting, 8 and 9 June 1992
- Nominating Committee Meeting, 10 June 1992
- Finance and Management Committee Meeting, 10 June 1992
- Executive Committee Meeting, 24 and 25 October 1992

Board Officers and Committees, 1992

Board Officers (1991-1992)

1991-92:

Chairperson	-	Dr. Peter Larkin
First Vice Chairperson	-	Mr. Senen Bacani
Second Vice Chairperson	-	Dr. E.A. Huisman
Secretary	-	Mr. Basilio Rodriguez, Jr.
Treasurer	-	Dr. Roger S.V. Pullin

Board Committees

1. Executive Committee

Functions:
- To implement and execute the policies and decisions laid down by the Board.

- 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:

1991-92: Dr. Peter Larkin - Chairperson
Mr. Senen Bacani
Dr. E.A. Huisman
Dr. Zimani Kadzamira
Dr. Martin Bilio
Dr. Kenneth MacKay (ICLARM Director General)

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:

1991-92: Dr. E.A. Huisman
Dr. Peter Larkin
Mr. Senen Bacani
Dr. Zimani Kadzamira
Dr. Martin Bilio
Dr. Kenneth MacKay (ICLARM Director General)

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:

1991-92:
Dr. Martin Bilio - Chairperson
Dr. Agustin Ayala-Castañares
Dr. Peter A. Larkin
Dr. Edgardo Gomez
Dr. Philipp Muller
Dr. Kenneth MacKay (ICLARM Director General)

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:

1991-92:
Dr. Zimani Kadzamira - Acting Chairperson
Dr. Agustin Ayala-Castañares
Dr. Keishi Amano
Ms. Hannah King
Dr. Kenneth MacKay (ICLARM Director General)

Statement of Revenues, Expenses and Fund Balance (in US$)

	1992	1991
Revenues		
Grants	6,760,944	4,491,707
Consultancy and service fees	9,061	30,234
Publications	39,370	34,713
Overhead income	-	171,399
Interest income	6,867	23,126
Insurance and other expense refunds	9,735	4,388
Gain on foreign exchange	7,947	-
Miscellaneous	99,507	11,626
Total	6,933,431	4,767,193
Expenses		
Aquaculture	1,610,063	1,956,157
Capture Fisheries Management	798,804	750,079
Coastal Area Management	919,958	750,650
Coral Reef Systems	447,604	-
Library and Information Services	767,524	228,158
National Research Strengthening	438,155	-
Strategic Planning	256,312	185,344
Administration & Finance*	1,033,558	769,498
Translation loss (gain)	54,173	(80,485)
Total	6,326,151	4,559,401
Excess (Deficiency) of Revenues over Expenses before Other Charges	607,280	207,792
Other Charges	136,693	-
Excess of Revenues Over Expenses	470,587	207,792
Fund Balance at Beginning of Year	325,339	117,547
Fund Balance at End of Year	795,926	325,339

*Includes capital expenses.

1992 Sources of Support

1. Unrestricted Support

International Bank for Reconstruction and Development (IBRD)
Danish International Development Agency (DANIDA)
Government of Norway
Canadian International Development Agency (CIDA)
Australian International Development Assistance Bureau (AIDAB)
United States Agency for International Development (USAID)
Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ)
Ford Foundation
Philippine Government

2. Restricted Support

Activity	Sources of 1992 Support
ASEAN Coastal Resources Management Project	United States Agency for International Development (USAID)
Asian Fisheries Social Sciences Research Network III	International Development Research Centre (IDRC) of Canada
Bangladesh Aquacultural Research Project III	United States Agency for International Development (USAID)
Bellagio Environment Conference	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Bibliography of St. Mary's University	International Development Research Centre (IDRC)
A Collaborative Investigarion of Predation on Cultivated Giant Clams (Tridacnidae, Bivalvia)	Australian International Development Assistance Bureau (AIDAB)
Conference on Waste Management in the Coastal Areas of the ASEAN Region: Roles of Governments, Banking Institutions, Donor Agencies, Private Sector and Communities	ASEAN-Canada Centre (CAC)
Conference on Waste Management Problems in the Coastal Areas of the ASEAN Region	Asian Development Bank (ADB)
Directory for Education and Training Opportunities	Food and Agriculture Organization of the United Nations (FAO)
Establishment of a Database for Aquatic Organisms of Current and Future Potential Importance in Developing-Country Fisheries Development (I)	Commission of the European Communities (CEC)

Establishment of a Database for Aquatic Organisms of Current and Future Potential Importance in Developing-Country Fisheries Development (II)	Commission of the European Communities (CEC)
Establishment of a Database for Aquatic Organisms of Current and Future Potential Importance in Developing-Country Fisheries Development (III)	Commission of the European Communities (CEC)
Expansion of Giant Clam Production: Coastal Aquaculture Centre	Forum Fisheries Agency (FFA)
Experiments in New Approaches to Managing Openwater Fisheries in Bangladesh	Ford Foundation
Farming Systems Research (FSR) Methodologies Workshop for a Bangladeshi Research Scientist and Publication of a Training Manual on Gender Issues on FSR	Ford Foundation
FishBase (French Version)	Agence de cooperation culturelle et technique (ACCT)
Genetic Improvement of Farmed Tilapia (Phase I)	United Nations Development Programme (UNDP)
Genetic Improvement of Farmed Tilapia	World Bank (WB)
Genetic Improvement of Tilapia Species in Asia	Asian Development Bank (ADB)
Geographic Information System for Coastal Area Management and Planning	International Development Research Centre (IDRC) of Canada
Giant Clam Conservation and Cultivation Booklet	Greenpeace Foundation
Giant Clam Genetics Workshop	International Development Research Centre (IDRC) of Canada
Global Comparisons of Multispecies Trophic Modelling	Danish International Development Agency (DANIDA)
Global Scale Temporal Changes in Marine Ecosystems	National Oceanic and Atmospheric Administration
Hilsa Bangladesh Project Group	International Development Research Centre (IDRC) of Canada
ICLARM's Future Program	United Nations Development Programme (UNDP)
Infoterra Special Sectoral Source	Food and Agriculture Organization of the United Nations (FAO)

International Symposium for Tilapias in Aquaculture III	Agence de cooperation culturelle et technique (ACCT)
Interregional (Asia-Africa) Cooperation in Aquaculture	Government of France
Management Planning Expert	Danish International Development Agency (DANIDA)
Multivariate Analysis in Aquaculture: Selected Cases from Research and Production-Oriented Tilapia Culture	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Network of Tropical Fisheries Scientists	Norwegian Agency for International Development
ODA Giant Clam Project Phase III	Overseas Development Administration (ODA)
Pearl Oyster Study	Overseas Development Administration (ODA)
Research Collaboration between ICLARM and the Institute of Aquatic Biology	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Research Grant to T. Molea to Study the Effects of Various Zooxonthellae Strains on the Growth and Survival of Giant Clams	Asian Fisheries Society
Research in Rice-Fish Farming	Overseas Development Administration (ODA)
Research on the Development of Tropical Aquaculture Technology Appropriate for Implementation in Rural Africa (Phase III)	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Research on the Tilapia Genetic Resources of Ghana for their Future Conservation and Management in Fisheries and Aquaculture	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Research Program on the Impact of Fish Culture within the Farming Systems in Bangladesh	International Fund for Agricultural Development (IFAD)
Resource and Ecological Assessment for San Miguel Bay	Department of Agriculture of the Philippines
Review of Strategies for Common Properties on Coastal Fisheries Management	International Development Research Centre (IDRC) of Canada
Rice-Fish Asia Working Project Group (CLSU-FAC/ICLARM)	International Development Research Centre (IDRC) of Canada

Rider to the Contract on the Establishment of a Database (FishBase) for Developing Countries Fisheries Development	Commission of the European Communities (CEC)
Selective Fisheries Information Service	International Development Research Centre (IDRC) of Canada
Sierra Leone West Northwest Artisanal Fisheries and Community Development Research Cooperation between IMBO and ICLARM	Commission of the European Communities (CEC)
Social Science Research Fellowship of Eric Worby	Rockefeller Foundation
Social Science Research Fellowship of William Sunderlin	Rockefeller Foundation
Socio-Economic Study of the Impact of a Fish Culture Extension Program on the Farming System in Bangladesh	Danish International Development Agency (DANIDA)
Software Stock Assessment Project	Food and Agriculture Organization of the United Nations (FAO)
Strategic Plan (ICLARM)	International Development Research Centre (IDRC) of Canada
Study of the Puttalam/Mundal Lake Estuarine System and Associated Coastal and Estuarine Waters	Swedish Environmental Research Institute (SAREC)
Third World International Symposium on Tilapia in Aquaculture (ISTA III)	Government of France
Training of J.P.T. Dalsgaard	Danish International Development Agency (DANIDA)
Workshop on Management of Coral Reef Resource System	Australian International Development Assistance Bureau (AIDAB)

Meetings Attended, Papers Presented

Second Regional Consultation on Climate Change, Puncak and Jakarta, Indonesia, 20-31 January. (J.N. Paw).

Paper presented:

Paw, J.N. Impact of climate change on ocean and coastal environment in Southeast Asia.

AFSSRN Team Leaders' Meeting, Manila, Philippines, 22-24 January. (A.A. Agulto; J.E. Padilla; H.M. Montalvo; R.S. Pomeroy).

Paper presented:

Padilla, J.E. A bi-criteria programming model for fisheries management in tropical countries.

Workshop on Culture of Magur (*Clarias gariepinus*), Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 2 February. (M.V. Gupta).

Workshop to Produce a Farmer-Proven Integrated Agriculture-Aquaculture: A Technology Information Kit, International Institute of Rural Reconstruction, Silang, Cavite, Philippines, 2-15 February. (M. Ahmed; M.P. Bimbao; A. Contemprate; C.R. dela Cruz; J.P.T. Dalsgaard; M.V. Gupta; C. Lightfoot; R.P. Noble; M. Prein; R.S.V. Pullin; J. Sollows; E. Worby).

Papers presented:

Ahmed, M. and M.P. Bimbao. Economic considerations in introducing integrated agriculture-aquaculture technologies.

Bimbao, M.P. Bibliography on integrated farming.

Bimbao, M.P., J.P.T. Dalsgaard and F.V. Fermin. The case of rice-fish farmer Mang Isko, Dasmariñas, Cavite, Philippines.

dela Cruz, C.R. Rice-fish systems in Indonesia.

dela Cruz, C.R. Sawah, tambak rice-fish system in Indonesia.

dela Cruz, C.R., R.C. Sevilleja and J. Torres. Rice-fish in Guimba, Nueva Ecija, Philippines.

Gupta, M.V. Culture of short-cycle species in seasonal ponds and ditches of Bangladesh.

Gupta, M.V. and F. Noble. Integrated poultry-fish farming.

Lightfoot, C. and J. Gonsalves. Introduction.

Little, D., N. Innes-Taylor, D. Turongruang and J. Sollows. Fry nursing in rice-fish systems.

Noble, R.P. and C. Lightfoot. Working with new entrants to integrated agriculture-aquaculture.

Pullin, R.S.V. Integrated agriculture-aquaculture and the environment.

Sollows, J. Site selection: where to culture fish with rice?

Sollows, J. Preparation of field for rice-fish culture.

Sollows, J. Stocking for rice-fish culture.

Sollows, J. Fish as a component of integrated pest management (IPM) in rice production.

Sollows, J. Feeding and maintenance in rice-fish systems.

Sollows, J. and C.R. dela Cruz. Rice management in rice-fish culture.

Sevilleja, R., J. Torres and D. Little. Using animal wastes in fishponds.

Worby, E. Sociocultural considerations when introducing a new integrated agriculture-aquaculture technology.

IVth World Congress on National Parks and Other Protected Areas, Caracas, Venezuela, 10-21 February. (M. Pido).

Paper presented:

Pido, M. 1992. Exploratory notes on the role of military and police forces in protected area management with emphasis on some coastal parts in the Philippines.

Fifth ALCOM Steering Committee Meeting, Club Makokola, Mangochi, Malawi, 11-14 February. (D. Jamu).

Technical Consultation on "Genetical Methods for the Discrimination of Fish Populations, both in Aquaculture and Conservation, Hamburg, Germany, 20-22 February. (A.E. Eknath).

Paper presented:

Eknath, A.E. Morphometric and biochemical approaches to characterize tilapias.

Annual Meeting of Directors of West African Fisheries. Abidjan, Côte d'Ivoire, 27-29 February. (E. Kaunda).

Presentation of FishBase project and objectives in Africa.

Seminar on Exotic Species Threats to African Aquatic Ecosystems, Cornell University, The Biological Station, Bridgeport, New York, USA, 23 February. (B.A. Costa-Pierce).

Seminar presented:

Costa-Pierce, B.A. Exotic species threats to African aquatic ecosystems.

Seminar on Fisheries Ecology and Environmental Threats to Lake Malawi, Africa, Cornell University, Department of Natural Resources, Ithaca, New York, USA, 3-4 March. (B.A. Costa-Pierce).

Seminars presented:

Costa-Pierce, B.A. Smallholder aquaculture development in Malawi, Africa.

Costa-Pierce, B.A. Fisheries, ecology and environmental threats to Lake Malawi, Africa.

Special Seminar, School of Biological Sciences, James Cook University of North Queensland, Townsville, Australia, 3-5 March. (D. Pauly).

Paper presented:

Pauly, D. Population dynamic studies of tropical fishes: a comparative approach.

ICLARM/AIDAB Workshop on Management of Coral Reef Resource Systems, Australian Institute of Marine Science, Townsville, Australia, 3-5 March. (R. Froese; K.T. MacKay; J.L. Munro, Convenor; D. Pauly).

Papers presented:

Froese, R. REEFBASE - a global database of coral reef systems and their resources.

Munro, J.L. Cultivation of fishes and invertebrates in coral reef environments.

Pauly, D. and V. Christensen - Modelling coral reef ecosystems.

Pomeroy, R.S. - Management systems for coral reef fisheries.

22nd Session of the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), Vienna, Austria, 7-14 March. (T.E. Chua).

BARC/ISNAR Workshop on Strategic Planning: Planning to Plan, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 9-10 March. (M.V. Gupta).

EEC Workshop and Planning Meeting for the Central and Northern Fish Farming Project, Mzuzu, Malawi, 9-13 March. (D. Jamu).

Workshop on Networking for Low-External Input and Sustainable Agriculture, International Institute of Rural Reconstruction, Silang, Cavite, Philippines, 9-15 March. (C. Lightfoot).

Paper presented:

Lightfoot, C. Networking and AFSRE.

Review Meeting on Fisheries Research Plan for the Fourth Five-Year Plan Period 1990-95, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 10 March. (M.V. Gupta).

Workshop on Coastal Area Management Guidelines, The World Bank, Washington, DC, USA, 16-18 March. (T.E. Chua).

USAID/SHARED NGO Agriculture Task Force Meeting, Blantyre, Malawi, 20 March. (B.A. Costa-Pierce).

Canadian Conference on GIS 1992, Ottawa, Canada, 24-26 March. (J.N. Paw).

Paster presented:

Paw, J.N., D.A.D. Diamante, N.A. Robles and T.E. Chua. Site selection for brackishwater aquaculture development and mangrove reforestation in Lingayen Gulf, Philippines using a geographic information system.

SEAFDEC Research Seminar, Iloilo, Philippines, 27 March. (H.M. Montalvo; R.S. Pomeroy).

Paper presented:

Pomeroy, R.S. Managing the commons: an institutional perspective on resource management.

National Research Coordination Meeting, Domasi, Malawi, 3 April. (F.J. Chikafumbwa; B.A. Costa-Pierce, Chairperson; D. Jamu; E. Kaunda; R.P. Noble).

SAS Users Group International Conference, Honolulu, Hawaii, 5-8 April. (C. Janagap).

Conference on University Research for Development, Bunda College of Agriculture, University of Malawi, Lilongwe, Malawi, 6-7 April. (B.A. Costa-Pierce).

CARICOM Workshop on Management of Coral Reef Resources, Tobago, Trinidad and Tobago, 12-15 April. (J.L. Munro).

Papers presented:

Munro, J.L. Conservation and management of coral reef resource systems in the Indo-West Pacific.

Munro, J.L. Options for rehabilitation, sustainable utilization and management of coral reef fishery resources.

Pacific Island Nation Technical Workshop on Fisheries Education and Training, Noumea, New Caledonia, 13-14 April. (T.E. Chua).

Seminar/Workshop on the Principles of Economic Valuation, Bali, Indonesia, 20-24 April. (A.A. Agulto; H.M. Montalvo; J.E. Padilla; R.S. Pomeroy).

Paper presented:

Pomeroy, R.S. Fisheries management and economic valuation.

AFSSRN Team Leaders' Meeting, Bali, Indonesia, 22 April. (A.A. Agulto; H.M. Montalvo; R.S. Pomeroy).

Seventh National Aquaculture Coordination Meeting, Lilongwe, Malawi, 23-24 April. (B.A. Costa-Pierce, F.J. Chikafumbwa, D. Jamu).

Workshop on National Consultation on Fisheries Extension, BOBP/Department of Fisheries, Fisheries Research Institute, Mymensingh, Bangladesh, 25-27 April. (M. Ahmed; M.V. Gupta).

Paper presented:

Gupta, M.V. and M. Ahmed. Aquaculture technology dissemination under International Center for Living Aquatic Resources Management (ICLARM) implemented projects.

Regional Workshop on Integrated Coastal Zone Planning and Management in ASEAN: Lessons Learned, Bandar Seri Begawan, Brunei Darussalam, 27-30 April. (T.E. Chua; S.C. Guerrero; C. Luna; J.N. Paw; M. Pido; R.S. Pomeroy; G. Silvestre).

Papers presented:

Chua, T.E. The ASEAN/US Coastal Resources Management Project: initiation, implementation and management.

Luna, C. and L. Quitos. Summary of the Lingayen Gulf coastal area management plan.

Paw, J.N. and M. Loo. The use of remote sensing and geographic information systems in coastal zone management.

Pido, M. and T.E. Chua. A framework for rapid appraisal of coastal environments.

Pomeroy, R.S. Economic valuation of coastal resources.

Scura, L.F., T.E. Chua, M. Pido and J.N. Paw. Lessons for integrated coastal zone management: the ASEAN experience.

World Fisheries Congress, Athens, Greece, 3-8 May. (M. Ahmed; T.E. Chua; D. Pauly).

Chairman's address:

Chua, T.E. History and goals of the World Fisheries Congress.

Papers presented:

Ahmed, M. An economic assessment model of riverine fisheries in Bangladesh.

Pauly, D. Assessment methodologies and fisheries management: how to keep making sense.

Pauly, D., F.C. Gayanilo, Jr., R. Froese and V. Christensen. The ICLARM software project.

Asian Institute of Technology Short Course on Integrated Aquaculture in Asia, Bangkok, Thailand, 4-28 May. (F.J. Chikafumbwa).

BARC/ISNAR Workshop on Long-Term Planning for Human Resource Development, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 5-6 May. (M.V. Gupta).

Workshop to Integrate Research Findings of the Joint Project on Small-scale Fishery and Shrimp Farming in Pak Phanang Bay: Options in Coastal Resources Management, Ko Samui, Thailand, 6-9 May. (H.M. Montalvo; R.S. Pomeroy).

FishBase National Steering Committee, Zomba, Malawi, 7 May. (B.A. Costa-Pierce; E. Kaunda; M.L.D. Palomares).

BARC/ISNAR Workshop on Research Priority Setting, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 19-20 May. (M.V. Gupta).

First Meeting for Establishing International Collaborative Linkage for Fish Genetics, Manila, Philippines, 30 May. (B.O. Acosta; A.E. Eknath; C. Janagap; R.S.V. Pullin; J. Rius; R. Velasco).

Workshop on Reducing Small Farmer Vulnerability in Bangladesh, Bangladesh Rice Research Institute, Joydebpur, Gazipur, Dhaka, Bangladesh, 30-31 May. (M.V. Gupta).

Paper presented:

Gupta, M.V. Aquaculture for small farmers - a technology development and dissemination strategy.

Workshop on International Concerns in the Use of Aquatic Germplasm, Caylabne, Cavite, Philippines, 1-5 June. (B.O. Acosta; A.E. Eknath; R. Froese; C. Janagap; R.S.V. Pullin; R. Velasco).

Paper presented:

Froese, R. A database approach to fish germplasm documentation.

FAO/Japan Expert Consultation on the Development of Community-Based Coastal Fishery Management Schemes for Asia and the Pacific, Kobe, Japan, 8-12 June. (T.E. Chua; R.S. Pomeroy).

Poper presented:

Chua, T.E., G. Silvestre, J.N. Paw, M. Pido and C. Luna. Coastal area monagement as framework for sustainable development of coastal fisheries: initiatives in Southeast Asia.

Meeting of the Multispecies Assessment Group of the International Council for Exploration of the Sea (ICES), Copenhagen, Denmark, 16-25 June. (V. Christensen).

Giant Clam Genetics Workshop, ICLARM, Manila, Philippines, 18-19 June. (M.H. Gervis; J.L. Munro; P.E. Munro, Convenor; C. Oengpepa).

Papers presented:

Gervis, M.H. Giant clam genetics and hatchery procedures.

Munro, J.L. Strategies for re-establishment of wild giant clam stocks.

Oengpepo, C. Country report: Solomon Islands.

Seventh International Coral Reef Symposium, Agana, Guam, 22-26 June. (R. Froese; M. Gervis; H. Govan; J. Hambrey; J.L. Munro; P.E. Munro; C. Oengpepa).

Papers presented:

Govan, H. Pests and predators of maricultured tridacnid clams.

Hambrey, J.B. and M.H. Gervis. The economic potential of village based farming of giant clams (*T. gigas*) in the Solomon Islands.

Munro. J.L., L.A. Gilkes, M.H. Gervis and J.B. Hambrey. Growth and survival of giant clam spat in floating ocean nurseries.

Poster presented:

Froese, R. FishBase, a biological database with data on growth, mortality, diet composition, and morphology of coral reef fishes.

Colombo '92. International Conference on Ocean Management in Global Change, Genoa, Italy, 22-26 June. (T.E. Chua).

Workshop on Indigenous Knowledge and Sustainable Development in the Philippines, Cavite, Philippines, 23-27 June. (R.S. Pomeroy).

Paper presented:

Pomeroy, R.S. The role of community-based management and indigenous knowledge in coastal fisheries management.

National Workshop on Transfer of Agricultural Technologies, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 23-29 June. (M.V. Gupta).

Working Group on Predation on Giant Clams, Agana, Guam, 27 June. (H. Govan, Convenor; J. Hambrey).

Poper presented:

H. Govan. Summary report on activities at the ICLARM Coastal Aquaculture Centre.

Seventh Annual Management Development Course for Senior Staff from CGIAR Centers, Wintergreen, Virginia, USA, 29 June-10 July. (D. Pauly, participant).

FAO/Department of Fisheries Final Seminar and Findings of the Lake Malawi Chambo Project, Nkopola Lodge, Mangochi, Malawi, 8-10 July. (B.A. Costa-Pierce; E. Kaunda).

Seminar on Satellite Remote Sensing and Geographic Information Systems in Agricultural Research, International Rice Research Institute, Los Baños, Laguna, Philippines, 20-22 July. (Z.N. Alojado; J.N. Paw).

Workshop on Developing Rapid Rural Appraisal (RRA) Procedures for Coastal Zone, Silliman University, Dumaguete City, Philippines, 20-24 July. (M. Pido).

Lecture:

Pido, M. The rapid appraisal experience in Palawan and ICLARM's RACE concept.

MAGFAD/FD/ICLARM Workshop to Produce an Information Kit on Integrated Agriculture-Aquaculture for Fisheries Department Aquaculture Extension Officers, Malawi Institute of

Education, Domasi, Malawi, 27-31 July. (F.J. Chikafumbwa; D. Jamu; E. Kaunda; C. Lightfoot; R.P. Noble).

Papers presented:

Bauer, C., F.J. Chikafumbwa and S. Langston. Feeding of *Tilapia rendalli* and *Orechromis shiranus*.
Chikafumbwa, F.J. Integrated animal-fish systems.
Chikafumbwa, F.J. Integrated rice-fish systems.
Chikafumbwa, F.J. Integrated vegetable-fish systems.
Chikafumbwa, F.J. Seasonal fish farming in rain-fed areas.
Jamu, D. and B. Rashidi. Site selection and pond construction.
Jamu, D. Liming and pond fertilization.
Jamu, D. Making compost for fishponds.
Kaunda, E. Advising farmers on the techniques to use for harvesting fish from ponds.
Kaunda, E. Making and using a reed fence to harvest fish from ponds.
Kaunda, E. and A. Janke. Harvesting in nondrainable ponds.
Noble, R.P. How to use information kit.
Noble, R.P. Introduction to information kit.
Noble, R.P. and C. Lightfoot. Working with new entrants to integrated agriculture-aquaculture.

Tenth Standing Conference for Eastern, Central and Southern African Librarians, Dar es Salaam, Tanzania, 27 July-1 August. (C. Jamu).

Paper presented:

Jamu, C. Evaluation of the aquatic sciences and fisheries abstract searches in Africa.

National Fisheries Research Program Annual Research Review, Bureau of Soils and Water Management, Diliman, Quezon City, Philippines, 29-31 July. (M.L.D. Palomares, evaluator).

Foundation Course on Environmental Management, Tagaytay City, Philippines, 9-14 August. (M.P. Bimbao).

ISNAR/BARC Workshop on Human Resource Development Planning, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 17-18 August. (M.V. Gupta).

Meeting of CGIAR Social Scientists, The Hague, The Netherlands, 17-20 August. (R.S. Pomeroy).

Paper presented:

Pomeroy, R.S. Institutional arrongements for community-based coastal fisheries management: common property resources.

Fifteenth Program Commitee Meeting, Southeast Asian Fisheries Development Center, Singapore, 18-21 August. (J.L. Maclean).

Malawi Award for Scientific and Technology Achievement and Commemoration of Scientific Revival Day of Africa in Blantyre, Malawi, 29-30 August. (F.J.Chikafumbwa; D.M. Jamu; E. Kaunda).

Poster presented:

Chikafumbwa, F.J., D. Jamu and E. Kaunda. Aquaculture technology development appropriate for rural Africa.

International Workshop on Genetics in Aquaculture and Fisheries Management, University of Stirling, UK, 31 August-4 September. (L. Agustin).

Paper presented:

Agustin, L., R. Froese, A. Eknath and R.S.V. Pullin. Documentation of genetic resources for aquaculture - the role of FishBase.

NARA-NARESA-SAREC Workshop on Coastal Ecosystem Study Programme, Colombo, Sri Lanka, 8-9 September. (J.E. Padilla).

Twelfth Annual Farming Systems Symposium, Association for Farming Systems Research/ Extension, Michigan State University, East Lansing, Michigan, USA, 13-18 September. (M. Ahmed; Clive Lightfoot; Reg Noble).

Paper presented:

Lightfoot, C. and R.P. Noble. Sustainability and on-farm experiments: ways to exploit participatory and systems concepts.

Poster presented:

Ahmed, A. and M. Abdur Rab. Feasibility of adopting aquaculture without detriment to existing farming practices: a case of Bangladesh farming systems.

Conference of the International Association for the Study of Common Property, Washington, DC, USA, 17-20 September. (M. Ahmed).

Paper presented:

Ahmed, M., D. Capistrano and M. Hossain. Redirecting benefits to genuine fishermen: Bangladesh's new fisheries management policy.

DANIDA CGIAR Day, Orientation for Danish Agricultural Institutions, Copenhagen, Denmark, 18 September. (V. Christensen).

Lecture:

Christensen, V. Working in the CG system.

International Symposium on Indigenous Knowledge (IK) and Sustainable Development, International Institute of Rural Reconstruction, Silang, Cavite, Philippines, 20-26 September. (M.L.D. Palomares).

Paper presented:

Palomares, M.L.D. and D. Pauly. FishBase as a worldwide computerized repository of ethno-ichthyology or indigenous knowledge on fishes.

Third ASEAN Science and Technology Week, Singapore, 21-25 September. (R. Atanacio; R.C. Josue).

Exhibit of ASEAN/US CRMP publications.

Invited Speakers Series, Department of Anthropology, McGill University, Montreal, Canada, 24 September. (E. Worby).

Paper presented:

E. Worby. Journeys of power, gifts of rain: the flow of objects through social and ritual time in Gokwe, Zimbabwe.

80th ICES Statutory Meeting, Rostock, Germany, 24-29 September. (V. Christensen; R. Froese).

Papers presented:

Christensen, V. A model of trophic interactions in the North Sea in 1981, the Year of the Stomach.

Froese, R. Progress report on FishBase.

Froese, R. Synopsis of biological data on *Platichthys flesus* (L.), ICES Sub-division 24, using the FishBase data format.

Froese, R. Synopsis of biological data on *Clupea harengus* (L.), ICES assessment units 22 and 24, using the FishBase data format.

International Society of Ecological Modelling (ISEM) Eighth International Conference on the State-of-the-Art in Ecological Modelling, Kiel, Germany, 28 September-2 October. (V. Christensen, panelist in round-table discussion on "Modelling as a Tool for Management of Natural Resources in Developing Countries").

Paper presented:

Christensen, V. On the behavior of some proposed goal functians for ecosystem development.

Pastoral and Agrarian Studies Equipe, McGill University, Montreal, Canada, 30 September. (E. Worby).

Slide/lecture presented:

E. Worby. Ponds as common property in Bangladesh.

Workshop on the Protection and Sustainable Use of Wetland Resources in the Philippines, Institute of Forest Conservation, University of the Philippines, Los Baños, Laguna, Philippines, 30 September-2 October. (J.E. Padilla).

Paper presented:

Padilla, J.E. and D. Pauly. The role of ICLARM in wetland protection, utilization and management.

Asian Regional Training of Trainers and Meeting of Distributors of UNESCO's CDS/ISIS Software Package, Diliman, Quezon City, Philippines, 5-9 October. (N.I. Jhocson).

Meeting of the International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC), Bremerhaven, Germany, 5-9 October. (J.L. Maclean).

JICA Fisheries Sector (Project Formulation Survey) Meeting, Lilongwe, Malawi, 14 October. (D. Jamu).

NGO Fish Culture Workshop: Strategies Towards Benefitting the Poor. Organized by the Intermediate Technology Development Group and Association of Development Agencies in Bangladesh, Dhaka, Bangladesh, 15-17 October. (E. Worby).

Workshop on Participatory Research Methods for Coastal Resources Development, Iloilo City, Philippines, 18-23 October. (M. Dalusung; M. Pido).

Lecture:

Pido, M. Participatory processes in rapid appraisal and RACE concept.

Seminar on Participatory Rapid Rural Appraisal: Methods and Experiences from South Asia, Quezon City, Philippines, 26 October. (M.P. Bimbao).

International Centers Week, Washington, DC, USA, 26-30 October. (J.L. Maclean).

The Third Asian Fisheries Forum, World Trade Centre, Singapore, 26-30 October. (A.A. Agulto; M. Ahmed; H. Bolivar; T.E. Chua; A. Cruz-Trinidad; L.B. Dizon; A.E. Eknath; L. Garces; M.V. Gupta; M.A. Juinio; I. Lane; C. Luna; J.E. Padilla; D. Pauly, Session Chairperson; J.N. Paw; R.S. Pomeroy, Symposium Coordinator and Chairperson, Socio-economics in Fisheries; G. Silvestre).

Keynote address:

Chua, T.E. Asian fisheries towards the year 2000: a challenge to fisheries scientists.

Papers presented:

Ahmed, M., M.A. Rab and M.P. Bimbao. Problems and potentials of fish farming in small waterbodies in Bangladesh.

Akhteruzzaman, M., A.H.M. Khohinoor, A. Rahman and M.V. Gupta. Red tilapia production potential under low-input management in Bangladesh.

Bolivar, H., M. de Vera, R. Reyes, R.B. Bolivar, H.B. Bentsen and A E. Eknath. Early growth and survival of eight strains of Nile tilapia (*Oreochromis niloticus*) and their crosses.

Cruz-Trinidad, A. Modifying domestic resource cost to reflect environmental cost of prawn farming in the Philippines.

Eknath, A.E., J.B. Capili, J.C. Donting, E.E. Dionisio, R.A. Reyes, N.D. Gerundo, M.M. Tayamen and R.S.V. Pullin. Experiences with the importation and quarantine of germplasm for developing a national tilapia breeding program in the Philippines.

Garces, L.R. and D.J. Mendoza. A review of the chemicals used in aquaculture activities in the Philippines.

Gentiles-Torres, A., M.A. Juinio and E.D. Gomez. Natural diets of tropical spiny lobsters *Panulirus* spp.

Luna, C. Common property management: the case of Lingayen Gulf.

Padilla, J.E. and A. Cruz-Trinidad. Duality in socioeconomic conditions in capture fisheries: an investigation.

Paw, J.N., N.A. Robles and Z.N. Alojado. The use of geographic information systems: a case study of three sites in the Philippines.

Silvestre, G.T., S. Selvanathan and H.A.W. Ranimah. Assessment of the shrimp resources in the Brunei River estuary and adjacent waters.

Posters presented:

Dizon, L.B. The impact of two Philippine fisheries journals on international literature.

Palomares, M.L.D. and D. Pauly. Use of FishBase for assembling information on the fishes of Cambodia, Laos and Vietnam.

International Food Policy Research Institute Nutrition Workshop, Washington, DC, USA, 27 October. (J.L. Maclean).

AFSSRN Team Leaders' Meeting, Singapore, 29 October. (A.A. Agulto; R.S. Pomeroy).

Consultative Meeting on ICLARM's Role in Strengthening National Aquatic Research Systems (NARS) of Developing Countries, Singapore, 31 October-1 November. (M. Ahmed; A. Eknath; R.S.V. Pullin).

Public Awareness Association Meeting, International Food Policy Research Institute, Washington, DC, USA, 2-4 November. (J.L. Maclean).

Asian Farming Systems Association Symposium. Sustainable Agriculture: Meeting the Challenge Today, Colombo, Sri Lanka, 2-5 November. (M. Ahmed; M.P. Bimbao; J.P.T. Dalsgaard; M.V. Gupta; C. Lightfoot; R.S. Pomeroy).

Papers presented:

Ahmed, M., M.A. Rab and M.V. Gupta. Impact of new aquaculture technologies: preliminary results of an extension program on the farming systems of Bangladesh.

Gupta, M.V. and M.S. Shah. NGO linkages in developing aquaculture as a sustainable farming activity - a case study from Bangladesh.

Lightfoot, C., J.P.T. Dalsgaard, M.P. Bimbao and F. Fermin. Farmer participatory procedures for managing and monitoring sustainable farming systems.

Pomeroy, R.S. and M.P. Bimbao. Economic analysis of integrated farming systems: some methodological issues.

Poster presented:

Pullin, R.S.V. and M.P. Bimbao. Network of Tropical Aquaculture Scientists.

Second National Symposium in Marine Science, Mindanao State University, Tawi-Tawi, Philippines, 5-7 November. (E. Capuli).

Paper presented:

Capuli, E. and R. Froese. A preliminary checklist of Philippine fishes produced with FishBase, a global biological database on fishes.

FAO Expert Consultation on Utilization and Conservation of Aquatic Genetic Resources, Grottaferrata, Italy, 9-13 November. (A.E. Eknath; R.S.V. Pullin.

Consultative Workshop on the Management of San Miguel Bay, Naga City, Philippines, 26-27 November. (San Miguel Bay Project staff).

Fifth International Conference on New Information Technology, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, 30 November-2 December. (J.L. Maclean; R.M. Temprosa).

International Conference on Improving Soil Management for Intensive Cropping in the Tropics and Sub-Tropics, BARC/Soil Science Society of Bangladesh, Dhaka, Bangladesh, 1-3 December. (M.V. Gupta).

AFSSRN Workshop on Fisheries Management and Policy Research in Malaysia, Selangor, Malaysia, 2-3 December. (R.S. Pomeroy).

Annual Meeting of the American Anthropological Association, 5 December. (E. Worby).

Paper presented:

E. Worby. "You have come to civilize us": mirrors in the culture of modernity.

AFSSRN Workshop on Methods for Fisheries Socioeconomic Research, ICLARM Headquarters, Manila, Philippines, 7-9 December. (J.E. Padilla, lecturer; M.L.D. Palomares, lecturer; D. Pauly, lecturer; R.S. Pomeroy).

Fourth Governing Council Meeting of the Network of Aquaculture Centres in Asia-Pacific (NACA), Hong Kong, 8-11 December. (R. Froese).

Presentation of FishBase and of ICLARM statements.

ADVISORY SERVICES, TRAINING, SEMINARS

Coastal Area Management

Dr. Chua Thia-Eng served as a panel member of the Commission of the European Communities (CEC) Science and Technological Development (STD3) to evaluate research proposals for CEC funding on 25-27 February. He also served as team leader of a seven-man UNDP Global Environment Facility project formulation mission for preparing activities towards the prevention, control and management of the East Asian seas from 5 to 21 December.

Mr. Geronimo Silvestre and Dr. Jose Padilla reviewed the progress of the Swedish Agency for Research Cooperation with Developing Countries (SAREC) coastal ecosystem research cooperation with the National Aquatic Resources Agency (NARA) of Sri Lanka on 6-12 September.

Capture Fisheries Management

Dr. Villy Christensen served over a three-week period in February 1992 as Visiting Professor at the Asian Institute of Technology, Bangkok, Thailand, teaching a course for graduate students in Ecological Engineering and Modeling.

Dr. Daniel Pauly gave a special lecture series on Application of Trophic Interaction in Tropical Fish Population Dynamics: An Introduction to the Use of the ECOPATH II Software System, at the Center for Tropical Marine Ecology (ZMT), Bremen University, Germany, on 11-14 May 1992, and at the University of Bergen, Norway, 20-22 May 1992. He also acted as "Opponent" of Ms. Gabriella Bianchi during the defense of her thesis on "Demersal assemblages of tropical continental shelves," presented at the University of Bergen, 19 May 1992.

Dr. Christensen successfully defended his Ph.D. at the Royal Danish School of Pharmacy, Department of Environmental Chemistry, Copenhagen. The title of the thesis was "Network Analysis of Trophic Interactions in Aquatic Ecosystems;" it included 13 publications related to ecosystem modeling, all part of Dr. Christensen's scientific work on the ECOPATH project at ICLARM. The background and major findings of the project were presented by Dr. Christensen as part of a public lecture at the Royal Danish School of Pharmacy on 15 June 1992.

Dr. Christensen executed a short-term consultancy at FAO headquarters, Rome, Italy, 4-7 October 1992, on the

introduction of exotic predators in pelagic ecosystems. This resulted in a report entitled "Reflections on the Pelagic Food Web Structure in the Black Sea" co-authored with Dr. John F. Caddy of FAO.

Dr. Pauly taught an international diploma course on Assessment and Modeling of Artisanal Fisheries at the Programa EPOMEX, Universidad Autónoma de Campeche, Mexico, 9-13 November 1992.

Mr. F.C. Gayanilo organized and taught a training course in Fish Stock Assessment and Management at the Mindanao State University at Naawan, Misamis Oriental, Philippines, 7-12 December 1992.

Mr. Mario de los Reyes, a Philippine Ph.D. student at the University of Hamburg (Germany), spent the period from mid-1991 to mid-1992 at ICLARM HQ and during this time collected primary and secondary data from the largest lake in the Philippines, Laguna de Bay, for his dissertation. His work includes three models of energy flows in Laguna de Bay constructed under the supervision of Drs. Christensen and Pauly.

Mr. Ernesto Arias-Gonzales, a Mexican Ph.D. student at the Université de Perpignan (France), spent four weeks (28 September - 30 October) at ICLARM HQ preparing two models of the trophic interactions in a shallow coral reef area of a French Polynesian island. Dr. Pauly and Prof. R. Galzin were advisers of Mr. Arias-Gonzales, whose work during the stay at ICLARM was carried out in close cooperation with Dr. Christensen.

Aquaculture

The program staff undertook a wide range of advisory and other services in 1992. The Program Director, Dr. Roger Pullin, was a member of the External Evaluation Panel of the USAID-funded Pond Dynamics/Aquaculture Collaborative Research Support Program (CRSP). Dr. Pullin also continued to work as a member of the Advisory Panel of the UNDP/FAO Sepik River Fish Stock Enhancement Project, Papua New Guinea, and with Dr. Ambekar Eknath, joined an International Consultation on Aquaculture Genetics, convened by FAO in November.

Dr. Clive Lightfoot was one of the two reviewers for the FAO/SIDA Farming Systems Programme for Eastern and Southern Africa (Botswana, Kenya, Tanzania, and Zambia) for five weeks in October-November.

Dr. Mark Prein assisted the Programme for Rural Action (PRA), supported by the Deutsche Gesellschaft für Technische Zusammennarbeit (GTZ) Gmbh, in preparing terms of reference for a study on the productivity and potential of integrated agriculture-aquaculture use of village reservoirs in northern Ghana.

Dr. Lightfoot and Mr. Peter Dalsgaard provided training and advisory services on field research methods and software for researchers at the Mekong Delta Farming Systems Research and Development Centre, Can Tho University, Vietnam.

Program staff were also active in providing editorial reviews for international journals, among which Dr. Clive Lightfoot's position as Executive Editor of the Journal of the Asian Farming Systems Association deserves special mention. He also attended their Board meetings in September (Thailand) and November (Sri Lanka). Dr. Pullin serves on the Editorial Advisory Board of the same journal and on the Boards of "Aquaculture and Fisheries Management" and the journal of the Asian Fisheries Society, "Asian Fisheries Science."

Program staff also serve on the Boards of international organizations: Dr. Eknath is a member of the Board of the International Association of Geneticists in Aquaculture for Farming Systems Research and Extension, and on the International Symposium Organizing Committee of the Asian Farming Systems Association.

Other services provided by program staff in 1992 included reviewing of research proposals for donor organizations, including IDRC and the International Foundation for Science and graduate supervision of developed- and developing-country scientists. Dr. Lightfoot supervises Peter Dalsgaard (Denmark) and Gesa Horstkotte (Germany) at ICLARM and, together with Dr. Reg Noble, Kate Welland (UK) who works in Malawi.

Aquaculture staff in Malawi provided the following services:

- An awareness seminar concerning ICLARM on-farm research given to delegates at the FAO Aquaculture for Local Community Development Programme (ALCOM) steering committee meeting Mangochi, Malawi, 13 February 1992 (F.J. Chikafumbwa).
- Pond management, hatchery and integrated farming systems advice and training for Mr. E.E. Sahini from Mbarali Rice Farm Ltd., Rujewa, Tanzania, 14-24 July 1992 (F.J. Chikafumbwa).
- Advice and training given to District Youth Officers on integrated agriculture-aquaculture systems, 10-14 August 1992. (F.J. Chikafumbwa, D.M. Jamu).
- Advice and training given to smallholder tobacco growers on integrated agriculture-aquaculture systems, June 1992. (D.M. Jamu).
- Resource persons at a Malawi-German Fisheries and Aquaculture Development Project (MAGFAD) planning workshop on "Plan of operation for women's promotion in fisheries and aquaculture," 9-11 December 1992. (Reg Noble, Emma Mafuleka).

Coastal Aquaculture Centre

Dr. J.L. Munro participated in a consultation on Management of Coral Reef Resources which was convened in Tobago by the Caribbean Community (CARICOM) in April. He also served as a member of review panel, which convened in Fiji in April, for an ACIAR-funded project on the use of underwater visual census methods for fish stock assessments.

No formal training courses were undertaken during the year but a number of collaborators participated in practical hands-on work experience programs under the auspices of the Coastal Aquaculture Network.

Information

Library staff carried out the following training activities:

- Lecture on ICLARM's Information Storage and Retrieval System for the seven participants to the 9th Small Industry Information Management Course (SINFOMAN), University of the Philippines Institute for Small-Scale Industries, Diliman, Quezon City. Philippines, 29 September 1992.
- Study Tour/Training Attachment with ICLARM Library and Information Services of the Coordinator of the Pacific Islands Marine Resources Information System (PIMRIS), University of the South Pacific, Suva, Fiji, 19 to 27 October 1992.
- On-the-job Training in Library and Information Systems, Procedures and Services for the Information Specialist of the Philippine Council for Aquatic and Marine Research and Development (PCAMRD), Los Baños, Philippines, 9 to 20 November 1992.

Mr. Jay Maclean continued as Executive Editor of the journal "Asian Fisheries Science" and several other Information staff were responsible for preparing the journal for press. There were three issues in 1992.

Seminar Series

Numerous visitors are welcomed at ICLARM each year. While some of them come to work with members of staff, it was decided to try to make their expertise and experience more widely known to staff as well as to interested colleagues in nearby institutions with which we collaborate. Thus began the ICLARM Seminar Series in 1991.

Below are presented the seminars held in 1992.

Seminar	Date	Speaker	Title
92/1	15 Jan. 1992	Dr. Garry Russ Senior Lecturer Department of Marine Biology James Cook University of North Queensland Australia	Marine Reserves and Fisheries Production on Coral Reefs
92/2	23 Jan. 1992	Susan D. Russell Northern Illinois University Illinois, USA	Anthropological Research in Fisheries: discussion and project description
92/3	24 Jan. 1992	Jose Padilla Post-doc Fellow ICLARM	A Bicriteria Programming Model for Fisheries Management in Tropical Countries

Continued

Continuation

Seminar	Date	Speaker	Title
92/4	24 Jan. 1992	Parzival Copes Director Inst. of Fisheries Analysis Simon Fraser University Burnaby, Canada	Management Measures and Regulations Appropriate to Small-Scale Fisheries Conditions in the Philippines
92/5	20 Mar. 1992	Sven Erik Jörgensen DFH, Institut A Denmark	State of the Art in Ecosystem Modeling
92/6	7 April 1992	Edward Hviding Research Fellow University of Bergen Norway	Social Aspects of Aquaculture Development: The Case of Giant Clam Farming in Solomon Islands
92/7	27 April 1992	Michael D. Warren Director, CIKARD Iowa State University USA	Indigenous Knowledge and Development
92/8	5 May 1992	Rodolfo C. Undan SFR Project Regional Coordinator Central Luzon State University Muñoz, Nueva Ecija, Philippines	Small Farm Reservoirs for Water Conservation and Food Production
92/9	17 June 1992	Jim A. Litsinger Farming Systems Entomologist International Rice Research Institute Los Baños, Laguna, Philippines	Rice-fish Culture and Pest Management: Challenges and Implications
92/10	19 Aug. 1992	Roberto Lenton Director General International Irrigation Management Institute (IIMI) Sri Lanka	Irrigation Management: Considerations for Aquaculture

PUBLICATIONS AND CONSULTANCY REPORTS

Agüero, M., Editor. 1992. Contribuciones para el estudio de la pesca artesanal en America Latina. ICLARM Conf. Proc. 35, 116 p.

Agüero, M. 1992. La pesca artesanal en America Latina: una vision panoramica, p. 1-27. *In* M. Agüero (ed.) Contribuciones para el estudio de la pesca artesanal en America Latina. ICLARM Conf. Proc. 35, 116 p.

Ahmed, M. 1992. Determination of fisheries benefits from floodplain riverine systems in Bangladesh: a mathematical programming approach. Aquacult. Fish. Manage. 23(5): 599-622.

Ahmed, M. 1992. Status and potential of aquaculture in small waterbodies (ponds and ditches) in Bangladesh. ICLARM Tech. Rep. 37, 35 p.

Ahmed, M. and M.A. Rab. 1992. Feasibility of adopting aquaculture to increase resource productivity in existing Bangladesh farming systems. Naga, ICLARM Q. 15(4): 21-22.

Ahmed, M. and M.P. Bimbao. 1992. Economic consideration in introducing integrated agriculture-aquaculture technologies. *In* Farmer-proven integrated agriculture-aquaculture: a technology information kit. International Center for Living Aquatic Resources Management, Manila and International Institute of Rural Reconstruction, Silang, Cavite, Philippines.

Ahmed, M., D. Capistrano and M. Hossain. 1992. Redirecting benefits to genuine fishers: Bangladesh's new fisheries management policy. Naga, ICLARM Q. 15(4): 31-34.

Ahmed, M., M.P. Bimbao and R.C. Sevilleja. 1992. The economics of rice-fish in Asian mixed farming system - a case study of the Philippines, p. 207-216. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

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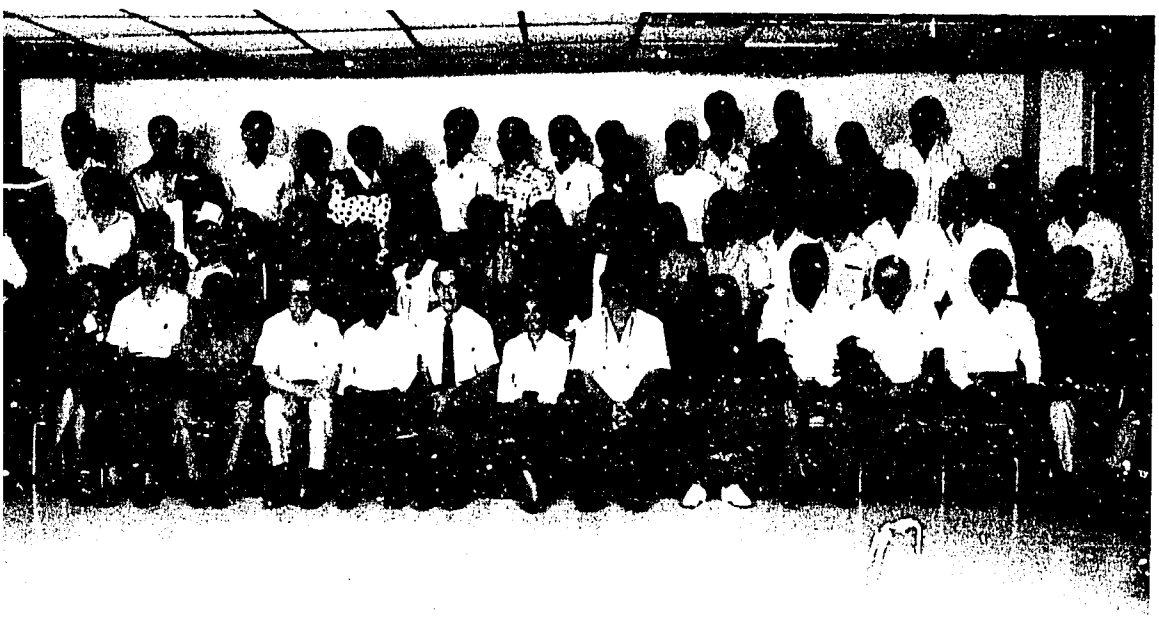


ICLARM Board and professional staff, late 1993.

ANNEX
Project Descriptions

Coastal Area Management Program Project Summaries

Project Title : ASEAN/US Coastal Resources Management Project

Funding Institution : United States Agency for International Development (USAID)

Cooperating Institutions

Brunei Darussalam : Department of Fisheries (coordinating agency), Department of Forestry, Department of Town and Country Planning, Marine Department, Department of Public Works, Brunei Museum, Universiti Brunei Darussalam and Department of Agriculture

Indonesia : Indonesian Institute of Sciences (LIPI) (coordinating agency), Directorate General of Fisheries (lead implementing agency), Research Institute for Marine Fisheries, Centre for Oceanological Research and Development, Centre for Agro-Economic Research, University of Indonesia, Bogor Agricultural University, Office of State Ministry of Demography and Life Environment

Malaysia : Ministry of Science, Technology and Environment (coordinating agency). Fisheries Department (lead implementing agency), Ministry of Defence Hydrography Section, Department of Agriculture, Drainage and Irrigation Department, Department of Town and Country Planning, Coordinating and Implementing Unit of the Prime Minister Department, Department of Geology, Department of Survey and Mapping, Universiti Pertanian Malaysia, Universiti Kebangsaan Malaysia, Universiti Sains Malaysia, Economic Planning Unit of the State Government of Johore, Forest Research Institute, Pusat Penyelidikan Ternak Air Payau, Universiti Malaya, SERES Sdn. Bhd. and Universiti Teknologi Malaysia

Philippines : Department of Science and Technology; Philippine Council for Aquatic and Marine Research and Development (coordinating agency); University of the Philippines (UP)-Marine Science Institute, College of Social Work and Community Development; UP-Visayas College of Fisheries; Bureau of Fisheries and Aquatic Resources; and National Economic and Development Authority (NEDA)-Region I

Singapore : National Science and Technology Board (formerly Science Council of Singapore) (coordinating agency), Primary Production Department, National University of Singapore-Department of Zoology and Department of Geography

Thailand : Office of the National Environment Board, Ministry of Science, Technology and Environment (cooperating agency); Department of Fisheries-Brackishwater Fisheries Division, Marine Fisheries Division and Phuket Marine Biological Center; Royal Forestry Department; Faculty of Forestry, Kasetsart University; Department of

Marine Science, Chulalongkorn University; and Faculty of Social Sciences and Humanities, Mahidol University

Duration : 1986-1991, extended until December 1992

Key Personnel ICLARM : Dr. Chua Thia Eng; Mr. Geronimo T. Silvestre; Mr. James N. Paw; Mr. Michael D. Pido; Ms. Socorro C. Guerrero; Mr. Len R. Garces; Ms. Madeleine L. Dalusung; Ms. Zoraida N. Alojado

Objectives

To increase existing capabilities within the Southeast Asian region for developing and implementing comprehensive, multidisciplinary and environmentally sustainable coastal resources management (CRM) strategies through:

- analyzing, documenting and disseminating information on trends in coastal resources development;
- increasing awareness of the importance of CRM policies and identifying and, where possible, strengthening existing management capabilities;
- providing technical solutions to coastal resources use conflicts; and
- promoting institutional arrangements that bring multisectoral planning to coastal resources development.

Results

The last year of CRMP implementation focused on the refinement, editing and publication of the integrated coastal zone management plans of the six countries; publication of remaining reports/documents; and administrative and financial audit.

Five of the six management plans have been published while that of Malaysia currently in press and is expected to be out in late January 1993. These plans are the final outputs of CRMP and activities undertaken for their completion are summarized below.

Brunei Darussalam. "The integrated management plan for the coastal zone of Brunei Darussalam" was completed after receiving the recommendations of the National Steering Committee and approval and adoption of the country's ministers. A companion volume to the plan is the 1991 national workshop proceedings, *"The coastal resources of Brunei Darussalam: status, utilization and management,"* which includes papers on capture fisheries, mangrove resources, fish communities in natural reef and artificial habitats, water quality, and island management and strategies, among others.

Indonesia. The goal of *"The integrated management plan for Segara Anakan-Cilacap, Central Java, Indonesia"* is sustainable development, the philosophy of which is to examine and provide solutions to development issues from a holistic perspective. It outlines plan strategies which include a zonation scheme for plan implementation; a task force to coordinate the planning activities; strengthening of government and nongovernmental interactions to achieve common goals; and design of specific projects to implement the plan.

Malaysia. "The coastal resources management plan for South Johore, Malaysia" is currently in press. The Johore State Government has included funding for plan implementation under the Sixth Malaysian Plan (1991-1996). The recommendations in the management plan are divided into two complementary groups. The first group, made up of five general recommendations, is designed to improve the integration of coastal resources planning and management initiatives. The second group of recommendations were based on an analysis of the resources and activities within coastal areas in the southern districts of Johore.

Philippines. "The Lingayen Gulf coastal area management plan" originally consisted of an integrated plan and seven separate action plans. With the assistance of a consultant team, the plan was compressed into a single document addressing the gulf's resource-use problems and recommending scientific and comprehensive management programs and projects. The plan has now been integrated into the NEDA regional development plan.

Singapore. *"Singapore's urban coastal area: strategies for management"* was to have been finalized in 1991 but was revised to include an action plan on marine pollution control and conservation and the role of artificial reefs in living resources enrichment. The plan was completed and published in 1992.

Thailand. *"The integrated management plan for Ban Don Bay and Phangnga Bay, Thailand"* originally consisted of four separate sectoral plans on coral reefs, mangroves, fisheries and land use. These were integrated into a single plan. The plan focuses on Ban Don and Phangnga Bays because these are the economic focal points of the region. It outlines the key problems and presents action plans and individual projects to mitigate them. The Thai cabinet had recently approved a budget of 147 million Baht (or US$6 million) for the management of the coastal zone including this plan.

The overall performance of CRMP was reviewed by representatives of the ASEAN member-countries and USAID at the last Project Steering Committee Meeting in April. They all concluded that the project has made significant impact with regard to policy orientation in the region which has resulted in greater commitment and enthusiasm from various countries to implement ICZM projects nationwide. Moreover, the project has not only strengthened collaboration between national institutions and institutions within the region but has also provided the opportunity for institutional and manpower development.

A system for coastal area management, derived from the project's experience, is shown in Fig. 1.

Training and Information Dissemination

Training and Publications. Since 1986, the project has successfully conducted nine short-term training courses, four regional workshops, and on-the-job and medium-term academic training programs. Benefitting under this component were 118 national staff. CRMP has also published 11 technical reports, a poster and seven education series; nine conference proceedings and a directory. The conference proceedings of the Regional Workshop on Integrated Coastal Zone Management in ASEAN: Lessons Learned and *"The resource ecology of the Bolinao coral reef system"* will be published in late January 1993. The project has also produced 15 issues of the *Tropical Coastal Area Management* (TCAM) newsletter.

Conference. To analyze and synthesize the project results and experiences, the Regional Workshop on Integrated Coastal Zone Management in ASEAN: Lessons Learned, was held at Bandar Seri Begawan, Brunei Darussalam in April 1992. Attended by some 50 participants from the region and outside, the workshop reviewed and assessed the CRMP. The final drafts of the six management plans were also presented for the comments and recommendations of national steering commitees. The workshop was organized in collaboration with the Department of Fisheries, Brunei Darussalam.

Project Title	:	**Geographic Information System for Coastal Area Management and Planning (GISCAMP)**
Funding Institution	:	International Development Research Centre (IDRC) of Canada
Cooperating Institutions	:	National Economic and Development Authority-Region I Office (NRO), San Fernando, La Union, Philippines
Duration	:	September 1991 - September 1993

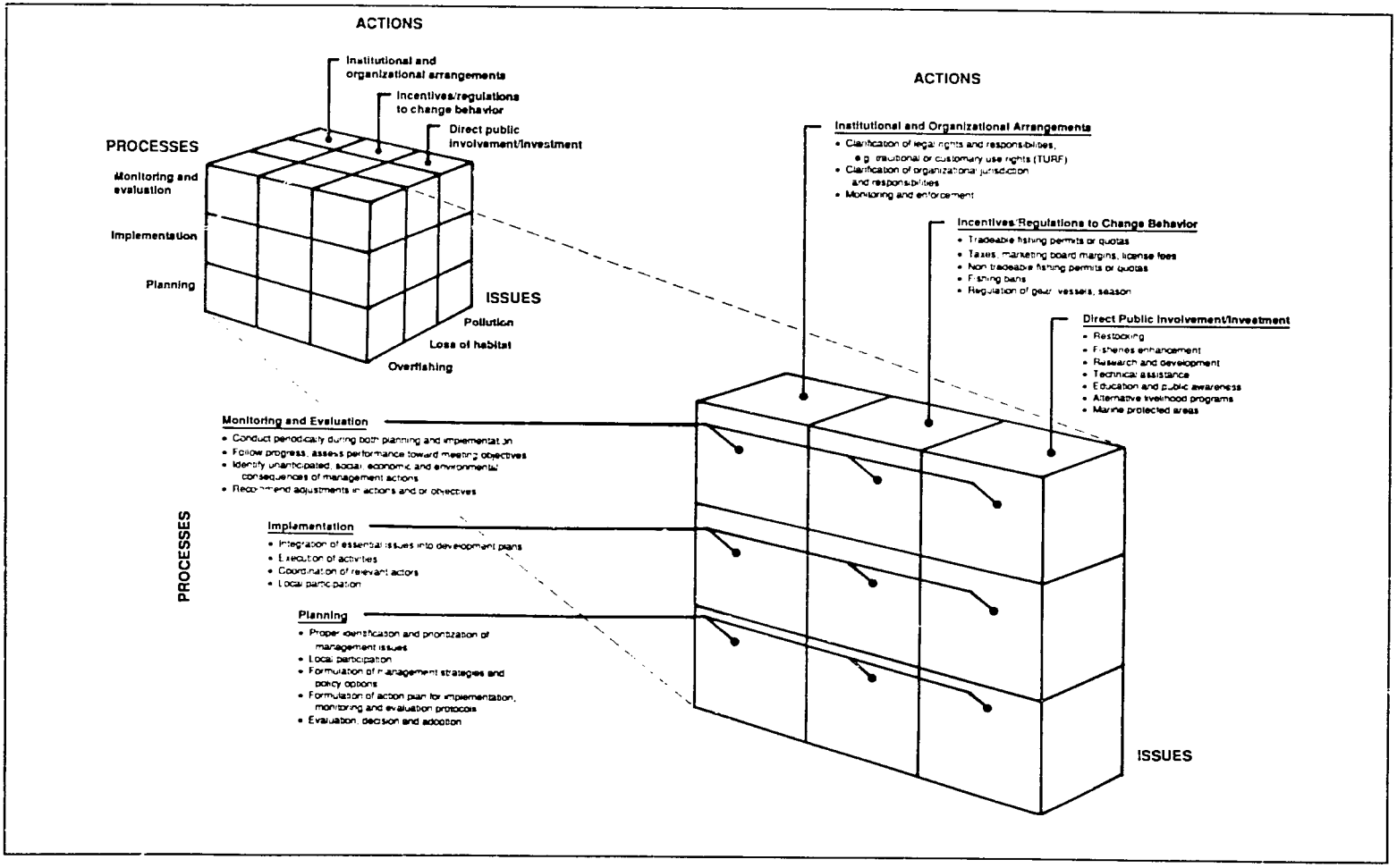


Fig. 1. Coastal area management system. Adapted from M.M. Hufschmidt. 1986. A conceptual framework for watershed management. *In* K.W. Easter, J.A. Dixon and M.M. Hufschmidt (eds.) Watershed resources management: an integrated framework with studies from Asia and the Pacific. Westview Press, Boulder, Colorado.

Key Personnel ICLARM : Dr. Chua Thia-Eng; Mr. James N. Paw; Mr. Noel Robles; Ms. Zoraida N. Alojado

NRO : Mr. Leonardo Quitos, Jr.; Ms. Agnes Grace Cargamento; Mr. Jonathan Guiang

Objectives

To upgrade 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

The project conducted an in-house training at ICLARM for the three NRO project staff from 26 February to 13 March 1992 which was continued at the project site. Meantime, data collection from various regional and national agencies was conducted throughout 1992, including data capture (digitizing the maps and encoding attribute data). A memorandum of agreement with NAMRIA was signed in late July 1992 to purchase the July and November 1991 aerial photographs of Lingayen Gulf, including the classification of a Landsat Thematic Mapper image purchased under the ASEAN/US CRMP. In mid-March, Mr. James Paw attended an IDRC project leaders' meeting in Ottawa, Canada, and also presented a poster paper on the use of GIS in selecting sites for brackishwater aquaculture and mangrove reforestation. A consultant, Dr. Kam Suan Pheng, from the Universiti Sains Malaysia, has been hired as project consultant to provide technical advice on the application of GIS in the coastal zone, evaluate the methodologies used and structure data for modelling. Three ground truthing sessions were conducted in December to secure information for the classification of the satellite image by NAMRIA. Areas covered Sual, Pangasinan to Agoo, La Union. The western side covering Bolinao and the Hundred Islands will be surveyed in early 1993.

Project Title : Resource and Ecological Assessment of San Miguel Bay, Philippines

Funding Institution : Department of Agriculture

Duration : April 1992-August 1993

Key Personnel ICLARM : Mr. Geronimo T. Silvestre; Dr. Robert Pomeroy; Mr. Cesar Z. Luna; Mr. Hermenigildo M. Montalvo; Mr. Len Garces; Ms. Madeleine L. Dalusung; Mr. Elviro A. Cinco; Mr. Marcos Jose M. Vega; Ms. Deborah Jean R. Mendoza; Mr. Rene Geraldo G. Ledesma; Ms. Ma. Concepcion R. Ricafrente; Mr. Quintin P. Sia III; Ms. Maharlina Luz G. Gorospe; Ms. Gigi B. Calica; Ms. Portia N. Bonilla; Mr. Noel Robles

Objectives

To assess the status and exploitation/utilization of the fisheries in San Miguel Bay.
To evaluate the status of 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.

- 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 investment opportunities for alternative livelihood) that maximize benefits from fishery resources utilization/exploitation and minimize sectoral conflicts and/or incompatibilities.

Results

San Miguel Bay, a major fishing ground in southern Luzon, Philippines, is one of the 12 priority bays of FSP currently implemented by DA. The project components are: (1) Situational Analysis; (2) Capture Fisheries Resource Assessment; (3) Ecological and Habitat Assessment; (4) Socioeconomic and Policy Analysis; and (5) Assessment of Management Implications.

The Situational Analysis component generated the *"Coastal environmental profile of San Miguel Bay, Philippines"*. The profile summarizes existing information on the status and utilization of fisheries and coastal resources/habitats. It also provides a synopsis of the biophysical, technological, economic and social and legal/institutional contextual features relevant to fisheries and coastal resource use in the area, and an assessment of existing and potential management issues relating to sustainable use of fisheries and other resources in the coastal zone, including information gaps and consequent research needs.

The coastal profile was presented during the Consultative Workshop on the Management of San Miguel Bay held in November 1992. The workshop discussed with resource managers and decisionmakers the existing conditions of San Miguel Bay, the resource management issues and problems in the coastal zone of the bay and mitigating measures. Among the management issues are environmental quality, resource utilization, socioeconomics and legal/institutional arrangements.

Activities under Components 2 to 5 are in progress.

Project Title : Asian Fisheries Social Science Research Network

Funding Institution : International Development Research Centre (IDRC) of Canada

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)

Duration : Phase I, 1983-1985; Phase II, 1985-1988; Phase III, 1989-1992

Key Personnel ICLARM : Dr. Robert S. Pomeroy (Coordinator); Mr. Herminigildo M. Montalvo; Ms. Ma. Angelina A. Agulto

Objectives

- To advance the professional capacities of its members and broaden the base of its membership.
- 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.
- To develop educational programs in the social sciences related to capture fisheries and aquaculture at the graduate and undergraduate levels in AFSSRN member institutions.
- To augment national activities of the AFSSRN with international linkages among its members.
- To promote the use of the AFSSRN research results through effective dissemination.

Results

The period covered in this report is the fourth and final year of the AFSSRN's Phase III. There was an upsurge of Network activities following the assumption of duties by the new Coordinator in January and after a team leaders' meeting later that month. The ten approved research projects were being implemented and a number of workshops, meetings and trainings were organized throughout the year.

In late December 1991, the International Development Research Centre (IDRC) of Canada approved the Network's request for an extension of Phase III from 31 March 1992 to 31 December 1992 with a corresponding budget supplement. With the additional funding, the Network was able to implement several activities in research and training.

An important major activity during the year was the external review of the Network's Phase III. The review, conducted by a two-man team in May, noted the significant contributions of the Network in the development of fisheries social science and trained researchers in the region. The review results were favorable and were the basis for continuing the Network into a fourth phase.

A Phase IV proposal has been drafted focusing on new directions in the management and development of coastal fisheries and aquaculture resource systems. The proposal, which emphasizes collaborative research, networking and training, was submitted to IDRC in October 1992 for funding of its initial year.

Other major highlights of Network activities were as follows:

1. approval and implementation of four additional research projects;
2. institutional visits of the Network Coordinator to member institutions;
3. holding of three team leaders' meetings, one regional seminar/workshop and four national workshops;
4. organization and conduct of the Special Symposium on Socioeconomics in Fisheries at the Third Asian Fisheries Forum in October 1992;
5. incorporation of the *AFSSRNews*, Network newsletter, into *Naga, the ICLARM Quarterly*; and
6. implementation of the Simon Fraser University/AFSSRN Visiting Scholars' Programme.

Research

With the additional funding from IDRC, the Network accepted four more research proposals which are to be completed within the extension period. These research projects are:

- *Review of Social and Economic Research in the Fishery Sector of the Philippines: Country Paper (Bureau of Fisheries and Aquatic Resources, Central Luzon State University, SEAFDEC Aquaculture Department, University of the Philipr nes at Los Baños and University of the Philippines in the Visayas)*

- *Risk Programming of Rice-Fish Production Systems in the Philippines (Central Luzon State University)*

- *A Framework for Evaluating Fisheries Law Enforcement and Compliance with Regulation (Universiti Pertanian Malaysia)*

- *Analysis of Water Resource Uses and Conflicts in the Pak Phanang River Basin: A Case Study of Chien Yai, Thailand (Kasetsart University)*

Of the ten original research projects, eight have been completed and a first draft of the technical reports submitted. These are:

Programming Models of Integrated Agriculture-Aquaculture Farms (Universiti Pertanian Malaysia)
The Management of a Shrimp Fishery: A Simulation-Optimization Approach (Universiti Pertanian Malaysia)
Labor Force Participation and Economic Contribution of Women in the Post-harvest Small-Scale Fisheries Sector, Kelantan, Peninsular Malaysia (Universiti Malaya)
Socioeconomic Study on the Oyster and Mussel Industry in Western Visayas (SEAFDEC Aquaculture Department)
Management of Mangrove Areas in Calauag Bay, Quezon Province (University of the Philippines at Los Baños)
Economics and Management of Gillnet and Seine Fishing in Guimaras Strait and Adjacent Waters (University of the Philippines in the Visayas)
Small-scale Fisheries and Shrimp Farming in Nakorn Bay: Options for Coastal Resources Management (Department of Fisheries, Kasetsart University and Prince of Songkla University)

Membership

The Central Research Institute of Fisheries (CRIFI) of Indonesia became a new member of the Network in 1992. It took over from the Research Institute of Coastal Aquaculture (RICA) which was the original member. RICA is one of the institutions under CRIFI and its team leader, who joined CRIFI, formally requested the Network to transfer the membership.

Initial steps were also taken to touch base with institutions in Bangladesh, Vietnam and China in preparation for an expansion in Network membership.

Meetings, Workshops and Training

Team Leaders' Meeting. The Network held three team leaders' meetings in 1992: 20-24 January (Manila, Philippines), 22 April (Bali, Indonesia) and 29 October (Singapore). The meetings focused on discussions of research project activities, other ongoing Network activities and planning future directions, specifically on expanding membership to include Vietnam, the People's Republic of China and Bangladesh.

Workshops. The Network organized and conducted one regional seminar/workshop, one special session at an international conference and four national workshops. The latter were designed to promote interaction among teams on a national level and to serve as a forum for presenting results of ongoing research.

- Seminar/Workshop on Principles of Economic Valuation, 20-24 April, Bali, Indonesia. Twenty-five Network team leaders and members participated in this

regional workshop, which was hosted and co-organized by the Central Research Institute for Fisheries of Indonesia.

- Symposium on Socioeconomics in Fisheries. The Network organized a special session on Socioeconomics in Fisheries at the Third Asian Fisheries Forum held on 27 October in Singapore. The program consisted of five contributed papers by Network members based on AFSSRN-funded research and two invited papers by well-known experts.

- A number of national workshops were held during the year:

Workshop to Integrate Research Findings of the Joint Project on Small-scale Fishery and Shrimp Farming in Pak Phanang Bay: Options in Coastal Resources Management, 6-9 May, Koh Samui, Thailand.

Training Course on Methods of Socioeconomic Analysis for Capture and Culture Fisheries in Indonesia, 22-27 June, West Java, Indonesia.

Workshop on Fisheries Management and Policy Research in Malaysia, 2-3 December, Selangor, Malaysia.

Workshop on Methods for Fisheries Socioeconomics Research, 7-9 December, Manila, Philippines.

AFSSRN/Simon Fraser University (SFU) Collaborative Agreement. In 1992, three Network members availed of the scholarships under the Visiting Scholars' Programme. Dr. Kusairi Mohd. Noh of the UPM team went to SFU in May 1992 for three months as part of his Network-funded research project on modeling. Drs. Mudiantono and Mrs. Indah Susilowati of Universitas Diponegoro are scheduled to start their visit in January 1993.

Two Network members, Mr. Rodelio F. Subade and Ms. Chona A. Iturralde, are making good progress in their Masters' program. They commenced graduate work at SFU in Fall Term 1991.

Two other Network members, Ms. Somying Piumsombun of Kasetsart University and Mr. Tai Shzee Yew of Universiti Pertanian Malaysia, have completed their Ph.D. studies in Fisheries Economics.

Midterm Evaluation of Phase III

On 16-30 May 1992, a two-man team conducted a review of the Network's Phase III to reassess its overall progress in accomplishing its objectives; to examine the importance of the linkages developed and promoted within and outside the Network as these relate to research for development; to assess the kind, scope and relevance of research conducted; and to recommend future directions that the work may go. The team was composed of Prof. Parzival Copes of SFU and Dr. Ponciano Intal of the Philippine Institute for Development Studies. They were accompanied by the Network Coordinator during the review exercise and visits to member-institutions in Southeast Asia.

In its final report, the team concluded that the AFSSRN has proven its worth to member-institutions over the years. They reported that before the Network's establishment, there was no mechanism in the region to pull together economists and other social scientists to promote research and training in the social science aspects of fisheries and aquaculture. The Network has been able to mobilize a core of fisheries economists for this purpose, which is its fundamental achievement.

The Network also played a significant role in improving members' research skills, supporting their research endeavors, providing opportunities to interact with and learn from other fisheries social science researchers in the region and expanding the professional pool of adequately trained researchers in fisheries and aquaculture social science.

Although the impact of Network activities on fisheries policy and aquaculture resource management has been modest, given the limited number of research studies completed under Network funding, it has helped members develop a growing capacity to address issues of fisheries policy and fisheries/aquatic resource management.

As a strategy for further development, the team recommended that the asymmetrical approach be applied as members have reached different levels of research competence in the fisheries field and have unequal needs for assistance in various aspects of institutional development. Collaborative funding by additional donors will allow for simultaneous support of the institutional maturation process of current Network members and the needs of additional members.

The continued integration of ICLARM and the AFSSRN was also recommended. ICLARM researchers should be interacting with the Network.

Phase IV Proposal

After the midterm evaluation of the Network in May, a proposal for a fourth phase was drafted. The AFSSRN identified the following needs to continue into another phase:

1. to translate social science information into policy management and development programs for sustainable coastal fisheries resources and aquaculture systems; and
2. to continue the professional and institutional development process initiated in the initial phases to address the uneven capabilities and maturation of member institutions.

Coordination

The Network Coordinator made four institutional visits during the first half of the year to member institutions to orient himself with and monitor ongoing research projects. Follow-up trips were made to provide technical assistance in research activities and in national workshops. Three team leaders' meetings were held to discuss ongoing activities and to plan future ones.

Work Plan for 1993

Networking, training and research activities will continue to be implemented as soon as the Phase IV proposal is approved. Specific activities to be carried out in 1993 are:

1. Research proposals will be accepted beginning the second quarter with funding support.
2. A team leaders' meeting will be held in June 1993.
3. Eight individual exchange visits by team members to other member institutions for research and/or training will be initiated. These inter-region and inter-country visits are primarily aimed at facilitating the transfer of expertise and as an effective means of strengthening institutional linkages between and among member institutions and member scientists.
4. Four national workshops focusing on research priority topics will also be conducted.
5. One regional workshop on a research priority topic will also be held.
6. New member institutions in Bangladesh, China and Vietnam will be identified and assistance in developing research, training and networking will be given.
7. The *AFSSRNews* will continue to be published. Other publications such as research reports and reprints will be produced as needed.
8. Per IDRC requirements, a project evaluation will be conducted at the end of the year.

Project Title	:	Tropical Fish Stock Assessment Project
Funding Institution	:	Unrestricted core
Cooperating Institutions	:	Predominantly in-house studies, with informal linkages with various research institutions
Duration	:	Continuous from July 1979

Key Personnel ICLARM : Dr. Daniel Pauly; Mr. Felimon Gayanilo, Jr.; Mr. Geronimo Silvestre; Ms. Annabelle Cruz-Trinidad; Dr. Rainer Froese; Dr. Villy Christensen; Dr. Maria Lourdes Palomares; Dr. Jose Padilla

Objectives

To increase our understanding of the dynamics of exploited tropical/subtropical fish communities.

To develop stock assessment methods which are straightforward and readily applicable to tropical and subtropical stocks.

Results

This project continued to generate new insights on the population dynamics of tropical fish and on methods to estimate their vital statistics, as required for fisheries management, and the results thus obtained are documented in the list of publications by project staff (p. 53-58).

For example, a general model of two-stage growth of fish, which occurs in free-ranging populations, in aquaculture ponds or in aquaria, was derived. This can be incorporated in pond dynamic models, or in trophic models of ecosystems exploited by multispecies fisheries, such as lakes (Fig. 2).

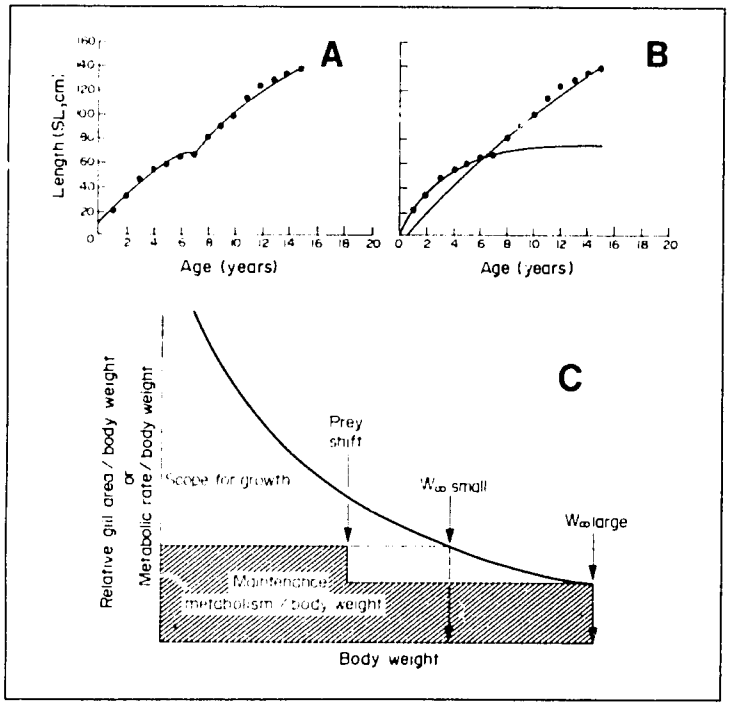


Fig. 2. Aspects of two-stage growth in Nile perch *Lates niloticus* in Lake Nasser, Egypt: A. Observed growth curve, with dots representing mean length-at-age, fitted with two-stage growth curve; B. The same length-at-age, fitted with two von Bertalanffy growth curves, of which each provides an estimate of asymptotic size (W_∞); C. Schematic representation of how the transition from zooplankton to fish in the diet of Nile perch reduces its maintenance metabolism, thus increasing its scope for growth (adapted from Soriano et al. 1992, see p. 58 for reference).

One "new" development was that ICLARM's early emphasis on the application of resource economics to tropical small-scale fisheries was re-established, leading to improvement over earlier work (Fig. 3), and to the conceptualization of a new approach for

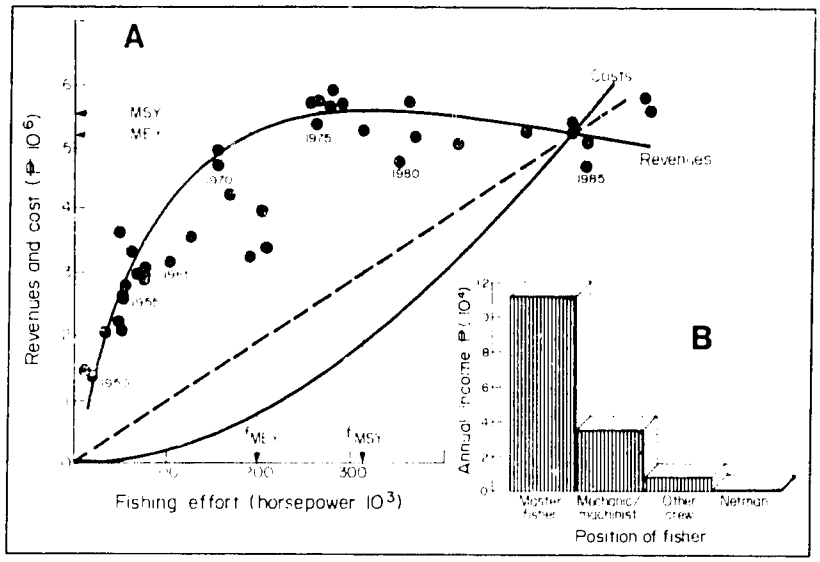


Fig. 3. Two aspects of the Philippine fisheries for small pelagic fishes: A. Global model showing decline of catches and gross revenues since mid-1970s, and total cost lines [dotted: assumed in an earlier ICLARM study; solid: based on a recent reanalysis (A. Cruz-Trinidad)]; B. Uneven distribution of incomes within the (small-scale) purse seine fishery of Iloilo and Negros Occidental, 1988-89 (J.E. Padilla).

the integration of length-based stock assessment (as incorporated on FiSAT, see p. 79) with multispecies, multigear bioeconomic modeling. We anticipate that a new software package based on this approach will be released in 1993, and become widely used to add the crucial economic dimension to biologically-oriented management.

Project Title		: Network of Tropical Fisheries Scientists (NTFS)
Funding Institutions		: Unrestricted core; Food and Agriculture Organization (FAO); Danish International Development Agency (DANIDA)
Cooperating Institution		: FAO/DANIDA Training Course in Tropical Fish Stock Assessment
Duration		: Continuous from April 1982
Key Personnel	ICLARM	: Dr. Daniel Pauly, *Fishbyte* Editor; Ms. Abbie Cruz-Trinidad, 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 of the NTFS expanded to 1,250 by the end of 1992. Among the new nominees were many course participants of training courses organized by the FAO-DANIDA Fish Stock Assessment Project.

Fishbyte became a regular section of *Naga, the ICLARM Quarterly*, while otherwise essentially retaining its format, i.e., consisting of an editorial, scientific contributions and news items. A comprehensive *Fishbyte* index, covering the years 1983-1991 and including author, species and geographic indices and an alphabetized list of articles, was published and distributed to all NTFS members, and other *Fishbyte* recipients. Also, 30 complete sets of *Fishbyte* were bound and distributed to the libraries of selected institutions.

Four network members came to ICLARM as visiting scientists from Bangladesh (2), France and Trinidad and Tobago, respectively.

Project Title : Socioeconomic Valuation of Coastal Resources of Southwestern Latin America

Funding Institution : Unrestricted core

Cooperating Institution : United Nations Economic Commission for Latin America and the Caribbean (ECLAC)

Duration : June 1990 to December 1992

Key Personnel ICLARM : Dr. Max Agüero; Mr. Edgardo Araneda; Ms. Angelica Arellano; Ms. Fabiola Bell; Ms. Ximena Flores; Mr. Exequiel Gonzalez; Mr. Carlos Olivares; Ms. Marisol Ruiseñor.

Objectives

- To identify the major processes, relationships and factors determining the dynamics of coastal resource uses.
- To identify existing data/information related to coastal resources evaluation, management and modeling purposes.
- To design, test and validate a mathematical programming model for the social and economic valuation of the most important coastal resources in selected areas of Southwestern Latin America.

Results

An external review conducted in June 1992, of this project concluded that "an excellent start has been made in methodological development", and that "the methodology being developed has the potential to become a useful tool to guide resource management decisions not just in Latin America but worldwide".

Due both to core funding constraints, and to the global potential of this methodology, it was decided, however, that this Chile-based project would end in December 1992, and for its objectives to become part of the social science research agenda to be pursued at Headquarters, as elaborated in ICLARM's Medium Term Plan.

The first element of this headquarter-based activity will be to make ready for dissemination, in the ICLARM Software series, the OPUS linear programming package developed by the project.

The second element will be the documentation of various applications and of their dissemination through the technical literature. We anticipate an emphasis on sites in Latin America and Southeast Asia, where much of the preparatory work required for such application has been done. The applications to Latin America will benefit from the reviews of artisanal fisheries in South America included in *Contribuciones para el estudio de la pesca artesanal en America Latina* edited by A. Agüero while the applications to Southeast Asia will benefit from the material assembled and the contributions published by the ASEAN/US Coastal Resources Management Project, another ICLARM project that ended in 1992.

Project Title	:	The ICLARM Software Project
Funding Institutions	:	Unrestricted core; Food and Agriculture Organization (FAO)
Cooperating Institutions	:	Predominantly in-house activity, with informal linkages with various individuals and research institutions
Duration	:	Continuous from 1986

Key Personnel ICLARM : Dr. Daniel Pauly; Dr. Rainer Froese; Dr. Villy Christensen; Dr. Jan Michael Vakily; Mr. Felimon Gayanilo, Jr.; Ms. Carmela Janagap; Ms. Grace Coronado; Mr. Dominador Tioseco; Mr. Edwin de Guzman; Mr. Eliseo Garnace (from November 1992)

Objectives

- To document and disseminate software for personal computers in the areas of fish population dynamics, fisheries and aquaculture economics and other fields of interest to ICLARM.

Results

The key events for this project in 1992 were: (i) the presentation, at the World Fisheries Congress (WFC), held in May in Athens, of the various ICLARM software developed recently; and (ii) the completion of a b-version of FishBase and its presentation in September 1992 to the Commission of the European Communities. Details of this project appear on p. 86.

The formal and informal software presentations at the WFC covered:

- the FAO/ICLARM Stock Assessment Tools or FiSAT, a package combining FAO's LFSA software and ICLARM's Compleat ELEFAN, to be released in 1993;
- B:RUN, a low level GIS for bioeconomic simulation of the coastal fisheries of Brunei Darussalam, also due for public release in 1993;
- SIERRA, similar to B:RUN, but for Sierra Leone (see p. 82);
- ECOPATH II (see p. 80)
- MAXIMS, a package for estimation of daily ration from daily changes of the stomach contents of fish, as required for ecosystem models.

They were used to initiate, with developers of fisheries-oriented software from various institutions, a dialogue on the principles which have so far guided software development at ICLARM, viz:

- if the product to be distributed is to be useful in tropical developing countries, then it must include methods that *can* be used, i.e., for which data are available or can readily be collected;
- the software intended for distribution *must* run on widely available, low-cost platforms, and *not* on sophisticated workstations;
- the software must be user-friendly — as determined by the intended users, *not* by its developer(s);
- the software generally should be introduced to its prospective users through training courses, not as a result of a purchase;
- the software must be free, or very cheap, and one must accept that it will be "pirated";
- the institution that produces the software in question must be willing and capable to handle the maintenance of this software, and to respond to users' inquiries and feedback.

This dialogue led to the decision that the FAO/ICLARM approach to software development for tropical fisheries research should be written up and presented at the October 1993 meeting of ICES, for discussion by the large number of specialists attending this annual meeting.

Project Title : Global Comparisons of Aquatic Ecosystems (ECOPATH)

Funding Institution : Danish International Development Agency (DANIDA)

Cooperating Institutions : Ecole Nationale Supérieure Agronomique de Toulouse (ENSAT), France; Center for Tropical Marine Ecology (ZMT), Germany; International Council for the Exploration of the Sea (ICES), Denmark; also many individual researchers in developing and developed countries.

Duration : Four years beginning February 1990

Key Personnel
ICLARM : Dr. Villy Christensen; Dr. Daniel Pauly; Mr. Edwin de Guzman; Ms. Rosandra Gayosa
ENSAT : Prof. Jacques Moreau
ZMT : Dr. Matthias Wolff

Objectives

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

Results

This project has centered around development and dissemination of the ECOPATH II software for straightforward parametrization and balancing of steady-state ecosystem models. ECOPATH models describe the energy flows in ecosystems and have been used in contexts as diverse as farming systems, aquaculture ponds, rivers, lakes, estuaries (Fig. 4) and oceans.

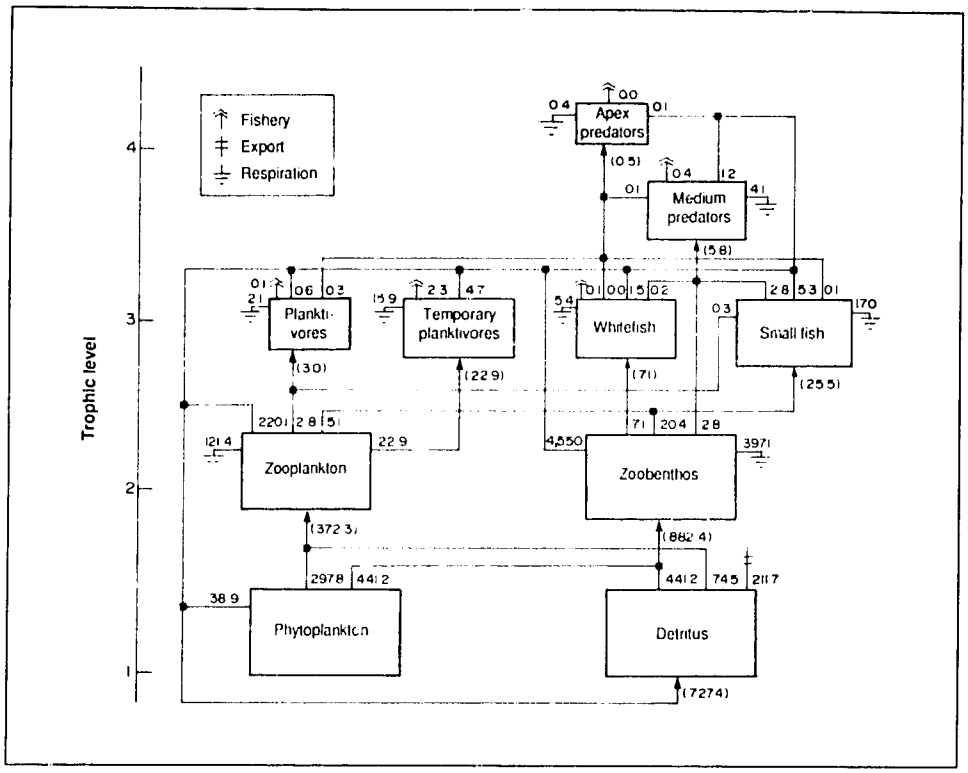


Fig. 4. Example of an ECOPATH II model from a temperate system: Schlei Fjord, northern Germany (from V. Christensen and D. Pauly. 1992. Ecol. Modelling 61:169-185, based on Nauen, C. 1984. Stud. Rev. Gen. Counc. Medit. (61) Vol. 1: 403-428).

In 1992, a new version (2.1) of the ECOPATH II software was released. This version was distributed to more than 200 persons or groups. Work in cooperation with ENSAT and ZMT led to the publication of French and Spanish versions of the ECOPATH manual.

Based on comparative studies of over 40 ecosystem models presented at a meeting in Copenhagen of the International Council for the Exploration of the Sea (ICES) in 1990 along with theoretical work and data analysis, the project leader submitted and successfully defended a Ph.D. thesis to the Royal Danish School of Pharmacy, Department of Environmental Chemistry, Copenhagen. This research represents an attempt to increase our understanding of ecosystem behavior and development.

Dr. Christensen was subsequently invited to join the editorial board of two scientific journals, *Ecological Modelling* and *Dana*.

Project Title : Climate and Eastern Ocean Systems (CEOS)

Funding Institutions : NOAA with supplementary funding from DANIDA (ECOPATH Project)

Cooperating Institutions : NOAA/National Marine Fisheries Service/Southwest Fisheries Center (SWFC), USA; French Government's Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM), France; Food and

Agriculture Organization of the United Nations (FAO), Italy; Alfred-Wegener-Institut für Polar-und Meeresforschung Bremerhaven (AWI), Germany; Copenhagen Modelling Group (CMG), Denmark; Universidad Nacional Agraria (UNA), Lima, Peru.

Duration : Two years, starting from September 1992

Key Personnel

ICLARM	:	Dr. Daniel Pauly; Dr. Villy Christensen
SWFC	:	Dr. Roy Mendelssohn
ORSTOM	:	Dr. Philippe Cury; Dr. Claude Roy
FAO	:	Dr. Andrew Bakun
AWI	:	Dr. Astrid Jarre-Teichmann; Mr. Wolf Hertlein
CMG	:	Dr. Sven E. Jfrgensen; Mr. Jfrgen Salomonsen
UNA	:	Dr. Jaime Mendo

Objectives

- CEOS General: Collaborative study of potential effects of global climate change on the living resources of the highly productive ecosystems of eastern ocean upwelling regions and on directly associated economic, cultural and ecological issues.
- ICLARM Specific: Assemble, summarize and interpret data on changes in the structure and dynamics of upwelling systems and their major fisheries resources.

Results

ICLARM's contribution to this project began in mid-year, through a series of meetings with USA- and Europe-based Project staff. These meetings led to a detailed published strategy. The ECOPATH II models of four major upwelling systems and the understanding to be derived from them form the bulk of ICLARM's contributions to the Project.

A two-day consultation between some Project personnel was held in June in Copenhagen on the development of a simulation model for management of the fisheries in the Peruvian upwelling ecosystem, to be based on concepts developed by Dr. Peter Muck during his work with ICLARM in Peru in 1990-1991. This model is to be developed by Mr. Hertlein as part of his Ph.D. studies.

Also, a two-day workshop on "Simulation Modelling of the Peruvian Upwelling Ecosystem" was held in August in Denmark. The workshop led to definition and conceptualization of the model, and to an offer by Mr. Salomonsen to assist Mr. Hertlein in programming the basic structure of the model.

Dr. Jaime Mendo initiated, in September, filling in of FishBase data entry form, i.e., The CEOS project component in Peru will provide complete coverage, through FishBase (see p. 86) of the fish of the Peruvian upwelling ecosystem. He also initiated work on a comprehensive synopsis of the Peruvian anchoveta (*Engraulis ringens*), another planned project output.

Project Title : Establishment of a Fisheries Database for the Development and Management of the National Fisheries of Sierra Leone

Funding Institution : Commission of the European Communities (CEC)

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

Duration		:	April 1991 to March 1993
Key Personnel	IMBO	:	Mr. P.A.T. Showers
	FD	:	Mr. A.R.C. James
	WNW AFCOD	:	Mr. C. Fournah
	ICLARM	:	Dr. Jan Michael Vakily

Objectives

- To evaluate the present status of the fisheries of Sierra Leone and the level of exploitation in both the industrial and small-scale sectors.
- To make recommendations of possible management strategies in the light of government priority to give preference to local fisheries, particularly small-scale and semi-industrial, over foreign fisheries.
- To devise a permanent system of fisheries data collection and computer-assisted handling of data for analysis and presentation, and to train Sierra Leonean personnel in their use.
- 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.

Results

The project is developing, implementing and testing a generic "Fishery Data Acquisition System (FiDAS)" that:

accommodates data from the whole range of fisheries activities in the coastal area (small-scale and commercial fishing and research);
limits to a minimum the inputs required for the database to be of practical use;
is flexible enough to accommodate and provide means of analysis for additional information if available.

Project activities in 1992 emphasized entering of data available in Sierra Leone, that is, from: (i) 27 joint Sierra Leone-Soviet fisheries research cruises carried out between 1976 and 1990; (ii) a 1990 frame survey of the small-scale fisheries; and (iii) daily landings statistics from four major fishing villages along the northern part of the coast.

Landing data from the small-scale fisheries are processed on a monthly basis in the context of an ongoing EC fisheries project.

Other activities in 1992 consisted of a comprehensive checklist of fish species occurring in Sierra Leone waters to complement entries in FishBase and a B.Sc. thesis honored with the Fourah Bay College "Dean's Prize", by Mr. A. Jalloh, on biomass estimates and depth distribution of carangids in Sierra Leone waters (see Fig. 5).

All activities are accompanied by both formal and on-the-job training of research personnel in fisheries science and modern information management.

Though initially developed for Sierra Leone, FiDAS's design enables rapid adaptation of the software to the fisheries of other countries. Important features of FiDAS include data exchange with other programs, notably FishBase (see p. 86) and SIERRA, a Low-Level Geographic Information System developed at ICLARM. The software will also be used to provide data/summaries for other organizations and projects such as the FAO or the Base de Données Regionale Maritime (BDRM) initiated by the African countries bordering the Atlantic.

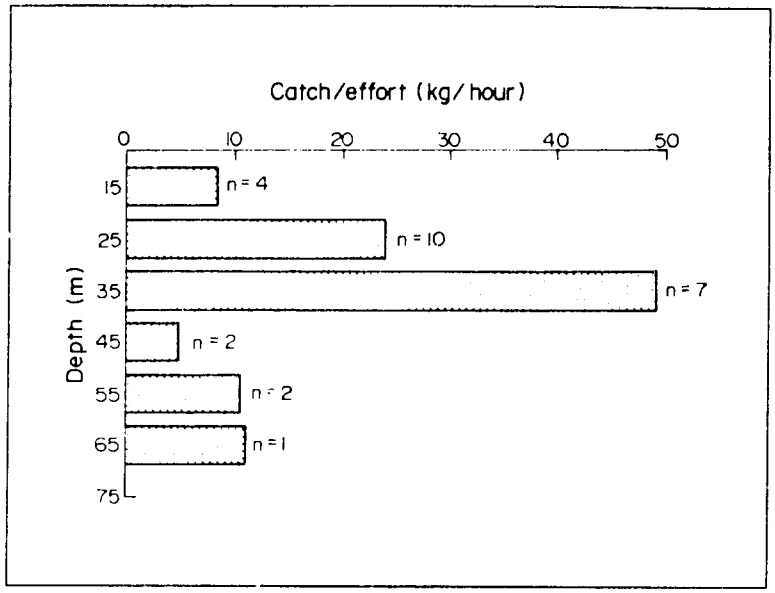


Fig 5. Depth-dependent distribution of catch per hour (kg) of jack *Caranx senegallus* (from A. Jalloh. 1992. Estimation of the biomass of carangids in Sierra Leone waters, based on joint Sierra Leone-Soviet fishery surveys, 1976 to 1990. Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone, Freetown, Sierra Leone. 47 p. B.Sc. thesis.).

Project Title	:	Improved Management of Openwater Fisheries in Bangladesh
Funding Institutions	:	Ford Foundation; International Development Research Centre (IDRC) of Canada
Cooperating Institutions	:	Department of Fisheries (DOF), Bangladesh; Fisheries Research Institute (FRI), Bangladesh
Duration	:	Three years, beginning July 1991
Key Personnel	ICLARM :	Dr. Mahfuzuddin Ahmed
	DOF :	Mr. A.K. Ataur Rahman; Mr. Md. Mokammel Hossain
	FRI :	Dr. M.A. Mazid

Objectives

- 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.
- 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.
- To provide technical assistance and guidance to Bangladesh scientists on methodologies of fisheries research.

Results

The Department of Fisheries (DOF), Bangladesh, has agreed to work in partnership with four leading NGOs and the fishing communities in order to increase participation of fishers in managing the inland fisheries; utilize NGO resources for input support to fishers in place of middlepersons; mobilize NGO experience in human development, training and organization building to create alternative or supplementary income opportunities for fishers; and thereby reduce pressure on the resources (Fig. 6). A co-management program is being implemented in 21 fisheries sites in a wide range of fishing environments.

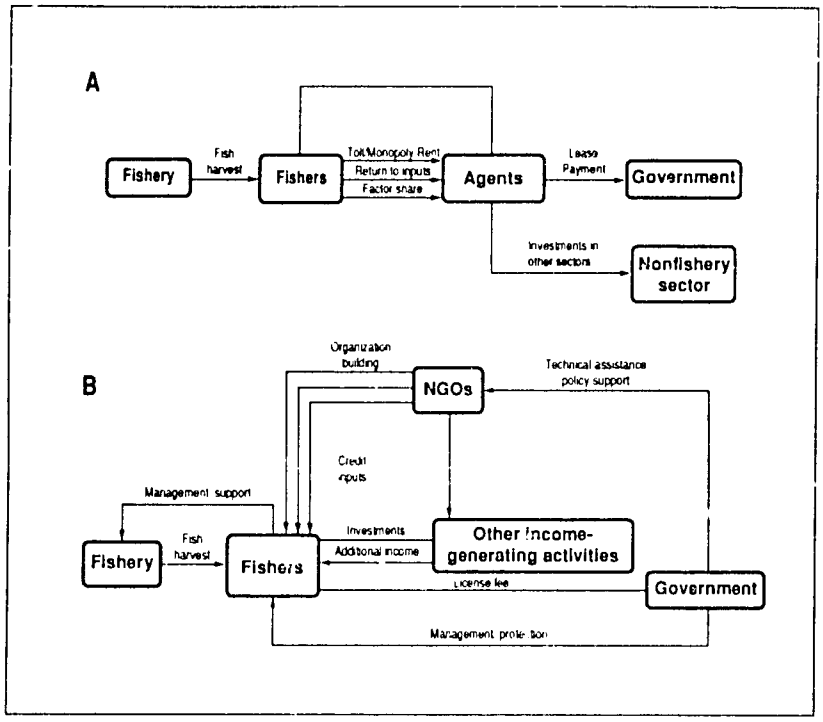


Fig. 6. Production relations, benefit distribution and management implication of inland fisheries in Bangladesh. A. the old system of leasing. B. the new system of licensing genuine fishers.

Emphasis was given to improve our understanding of the biological and socioeconomic dynamics of fisheries in various environments. Studies of population dynamics of few important species at four sites, including training of national scientists on methods of such studies, were initiated. With a supplementary grant from IDRC, Mr. G. Moula and M.L. Rahman from the Fisheries Research Institute (FRI) visited ICLARM HQ to work, under the general supervision of Dr. D. Pauly, on the stock identification and biology of hilsa; a preliminary account of this work was published in *Naga* by Rahman and Moula. Similarly, socioeconomic studies are currently being conducted on problems and opportunities in fishing communities.

Two groups of officials from DOF and the Ministry of Fisheries and Livestock visited the Philippines and Malaysia for two weeks on training-cum-study tour programs (Table 1).

Table 1. Training and study tour activities during 1992.

Name of Participants	Affiliation	Duration
Mr. A.Z.M. Nasiruddin	Secretary, MOFL	July 1992
Mr. A.K. Ataur Rahman	Director, DOF	July 1992
Mr. Ruhul Amin	Deputy Secretary, MOFL	July 1992
Mr. Tabibur Rahman	Deputy Director, MOFL	July 1992
Mr. Loqueman Ahmed	Joint Chief, MOFL	Nov. 1992
Mr. Md. Mokammel Hossain	Project Director	Nov. 1992
Mr. Mohammed Hatem	Assistant Secretary, MOFL	Nov. 1992
Md. Oliur Rahman	Thana Fisheries Officer, DOF	Nov. 1992
Md. Saleh Ahmed	Thana Fisheries Officer, DOF	Nov. 1992

MOFL = Ministry of Fisheries and Livestock
DOF = Department of Fisheries

Project Title : Development of a Database on Fisheries Resources (FishBase)

Funding Institutions : Commission of the European Communities (CEC), Association des Universités Partiellement ou Entièrement de Langue Française (AUPELF).

Cooperating Institutions : Food and Agriculture Organization of the United Nations (FAO), Italy; California Academy of Sciences, San Francisco (CAS), USA; Zoologisches Institut und Museum (ZIM), Hamburg, Germany; Expert Center for Taxonomic Identification (ETI) Amsterdam, The Netherlands; University of the Philippines, Marine Science Institute (UPMSI), Philippines; Department of Fisheries, Malawi; 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), France; Musée National d'Histoire Naturelle (MNHN), Paris, France; Université Blaise Pascal Clermont-Ferrand, Institut des Sciences Biologiques, Hydrobiologie des Eaux Douces (UBPCF); Musée Royal 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 Aquatic Resources (DLNR-DAR), USA; Programa Ecologia, Pesquerias y Oceanografia del Golfo de México (EPOMEX), Campeche, Mexico.

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

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
DOF	: Mr. B. Mkoko; Mr. Emmanuel Kaunda
IAB	: Dr. Martin Odei; Ms. Mamaa Entsua-Mensah
NAN-IMR	: Dr. Gabriella Bianchi
ENSAT	: Dr. Jacques Moreau
MNHN	: Dr. Jean-Claude Hureau
MRAC	: Dr. Guy Teugels
UBPCF	: Ms. Patricia Reyes-Marchant
IZAS	: Dr. Kwang-Tsao Shao
DLNR-DAR	: Dr. M. Kimberly Smith
EPOMEX	: Dr. Alejandro Yañez-Arancibia; Ms. Christina Bárcenas Barzos
ICLARM	: Dr. Rainer Froese; Dr. Maria Lourdes Palomares; Dr. Daniel Pauly; Ms. Susan Luna; Ms. Crispina Binohlan; Ms. Armi Torres; Ms. Liza Agustin; Ms. Maria Teresa Cruz; Ms. Pascualita Sa-a (since November 1992); Mr. Roberto Cada; Mr. Dominador Tioseco; Mr. Magnus Olsson Ringby (until July 1992)

Objectives

- 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.
- To maintain and distribute the database to researchers, teachers, planners and managers, with emphasis on developing-country agencies and institutions.

FishBase, as an electronic encyclopedia of fish, plays two major roles: Firstly, it helps strengthen the ability of National Agriculture Research Systems (NARS) to understand and manage their national fish resources by providing them with key information on their species. Secondly, FishBase documents key characters of fish germplasm and keeps track of its occurrence and status.

Results

As of December 1992, FishBase contained nomenclature and distribution by FAO area of more than 6,700 species (Fig. 7). While this is only a quarter of the estimated 24,000 recent species, this number already includes all fishes used commercially in capture fisheries or aquaculture, all threatened 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 project continued to receive valuable databases from collaborators for distribution through FishBase:

William N. Eschmeyer from the California Academy of Sciences made available his *Catalog of the genera of recent fishes* in the form of a database (GENERA) covering all the over 10,000 recent genera of fishes in the world;

Jean-Claude Hureau from the Musée National d'Histoire Naturelle, Paris, provided more than 7,000 occurrence records for several hundred species from his database GICIM. Negotiations are underway to distribute eventually the more than 70,000 records in GICIM through FishBase;

Edward D. Houde and C.E. Zastrow from the Center for Environmental and Estuarine Studies, Maryland, USA, have made available their database LARVDYN on ecosystem- and taxa-specific dynamic and energetic properties of fish larvae;

Kwang-Tsao Shao from the Institute of Zoology, Academia Sinica, Taipei, made available a database of the fishes of Taiwan.

The project signed two collaborative agreements with FAO for joint maintenance and improvement of the databases on international transfers and on strains. FishBase will also serve as the taxonomic backbone of a Fish Disease Information System that is developed by FAO. The State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources, will interlink their database on Hawaiian coastal fishes with FishBase. The Programa Ecología, Pesquerías y Oceanografía del Golfo de México (EPOMEX), Campeche, will use FishBase to develop databases on Mexican fishes and on lethal concentrations of various pollutants. The Alfred Wegener Institute, Bremerhaven, Germany, will use FishBase to develop a database on Antarctic fishes.

There is a vast literature on fish in languages other than English and many potential users with working languages such as Spanish and French.

A Spanish account of FishBase was therefore published in *JAINA*, the EPOMEX newsletter, pending preparation of a Spanish version of FishBase. Also, work on a French version was initiated, mainly by Dr. M.L. Palomares including French data entry forms, entry of French-language material, a strategy for covering the literature from West Africa, and from Cambodia, Laos and Vietnam and a French-language ichthyological structure for FishBase.

The results from these and other initiatives to strengthen FishBase will be made available to project collaborators in 1993 and, after verification, in the first CD-ROM version, to be released in 1994.

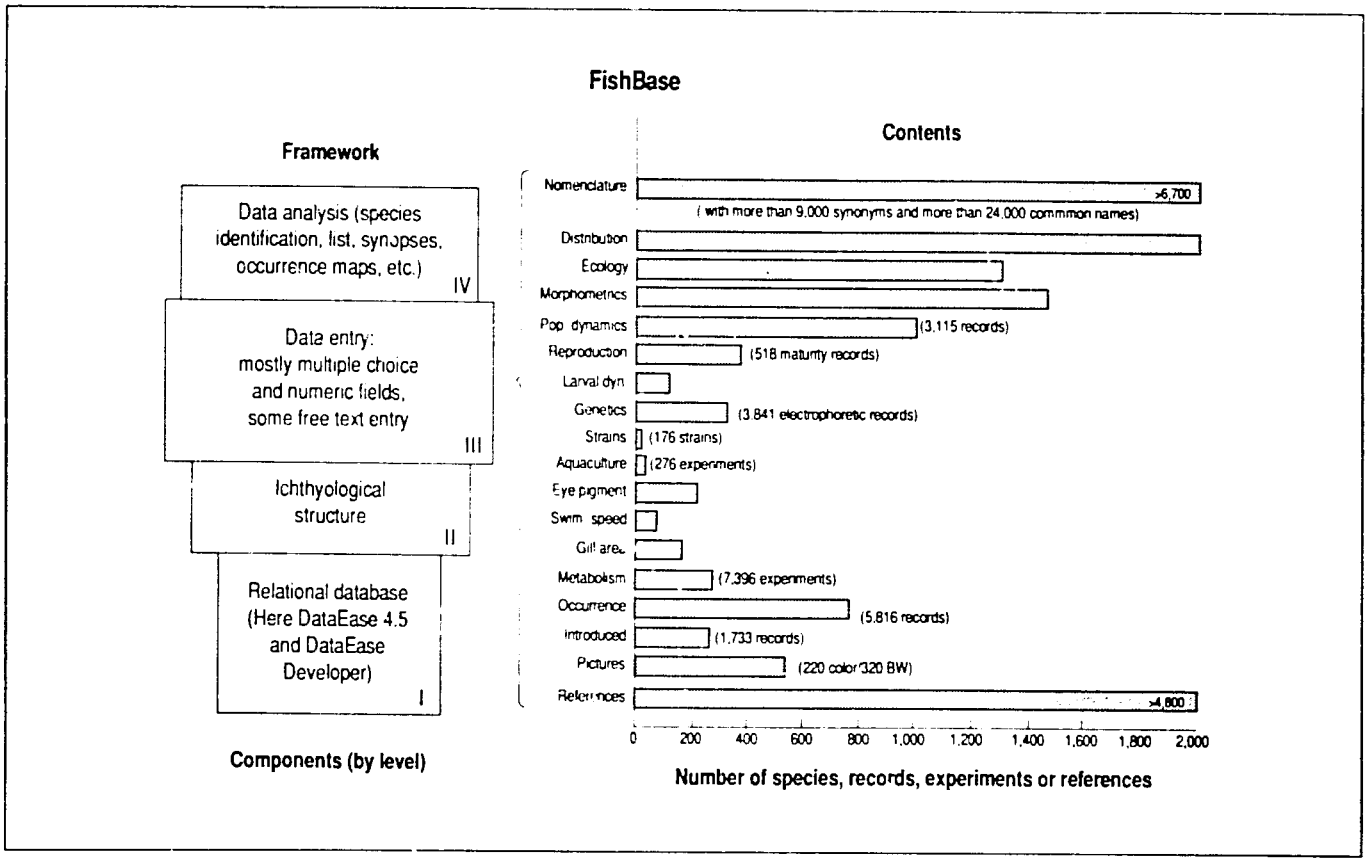


Fig. 7. Structure and contents of FishBase:

Left:

- Level I is represented by a commercial database, which can produce executable files that can be distributed royalty-free;
- Level II is the ichthyological structure, created by ICLARM staff in cooperation with various specialists throughout the world;
- Level III consists of the entries themselves, of which only a small fraction - the free text entries - will require translation when preparing versions of FishBase for languages other than English;
- Level IV consists of various graphical and statistical routines for the presentation and comparative analysis of the quantitative and categorical data entered in FishBase.

Right:

Information incorporated in FishBase as of December 1992. Note that the bars refer to the number of species (except for references). Numbers in parentheses indicate the number of records entered. There can be several records for one species.

Aquaculture Program Project Summaries

Project Title		: Network of Tropical Aquaculture Scientists
Funding Institution		: Unrestricted core
Duration		: Continuous from July 1987
Key Personnel	ICLARM	: Ms. Mary Ann Bimbao (Network Secretary); Dr. Roger Pullin (*Aquabyte* Editor)

Objectives

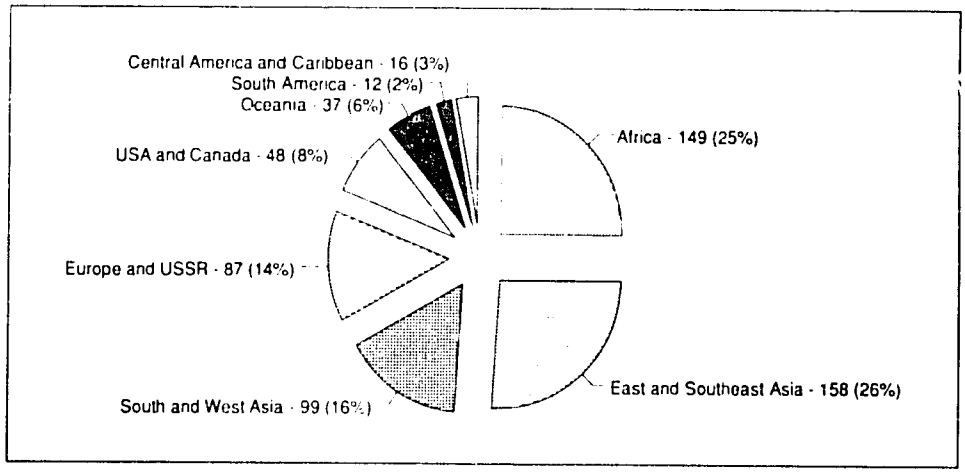
- To enhance communication among aquaculture scientists working in the tropics, especially in genetics, integrated agriculture-aquaculture farming systems and coastal aquaculture of tropical molluscs.
- To facilitate increased output by these scientists by assisting in information and database searches,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

Results

Starting this year, the NTAS newsletter, *Aquabyte*, was incorporated into *Naga, the ICLARM Quarterly*. The merger proved to be advantageous to NTAS members. It means that they will get more information not less: four issues a year, and articles and information on fisheries and coastal resources management, as well as aquaculture. An index was prepared of the contents of the eleven separate issues of *Aquabyte* published from 1988 to 1991.

Another structural change in *Aquabyte* concerns with French translations. We formerly translated into French and published in the same issue of *Aquabyte* only aquaculture articles of African origin. In future, we will select and translate material of special relevance for francophone developing countries irrespective of its origin. These translations will be published as separate items, catalogued in the ICLARM translation series, and will be sent to all NTAS members in francophone countries. This will further the objectives of the support from the French Government (see p. 90) that is used for Asia-Africa collaboration.

The NTAS secretariat distributed in April a questionnaire seeking members views on the NTAS and *Aquabyte* and proposing a new and more detailed description of their



Regional distribution of NTAS members: 606 scientists representing 87 countries.

research interests so that exchanges betweer members will be helped. The questionnaire was sent to 579 members and, to date, around 420 members have responded. The returns are now being processed and in 1993 we will publish a directory of NTAS members and an analysis of the responses.

The NTAS, though constrained by available financial resources, continued to assist members by answering requests for literature searches, reprints and reference materials. In August, 67 NTAS members whose research interests are farming management, extension, farming systems research, information, integrated farming systems, rice-fish farming systems, socioeconomics and training, were beneficiaries of free copies of the Technology Information Kit on Farmer-Proven Integrated Agriculture-Aquaculture produced by the International Institute of Rural Reconstruction and ICLARM.

An NTAS poster paper was presented by M.P. Bimbao at the Second Asian Farming Systems Symposium in Colombo, Sri Lanka.

Project Title	:	Asia-Africa Cooperation to Develop Aquaculture Technology
Funding Institution	:	Multilateral Division Ministry of Foreign Affairs, Government of France, Paris
Duration	:	Continuous from 1988
Key Personnel ICLARM	:	Dr. Roger Pullin; Ms. Catherine Lhomme Binudin, Ms. Mary Ann Bimbao

Objectives

To examine the scope for application of Asian aquaculture principles and practices in Africa.
To prepare and distribute information relevant to African aquaculture development, especially for francophone African countries.
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. In 1992, Ms. Catherine Lhomme Binudin, a French national, continued a translation program to assist francophone members of ICLARM's Network of Tropical Aquaculture Scientists (NTAS), who number over 80 from 19 countries, including 40 from francophone 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 ORSTOM. Ms. Binudin also finalized a French translation of the manual for ICLARM's ecological modeling software ECOPATH (see p. 80). These growing translation activities have led to the concept of a Translations Unit for ICLARM. Plans for this will be finalized in 1993.

Two study visits to Asia by francophone scientists were organized in 1992. Dr. Anis Diallo, Aquaculturist from the Centre de Recherches Océanographiies Dakar-Thiaroye (CRODT) participated in the ICLARM/International Institute of Rural Reconstruction (IIRR)

workshop in Silang, Cavite, on 2-15 February 1992, where he gave a presentation on rice-fish culture in the lower Casamance. This contributed to the output of the meeting - an information kit that depicts farmer-proven practices of integrating agriculture and aquaculture, where rational use of resources from farm by-products and wastes increases production. He also spent a week at ICLARM HQ for orientation on the FARMBASE and FishBase computer databases and also visited related institutions.

Dr. Valentine Yapi Chia, a visiting scientist from the Institut des Savanes, Bouaké, Côte d'Ivoire, visited ICLARM and its collaborating institutions in the Philippines from 7 to 18 February 1992. Dr. Yapi, a quantitative geneticist, observed the GIFT (Genetic Improvement of Farmed Tilapias) Project activities on tilapia breeding, electrophoresis and data analysis, and had discussions with GIFT Project (see below) leader, Dr. Eknath and other technical staff.

Project Title : Genetic Improvement of Farmed Tilapias (GIFT)

Funding Institution : Division for Global and Interregional Programmes of the United Nations Development Programme (UNDP/DGIP)

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 Marine Science Institute of the University of the Philippines (UPMSI); the Institute of Aquaculture Research of Norway (AKVAFORSK) through the Norwegian Center for International Agricultural Development (NORAGRIC/NORAD)

Duration : 1988 to 1991; extended up to June 1992

Key Personnel

NFFTRC/BFAR : Mr. Melchor Tayamen; Mr. Ruben Reyes; BFAR Ms. Jodecel Danting; Ms. Edna Dionisio; Ms. Felicisima Longalong; Mr. Marlon Reyes; Ms. Teresita Gonzales; Ms. Lilibeth Afan; Mr. Mar Danting

BFAR Satellite Stations :
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. Tereso Abella[1]; Mr. Antonio Circa

UPMSI : Ms. Ma. Josefa Pante; Ms. Ma. Theresa Rodriguez

AKVAFORSK : Dr. Trygve Gjedrem; Dr. Hans Bentsen; Dr. Bjarne Gjerde; Dr. Terje Refstie

ICLARM : Dr. Ambekar Eknath; Dr. Roger Pullin; Ms. Belen Acosta; Ms. Ravelina Velasco; Ms. Marietta de Vera; Ms. Carmela Janagap; Mr. Hernando Bolivar; Ms. Ma. Josephine France Rius

[1]Continuing studies for a Ph.D. degree at the University College of Swansea, Wales, UK.

Objectives

The project's primary thrust is to develop effective approaches and methods towards the production of improved breeds from low input, sustainable, warmwater aquaculture, using Nile tilapia (*Oreochromis niloticus*) as a testbed species, selecting better breeds for high growth rate and other economically important traits and providing improved breeds to national and regional testing programs and from thence to fish farmers.

Results

The project's fourth generation tilapia breeding experiment (the last such experiment for Phase I of the project) to estimate the response to selection (magnitude of genetic gain) and to test the genetically improved fish through farmer participatory research in a wide range of farming systems was completed in April.

The project's fifth generation experiment to estimate the magnitude of genetic gain from a second round of selection began in May. These also included test release of the selected fish to farmers. Details of these and other activities are as follows.

Response to Selection

A combined selection strategy was adopted. Breeders harvested following the termination of the third generation experiment were ranked on their breeding values, estimated from a linear combination of information on the individuals, their relatives (full-sibs, half-sibs), and heritability for growth performance. One hundred males and 200 females were selected for breeding from the 25 highest ranking families, out of the 123 families produced during the third generation. About 23,000 individually tagged fingerlings from 180 full-sib groups and 99 paternal half-sib groups were reared communally in 8 different test environments for 90 days. Three types of controls were used: i) progeny of individuals with average breeding values; ii) 'Israel' strain - presently the most widely cultured strain in the Philippines; and iii) progeny of 'Egypt' founder stock - the top ranking strain during the first generation trial.

- The average response to selection, across all test environments, was 23% (comparison with progeny from average parents).
- The selected fish were 75% faster growing than 'Israel' strain and 65% faster growing than the 'Egypt' strains.
- Heritability estimates for growth across test environments were 0.38 (sire component) and 0.53 (dam component).
- There was a significant positive correlation between growth and survival in the half-sib groups (0.2).
- The correlation of growth performance of half-sib groups across environments was 0.75.

On-Farm Trials

Progeny from 75 full-sib groups (out of the 180 full-sib groups produced) were pooled and random samples were drawn for testing in 26 farmer-operated environments representing various farming systems; backyard fishponds, cages, rice-fish and semi-intensive systems. The strategy was to compare the growth performance of the GIFT fish with the 'Israel' strain used by most farmers and/or the conventional farmers' strains stocked communally in equal proportions, in each of the different farming systems.

The GIFT fish grew on an average 60% faster than the 'Israel' strain. On the basis of recovery of tagged fish the GIFT fish showed on an average 50% better survival than the 'Israel' strain.

Selective Breeding Experiments, Including Farmer Participatory Research: Second Selection Experiment

Fish harvested following the termination of the fourth generation experiment were ranked based on their breeding values. One hundred males and 200 females were selected according to their estimated breeding values. Random mating was adopted during breeding and it was carried out in a nested mating design (1 male to 2 different females): 100 males were mated to 200 females to produce 200 full-sib families. Average performing individuals during the fourth generation experiment, 'Israel' strain, repeat mating of breeders used in the first round of selection, and the Sénégal strain replacement population (F_1) were all used as controls. Pairwise mating of the control groups was adopted.

Over 24,000 fingerlings (from 186 families) were tagged for family testing in six different environments. Fourteen families were not represented due to low number of fingerlings available since some females produced insufficient progeny. The test environments represented the earthen pond environments (BFAR/NFFTRC and FAC/CLSU ponds) and two cage environments (Laguna de Bay and San Pablo Lakes). The aim was to obtain better estimates of genotype x environment interaction among pond and cage farming systems. After stocking all the test environments, the remaining progenies of the GIFT strain were pooled, marked for additional testing in 25 farms. The aim was to compare the growth performance of the GIFT fish with the commercial 'Israel' strain. The target date for completion of this experiment is April 1993.

Collection of New Tilapia Germplasm

One of the key activities during the transition phase of the project (July to December) is the collection of additional Nile tilapia germplasm in Africa for more thorough evaluation and building of base populations for a national breeding program. Additional Nile tilapia were collected from Egypt in October from different waterbodies in Egypt (Marriott Lake, Idku, Manzalla, Timsah, Ismailia, Abbassa, near Timsah (Monsour) and the Suez Canal). As with previous introductions, the newly acquired founder populations were subjected to strict quarantine procedures.

Training

The Fifth Training Workshop on Quantitative Genetics of Tilapias was held at FAC/CLSU, Muñoz, Nueva Ecija, in May. Twenty researchers from the project's collaborating institutions participated. The workshop agenda included lectures and hands-on analysis of data from the project's fourth generation breeding experiment. It focused on estimation of genetic variance, heritability, response to selection, breeding values for selecting tilapia breeders for the fifth generation breeding experiment. In addition, a series of lectures and hands-on training on basic statistical methods for analysis of quantitative genetic data were held for the project staff. One project staff successfully completed her master's degree and three others are pursuing masteral studies.

Towards an Interregional Collaborative Research Network

The "First Meeting for the Establishment of International Linkages for Fish Genetics Research" was convened in May. The objective of this meeting was to discuss future collaborative plans for developing national fish breeding programs. The participants included 14 senior representatives from China, India, Ghana, Malawi, the Philippines, Thailand and Vietnam, as well as senior representatives from UNDP/DGIP and ICLARM. The outputs were guiding principles and possible mechanisms for an international network for fish genetics research.

Plans and Policies for Dissemination of Germplasm and National Breeding Programs

A strategic planning meeting on "International Concerns in the Use of Aquatic Germplasm" was convened in June. The participants were resource persons, internationally renowned for their contributions to applied genetics and breeding of fish, livestock and crops, and senior representatives from ADB, UNDP, FAO and national programs. The meeting focused on the important lessons from experiences in plant and animal breeding. The highlight was the formulation of protocols/guidelines concerning fish genetic research and germplasm distribution. The international experts commended the project and reviewed and endorsed future plans for the GIFT Project's Phase II.

Future Plans

The UNDP/DGIP has approved an expanded Phase II of the GIFT project for five years (January 1993 - December 1997).

Experiments for estimation of genetic gain and refinement of procedures for comparison will continue. The project team will also conduct experiments to estimate genetic variation for i) age at first spawning; ii) survival and growth in brackishwater; and iii) cold tolerance.

Additional subspecies or strains of *O. niloticus* will be collected from Africa for evaluation and possible inclusion in the on-going selection program and building up of the base populations.

Training will continue to be a very important activity targetting farmers, hatchery operators, research scientists and policymakers.

Project Title : FARMBASE[1]

Funding Institutions : Unrestricted core; Danish International Development Assistance (DANIDA)

Cooperating Institution : International Institute of Rural Reconstruction (IIRR)

Duration : June 1991 - June 1994

Key Personnel

ICLARM : Dr. Clive Lightfoot; Mr. Jens Peter Tang Dalsgaard; Ms. Mary Ann Bimbao; Ms. Teresita Lopez; Mr. Farlyz Felix Villanueva; Dr. Robert Pomeroy; Ms. Grace Coronado

IIRR : Mr. Frank Fermin; Mr. Nestor Roderno; Mr. Eusebio Imperial; Mr. Caloy Basilio; Mr. Scott Killough; Dr. Julian Gonsalves

Objectives

- To improve the way farmers manage land and water resources through integration of aquaculture and agriculture.
- To develop participatory research procedures for farmers to integrate aquaculture into their farming systems and improve their resource management skills.

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[1]To be renamed RESTORE (Research Tools for Natural Resource Systems Monitoring and Evaluation) in 1993.

- To develop database software and an analytical framework for monitoring the impact of integration on households and resource systems.

Results

Farmer participatory methods for drawing village maps and transects as well as individual farm system bioresource flow diagrams were further developed with an expanded group of farmer cooperators. The group now includes five farmers in barangay Pook Paliparan and nine farmers in barangay Kanutuhan, both in the Dasmarinas municipality, Cavite province, Philippines. The farmers drew models focus of their resource systems (e.g., fishponds, uplands, lowlands, etc.), management and integration through recycling of available on-farm resources and by-products. Further expansion to two new sites in the Philippines (Niugan and Naic, Cavite) was planned for 1993.

Primary data on whole farm systems gathered via these qualitative methods were entered and stored using the customized software FARMBASE. This will facilitate data analysis within farm systems as well as within communities across farm and resource systems. FARMBASE links qualitative methods and quantitative outputs for bioeconomic and ecological analyses and modelling. Connections will be made to other software including ICLARM's ecosystems modelling tool ECOPATH II, developed in-house (see p. 80). The latter analyzes ecosystem characteristics and quantifies a range of ecosystem attributes.

These outputs are expected to provide new insights into the sustainability of farming systems and the effects on systems performance of integrating agriculture and aquaculture. Performance indicators for farms and resource systems, such as diversity (numbers of cultured and utilized species), recycling, efficiency, and capacity, are calculated and plotted in kite diagrams (see Fig. 8). By supplementing monitoring data with historical data obtained from recall interviews, it is possible to plot the indicators over time for viewing trends within farms or making comparisons of developments between farms (see Fig. 9).

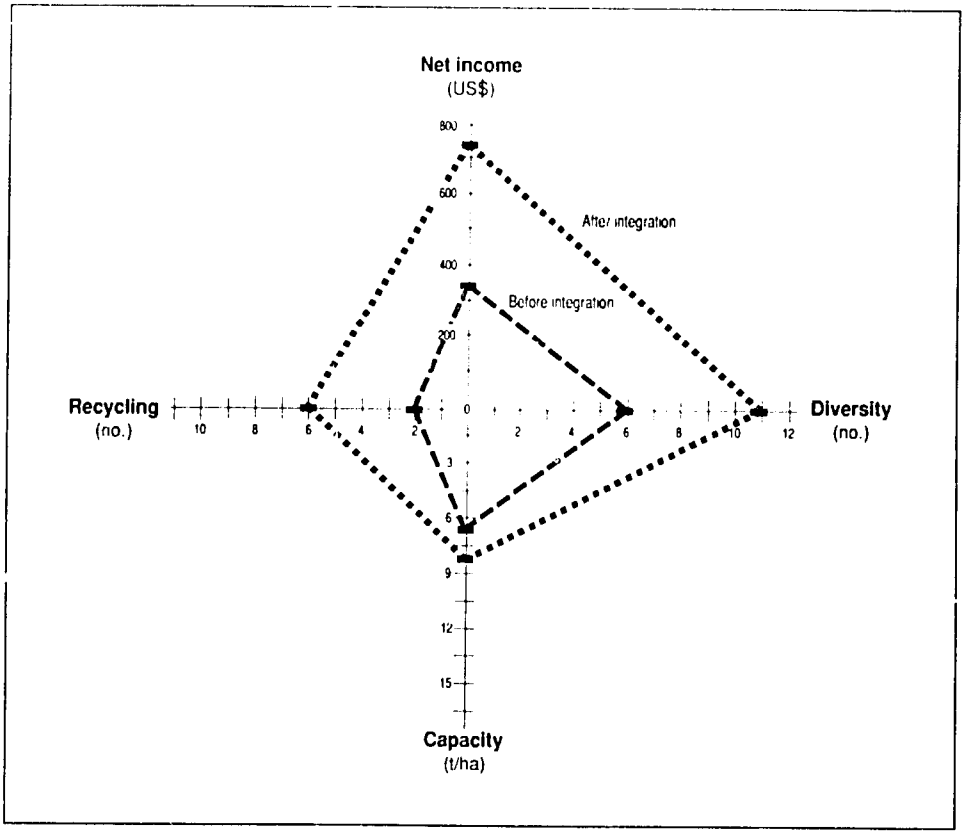


Fig. 8. Before and after integration: bioresource flows among resource systems, Cavite, Philippines.

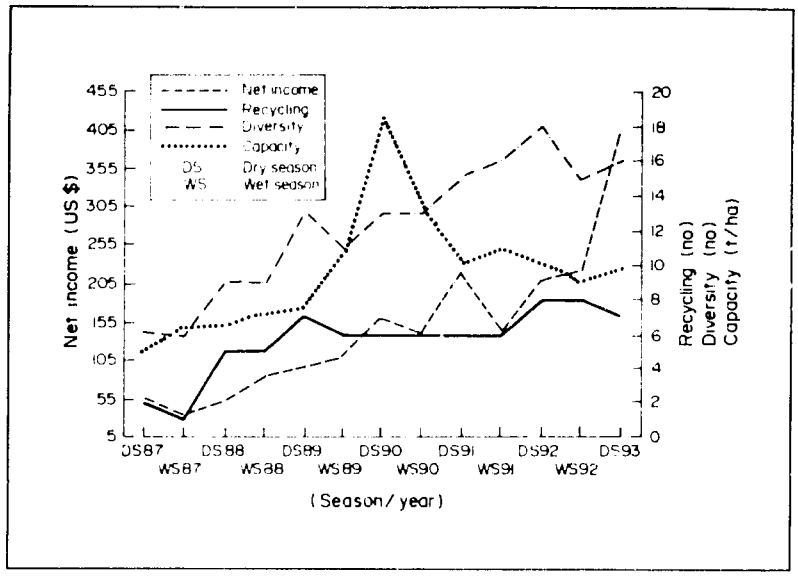
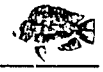


Fig. 9. Time series performance indicators by season, Cavite, Philippines.

In addition, the FARMBASE software has been linked with graphics software developed in-house. This facilitates the computerized drawings of farm transects, showing topographical features of resource systems with icons symbolizing crop, tree, livestock and aquaculture enterprises.



Project Title : Integrated Rice-Fish Research[1]

Funding Institutions : International Development Research Centre (IDRC) of Canada; Overseas Development Administration (ODA) of the United Kingdom; Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Germany

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); Goettingen University

Duration : January 1992 - ongoing

Key Personnel ICLARM : Dr. Catalino dela Cruz; Dr. Clive Lightfoot; Dr. Roger Pullin; Mr. Jens Peter Tang Dalsgaard; Ms. Mary Ann Bimbao; Ms. Gesa Horstkotte

Objectives

- 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.

[1]This project was formerly reported under the title 'Integrated Rice Fish Group'. ICLARM is now establishing an Integrated Resource Systems Group with a broader array of activities.

Results

Ricefield Ecology

Two ricefield ecology experiments were completed, adding to the information obtained previously on the impact of common carp *(Cyprinus carpio)* and Nile tilapia *(Oreochromis niloticus)* in enhancing ricefield ecosystems. The main positive effects were a 9-10% increase in rice grain yield and a 9-14% increase in nitrogen uptake during dry season; weed reduction by 10-67%; and beneficial influences on surface soil (e.g., in pH, organic matter and available phosphorus). Oligochaete worm populations considered beneficial for rice plants were significantly reduced (80-89%) by fish but this was offset to some extent by the bioturbation activities of fish which improve soil conditions and oxygenate water. Bioturbation by common carp seemed to enhance the mixing of orthophosphate into the soil, but also increased significantly (25.6%) the total solids (turbidity) in floodwater.

Rice-Fish Systems Modeling, Methodology Development

The project is using different tools to investigate the bioresource flows on rice-fish or potential rice-fish farms and the socioeconomic circumstances of farm families. This involves farmer participation in studies of how farmers manage natural resources and monitoring the impact of improvements. The methodology comprises rapid appraisal of the natural resources systems to which the farming community has access; modeling bioresource flows; and monitoring farmers' activities in managing natural resources. This is initiated by getting together a group of 10-15 community representatives, men and women, to indicate on a base map the natural resource systems in the village area and those outside to which they have access. Transects are constructed and discussed by the group, and corrections made until a consensus is reached.

Group sessions are also used to explore the potential of farmer-drawn conceptual models of bioresource flow models for helping households to improve resource management decisionmaking and experimenting skills. The household members sketch the natural resource systems and enterprises, including those systems beyond their farm to which they have access.

Results from the Philippines. In the Philippines (Central Luzon), the main source of income is rice farming and off-farm activities growing as secondary enterprises. About 38% of rice monoculture and 23% of fish farmers have off-farm sources of income. Thirty-one per cent of the rice monoculture farmers are engaged in vegetable growing vis-à-vis 61.5% in the case of rice-fish farmers. Rice-fish farmers devote more time to farming than rice monoculture farmers and have more diverse farming systems.

Rice-fish farmers with more financial resources feed their fish with rice bran and livestock feeds. However, more typically, rice-fish farmers use rice bran, animal manure and compost. Bioresource flows were identified involving crops other than rice. Squash and watermelon seemed to be more profitable than fish, easier to grow on a large scale with short culture periods and required less water.

Cash flows differed between farmers who fed their fish with rice bran (or mixed rice bran and hog mash) and those who grew their fish only in plots fertilized with animal manure (or combined manure and compost). The fed fish, predictably, grew faster than the unfed fish and could be harvested to generate income. The unfed fish were sold later, after the rice harvest. However, the net incomes from fish sales were similar for both systems: P7,712-10,785/ha for the fed fish; P6,500-10,345/ha for the unfed fish (US$1.00 = P26.00).

The work on farmer participatory methodology and rice-fish systems modeling has also involved visits to sites in Antique, Bicol and Iloilo and the Highland Cordillera Region. Investigations on "the economics of integrating fish into rice-based farming systems in Asia" began in July 1992 with funding from Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). This collaboration among ICLARM, the University of Goettingen (GU), Germany, and

IRRI will last for three years with work in the provinces of Nueva Ecija in Luzon and Antique in Panay Island. It will emphasize the benefits of fish to farmers, especially in integrated pest management (IPM). Earlier work on rice-fish farming was reviewed. The work plan developed in 1992 will be followed by full-scale implementation in 1993.

The rice-fish project team continued to have close interactions with the staff of IRRI with a view to planning a substantial multiagency, multidonor activity on the ecology of ricefields used for aquaculture. The main areas of mutual interest are fertility and IPM.

Training

Four participants from China, Malaysia and the Philippines were supported to attend the ICLARM-IRRI Workshop to produce a Technology-Proven Information Kit for Integrated Farming, 2-15 February, at the International Institute of Rural Reconstruction, Cavite, Philippines. IDRC supported the project's training activities in Vietnam and this support will extend to 1994. Mr. Le Thanh Duong, Deputy Director of the Mekong Delta Farming Systems Research and Development Center, University of Cantho in Vietnam, spent three weeks training on integrated farming systems at ICLARM from 17 February to 5 March 1992. He also participated in the ICLARM-IIRR workshop, where he presented a paper on "Implementation of Rice-Shrimp Farming Systems in a Freshwater Water Area of the Mekong Delta of Vietnam".

The visit introduced Mr. Duong to other scientists and institutions in the Philippines with similar research interests, namely the IIRR, the Freshwater Aquaculture Center of the Central Luzon State University (FAC/CLSU), and the Department of Agriculture (DA).

Project Title		: Agricultural Research Project-II (Supplement)
Funding Institution		: United States Agency for International Development (USAID)
Cooperating Institutions		: Bangladesh Agricultural Research Council (BARC); Fisheries Research Institute (FRI), Bangladesh
Duration		: May 1989 - June 1993
Key Personnel	BARC	: Dr. A.K.M. Nuruzzaman
	FRI	: Dr. Md. Aminul Islam/Dr. M.A. Mazid
	ICLARM	: Dr. Modadugu V. Gupta; Dr. Clive Lightfoot; Dr. Roger Pullin; Ms. Mary Ann Bimbao

Objectives

The Government of Bangladesh (GOB) is implementing the USAID-funded Agricultural Resesarch Project II (Supplement) for strengthening its National Agricultural Research System to increase domestic food supply, small farm incomes and rural employment. One of the sectors to be developed through the project is aquaculture. This has been given high priority by the GOB. ICLARM is assisting the planning and implementation of aquaculture research, training and extension.

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

- To assist the FRI in planning and implementation of aquaculture research.
- To recommend specific research ideas/technologies that could be incorporated in farming systems research.

- To provide technical guidance for farming systems research incorporating aquaculture.
- To assist extension agencies, including NGOs, in disseminating research results to farmers and fishers.

Results

Farmer Participatory Research

On-station research has shown the feasibility of producing 4-6 t/ha/year of fish through polyculture of carps, using mustard oil cake and rice bran feeds. Farmers were reluctant to use oil cake due to its high cost. Hence, farmer participatory studies were undertaken to assess fish production using only rice bran or with rice bran and oil cake as supplementary feeds, accompanied by fertilization with manures. Production of 1.8-2.2 t/ha were obtained in six months rearing with rice bran alone as supplementary feed, and 2.6-3.1 t/ha in 7.5-8.5 months rearing from ponds which received rice bran and oil cake in a 3:1 ratio.

On-farm studies confirmed the sustainability of culturing short-cycle species such as Nile tilapia *(Oreochromis niloticus)* or silver barb *(Puntius gonionotus)*, in seasonal ponds, with production of 1.2-1.8 t/ha in 4-6 months rearing. Discussions with farmers revealed that they would be interested in culturing more than one species in their ponds, especially due to the susceptibility of *P. gonionotus* to ulcerative disease syndrome. Hence, trials were initiated in farmers' ponds with polycultures of silver barb, Nile tilapia, silver carp *(Hypophthalmichthys molitrix)*, rohu *(Labeo rohita)* and mirror carp *(Cyprinus carpio)*. Ponds stocked with these four species at a density of 17,250 per ha gave production of over 2 t/ha in 5-6 months.

Studies were undertaken in 52 plots to assess the feasibility of integrating fish culture with rain-fed rice farming. Three species combinations: (i) silver barb alone, (ii) mirror carp alone and (iii) silver barb plus mirror carp, at a stocking density of 3,000 fingerlings/ha were tried. Due to low rainfall this year, ricefields had water for only 54 days before fish were harvested. In spite of this, average production of 76, 100 and 157 kg/ha, respectively, were obtained with the above species combinations. Net benefits from fish culture amounted to an average of Tk 2,118/ha (US$55/ha). Sixty-five per cent of the farmers reported increases in rice yields (8.8%) from fields with fish, as compared to fields without fish. Most farmers assessed integration as beneficial because: (i) rice yields are higher from fields with fish; (ii) there is additional income from fish; (iii) there is less weed infestation; (iv) there is low pest infestation, indicating IPM; (v) the presence of fish makes farmers visit fields often, leading to better rice agronomy; and (vi) water from ditches and canals can be used for supplementary irrigation when needed.

Assistance was provided to the Bangladesh Rice Research Institute, in integrating fish culture in the deepwater rice environment. Studies undertaken in 21 x 21 x 3 m net enclosures indicated fish production as high as 4-6 t/ha, with supplementary feeds. However, the high cost of making net enclosures is a constraint for adoption by farmers. Ways of reducing costs are being investigated.

Assistance to Farming Systems Research

ICLARM provided assistance to FRI in the planning and implementation of aquaculture research programs. Assistance was also provided to Bangladesh Agricultural Research Institute, Bangladesh Jute Research Institute and Bangladesh Sugarcane Research Institute, for incorporating aquaculture as an enterprise in their farming systems research in different agroecological zones. A two-day workshop for reviewing the farming systems research program revealed that the work undertaken so far has resulted in developing techniques for utilization of under- and unutilized water resources in homestead areas for aquaculture. An impact survey undertaken at the Ishurdi Centre revealed that, in two years, the number of ponds used for aquaculture has increased by 50% and yields have increased from 338 to

1,530 kg/ha. The workshop identified nonavailability of fingerlings in rural areas as a major constraint for large-scale expansion of aquaculture.

Assistance was provided to the FRI in breeding and rearing of local catfish *Clarias batrachus*. These efforts resulted in higher hatching rates and increased survival of fry from 20 to 50-90%. Cryopreservation of catfish sperm was also demonstrated. Guidance was also provided to FRI scientists for breeding *Pangasius pangasius* and *P. sutchi* for the first time in Bangladesh.

Technology Transfer and Feedback to Research

The results of farmer participatory research for optimizing fish productions from seasonal and perennial ponds, using on-farm agricultural wastes and by-products, created much interest among the developmental agencies (both Government and NGOs) and requests were received for assistance in transferring the technologies. In view of the need for feedback to researchers as to how the technologies are performing in different agroecological regions of the country and the need if any, for further research, a collaborative program was initiated with BARC, FRI and nine NGOs [Bangladesh Rural Advancement Committee (BRAC), Proshika, Caritas, Rangpur-Dinajpur Rural Services (RDRS), Tengamara Mohila Sobuj Sangstha (TMSS), Unnayan Sangha, Jagorani Chakra, Uttaran and Gandhi Ashram Trust]. Through this program, some 300 demonstration activities are being organized in different parts of the country and monitored by scientists. Over 1,200 farmers have been trained through the program. Within six months of the initiation of the program, farmers have been able to double their fish production.

Earlier work had indicated that production of *P. gonionotus* from seasonal ponds and ditches could be increased to 1.2-1.8 t/ha in 4-6 months. This technology was adopted by thousands of farmers throughout the country. A survey of 253 farmers, to assess the

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

Sl. No.	Course	Date	Participants	No.
1.	Broodfish and hatchery management	12-16 April	NGO extension workers	18
2.	Nursery pond management	19-23 April	NGO extension workers	26
3.	Nursery pond management	3-9 May	NGO extension workers	25
4.	Pond fish culture management	16-22 May	NGO extension workers	25
5.	Integrated fish farming	27-30 May	NGO extension workers	25
6.	Pond fish culture management	21-27 June	NGO extension workers	20
7.	Fish culture in seasonal ponds	22 June	NGO farmers	58
8.	Fish culture in perennial ponds	25 June	NGO farmers	41
9.	Pond fish culture management	4-10 July	NGO extension workers	19
10.	Pond fish culture management	19-25 July	NGO extension workers	27
11.	Pond fish culture technology transfer	27-30 July	NGO officers	16
12.	Rice-fish culture	3 August	Department of Agriculture extension officers and block supervisors	79
13.	Research planning and management	9-13 August	FRI scientists	25
14.	Pond fish culture	9-13 August	NGO extension workers	15
15.	Artificial breeding, fry and fingerling rearing of *Clarias* spp.	3 September	DOF farm managers and FRI scientists	10
16.	Pond fish culture	6 September	NGO farmers	56
17.	Pond fish culture	27 September	NGO farmers	69
18.	Socioeconomic aspects of aquaculture; basic concepts, acquisition of data and information and methods of analysis	7-24 December	FRI scientists	27

Total no. of persons directly trained by the project, 581; scientists, 62; extension workers (government and NGOs), 295; farmers, 224.

adoption/impact of silver barb culture and to identify further research needs, revealed that the farmers on an average obtained 1,345 kg/ha in six months. The farmers were able to obtain a net benefit of Tk 30,912/ha (US$795/ha). Nearly 36% of the adopters were women who, through aquaculture, contributed to incomes and nutrition of their families.

Training

With the successful demonstration of the benefits of sustainable, low-cost aquaculture practices developed by the project, requests were received from 52 NGOs for training 553 of their extension workers (431 men and 122 women) as trainers, so that they will be able to transfer the technology to farmers throughout the country. In compliance with these requests, ICLARM assisted the FRI and BARC in organizing 15 training programs during the year, to a total of 216 NGO and 79 Government extension workers and 224 farmers (Table 2). In addition, three training programs were organized for the scientists of FRI and the Department of Fisheries on (i) breeding and larval rearing of *Clarias* spp., (ii) socioeconomic aspects in aquaculture research and (iii) fisheries research planning and management.

A study tour of fisheries research and development activities in the Philippines and Thailand was organized for the Director and Chief Scientific Officer of FRI.

Assistance was provided to FRI in bringing out four training manuals (in Bengali) on different aspects of aquaculture and an extension pamphlet on carp polyculture.

Project Title	:	Socioeconomic Impact of a Fish Culture Extension Program on the Farming Systems of Bangladesh
Funding Institutions	:	International Fund for Agricultural Development (IFAD); Danish International Development Assistance (DANIDA)
Cooperating Institutions	:	Bangladesh Agricultural Research Council (BARC); Department of Fisheries (DOF) Bangladesh; Fisheries Research Institute (FRI), Bangladesh
Duration	:	June 1990 - June 1994
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 Bimbao; Dr. Modadugu Gupta; Dr. Clive Lightfoot; Dr. Roger Pullin

Objectives

The main objective is to assess the socioeconomic impact of extending fish culture techniques to rural households and communities. Specific objectives are:

- To identify appropriate fish culture and extension practices, with respect to cost-effectiveness and output efficiency in whole farm systems.
- To identify the most important factors affecting these systems.
- To determine the degree to which intensified extension affects adoption of aquaculture technology by farming communities.

- To evaluate changes in an area targetted for aquaculture extension by determining its impact on various social groups in terms of welfare indicators (income, employment, nutrition, education and participation).
- To provide guidelines for future policies and strategies of aquaculture extension appropriate for the farming systems of Bangladesh.
- To provide training on fish culture techniques, extension and socioeconomic research.
- To develop a framework as a practical tool for assessing the socioeconomic impact of fish culture practices within the farming systems of Bangladesh and for application in other developing countries.

Results

The project team continued to collect comparative information on socioeconomic circumstances of the households of pond operators or owners in two thanas (subdistricts): one having a program of fish culture extension (the target thana) and another without any such program (the control thana). The methodologies for extension support and socioeconomic monitoring are summarized in Fig. 10.

Socioeconomic research activities were undertaken in both the target (Kapasia) and control thanas (Sreepur) (Table 3). Analysis of data from a benchmark survey of household socioeconomics, farm resource allocation and fish marketing in the study area continued throughout the year. In addition, significant progress was made in the impact data collection and evaluation.

Table 3. Socioeconomic Impact of Fish Culture Extension Program on the Farming Systems of Bangladesh: Activities in 1992.

Type of activities	No. of units/ samples	Study unit	Progress of work
1. Household socio-economic survey	333	Sample households	Draft report
2. Fish market survey	21	Sample market	Draft report
3. Fish disease monitoring	257	Farmer cooperators ponds	Draft report
4. Fish market monitoring	21	Sample markets continuing	Data collection
5. Record keeping	257	Farmer cooperators ponds	Data processing
6. On-farm research	14	Farmer cooperators	Data collection continuing
7. Farm monitoring	80	Sample farm households	Data collection continuing
8. Waterbody survey in two newly added unions	Census	Small waterbodies	Data collection continuing
9. Resource system maps and transects	25	Sample farms	Data collection continuing

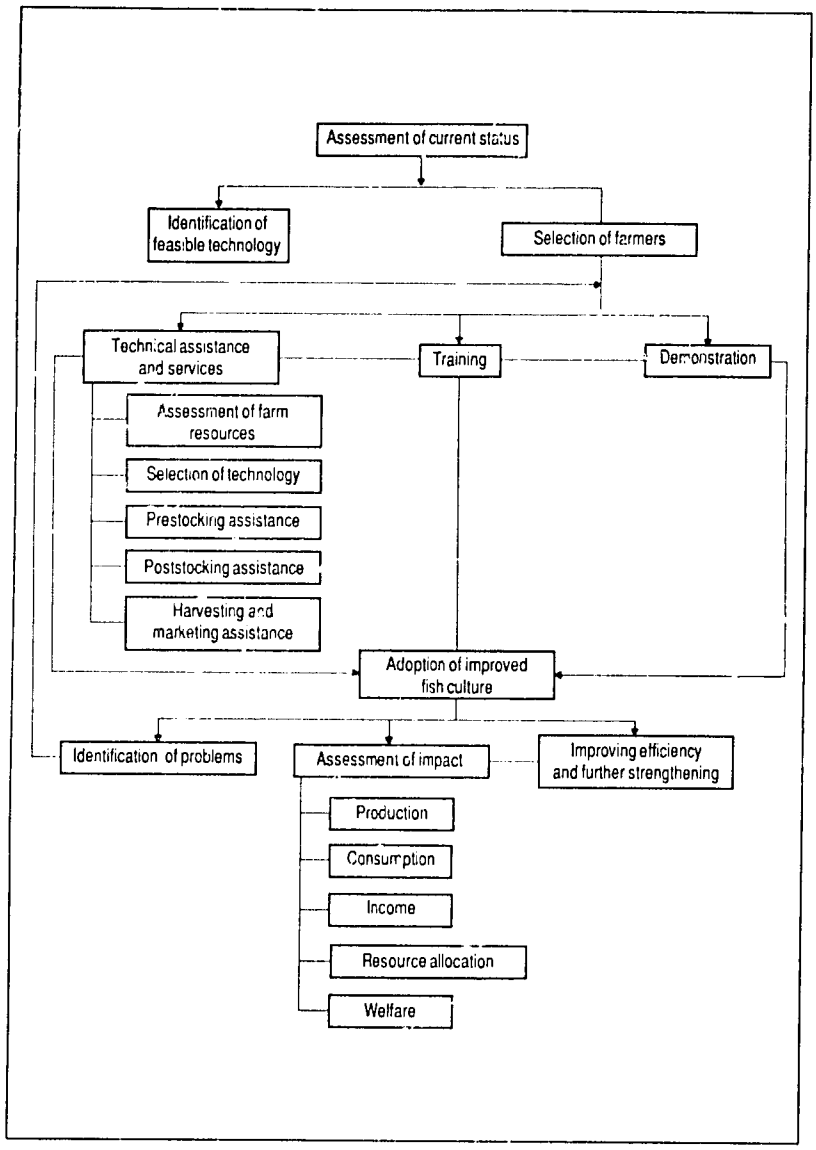


Fig. 10. Methodologies for aquaculture extension and assessment of its impact under the project Socioeconomic Impact of Fish Culture Extension Program on the Farming Systems of Bangladesh.

Socioeconomic Research

The benchmark household survey included identification of on-farm resources that can be used as inputs for pond aquaculture. Results showed that farm households in the target thana generated each year, on average: 1.0 t rice bran, 3.0 t cowdung and 0.8 t kitchen wastes. In the control thana, these resources were similar: 1.0 t, 3.8 t and 0.9 t, respectively. However, these resources are mostly used for raising crops and livestock.

Aside from the benchmark surveys, regular monitoring of farm activities was continued to assess if labor, capital and other farm resources are constraints, and thereby to determine the reallocation of resources that would be necessary for adoption of aquaculture technology. Monthly monitoring of representative fish markets was also initiated, to observe the

periodic movements of fish supply and prices and to determine to what extent a large increase in the regular supply of fish from ponds would affect prices.

Pond Aquaculture Research and Extension

The project team conducted some limited on-farm aquaculture trials: 14 ponds selected from one union of the target thana were stocked with four different polycultures in order to indicate fish growth and total productivity.

Most of the extension activities undertaken in 1991 were continued (Table 4) and some were expanded to cover more farmer cooperators in the target thana. The project team also provided assistance to nursery operators in order to ensure the timely stocking of farmer cooperators' ponds. Six nursery ponds covering 0.32 ha were stocked with rohu, mrigal, silver carp and mirror carp and produced a total of 95,000 fingerlings. These nursery operators earned a 300-400% profit over their production costs.

Project extension workers continued to provide assistance to novice farmer cooperators. Record-keeping books were distributed to 73 selected farmer cooperators. The remainder have record cards to document basic data on their fish culture operations.

The first year's extension effort led to the production of 49.6 t of fish from 257 cooperator farmers' ponds totalling 20.41 ha. Pre-extension annual production in these ponds, estimated through the benchmark survey, was only 17.60 t.

One major problem faced by farmers was the spread of ulcerative disease syndrome. Almost 40% of farmer cooperators' ponds were affected, with silver barb the most vulnerable species. No Nile tilapia ponds were affected. The disease was less severe in ponds that were either newly excavated or had no history of disease but there were no clear predictors for the spread of this disease.

Table 4. Training and extension activities.

Type/Name of activities	Title/Description	Duration	Numbers	Origin of participants
1. Selection of new farmer cooperators	Expansion of extension service	January	228	Farmer cooperators
2. Nursery assistance	To ensure fingerling supply	January-June	6	Farmer cooperators
3. Review workshop/ training	Sharing fish culture techniques	27 June - 15 July	252	Farmer cooperators
4. Farmers training	Basic fish culture techniques	28-29 December	25	Newly included farmer cooperators
5. Assistance for fish culture in beels	Expanded application of aquaculture technology	May - December	150	Farmer cooperators
6. Assistance in rice-fish culture	Expanded application of aquaculture technology	May - December	4	Farmer cooperators
7. Extension service	Pond preparation and fingerling stocking	June - August	320	Farmer cooperators
8. Extension service	Pond visit and post stocking management	Cont. since August	320	Farmer cooperators
9. Farmers rally	On farm demonstration and discussion among farmers	December continuing	50	Farmer cooperators

The project team also initiated extension, training and advisory services through which a few farmers began to stock fish in ricefields and in seasonal waterbodies known as beels (low lying areas): eight beels, covering 11.7 ha.

Workshops and Training

At the end of June, the project team held a series of review workshops for farmers on fish culture. The main purpose was to enable farmer cooperators to share experiences acquired during the first year of the project: 252 farmer cooperators participated. A two-day training program for farmer cooperators in unions newly included of the target thana was held at the end of the year. This emphasized basic fish culture techniques: pond preparation, stocking, feed and fertilization, harvesting and marketing: 25 fish farmers participated. Farmer rallies were held in December. The participants visited about 50 farmer cooperators' ponds and observed their production of fish.

Project Title : Research for the Future Development of Aquaculture in Ghana

Funding Institution : Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (BMZ)/Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Germany

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

Duration : June 1991 - May 1993

Key Personnel

IAB : Mr. Joseph K. Ofori; Mr. Ambrose Asamoah
GhRRM : Mr. David Owusu; Mr. Alex Bach
IRNR : Mr. Alfred Dassah; Mr. Francis Ulzen-Appiah; Mr. H. Bulley; Ms. B. Fiawotsror
IIRR : Mr. Frank Fermin; Dr. Isaac Bekalo; Dr. Julian Gonsalves
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 past and current situation of aquaculture in Ghana was reviewed and assessed through literature studies and numerous visits to existing and abandoned operations in the Upper East, Northern, Ashanti, Western, Central, Eastern, Volta and Greater Accra Regions. Many of the approximately 2,000 fish farmers are relatively rich persons but most of their ponds are poorly sited, badly constructed (with heavy machinery through bank loans) and badly managed. Such farmers view aquaculture as a "stand-alone" cash-generating enterprise quite separate from other on-farm operations. Often, they are town-based professionals.

A large amount of secondary data on the geographical, biological, agricultural, socioeconomic and cultural factors that affect aquaculture development has been compiled. The project's socioeconomic consultant, Dr. Kenneth Ruddle, visited the project and initiated analyses aimed at describing farm households in terms of their biological and economic characteristics. Further socioeconomic studies were made on small-scale farm households in seven regions in central and southern Ghana. These will provide data on crop systems and production patterns, cycles of farming activities, daily time allocations, inputs and outputs from farm operations, gender-related issues and constraints to farming activities.

At IAB's Aquaculture Research and Development Center (ARDEC), in Akosombo, growth experiments were performed in 10 ponds using different residues (animal manures) available on farms of small-scale households. These demonstrated that good fish growth can be achieved based on these inputs.

Field studies using such methods of farming systems research as rapid rural appraisal, resource-flow diagrams, farm transects, and farmer interviews were performed to understand existing farming systems, and to identify potential new entrants to integrated agriculture-aquaculture among small-scale, resource-poor farmers. Methods and strategies of farmer adoption were evaluated and refined. These revealed that farmers: (a) are well aware of the degraded condition of their resources, and (b) quickly understand the benefits of integration in terms of enhanced production, based on existing resources (own labor, on-farm residues).

On-farm participatory research was initiated with farmers in Mampong valley (Akuapem, Eastern Region), in cooperation with the Ghana Rural Reconstruction Movement (GhRRM) and the International Institute of Rural Reconstruction (IIRR). A test group of nine farmers adopted aquaculture-agriculture integration on their farms, based on their own designs. Although novices to fish culture, these achieved high extrapolated values of annual fish production (about 10 t/ha/year) in small, self-constructed ponds, using only on-farm residues and manure. In addition, vegetables were planted on pond dikes and adjacent plots and fertilized with pond water and mud. Vegetable wastes were added to the ponds. Overall, the adoption of integration led to an increase in overall farm production of 34% or US$520/household/year.

At ICLARM headquarters in Manila, software development continued (a) for the storage, management and analysis of farm data, and (b) to generate village and farm transects on-screen (based on vector graphics) in order to describe and evaluate the different farming systems in their present state, and to monitor changes as farmers integrate aquaculture into their activities.

Project Title : Research on the Tilapia Genetic Resources of Ghana for their Future Conservation and Management in Aquaculture and Fisheries

Funding Institution : Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Germany

Cooperating Institutions		:	The Institute of Aquatic Biology (IAB) in Accra, Ghana; the Zoological Institute and Museum of the University of Hamburg (ZIM/UH)
Duration		:	Planning phase, January - June 1991; project phase, July 1991 - June 1994
Key Personnel	IAB	:	Dr. Eddie Kofi Abban
	ZIM/UH	:	Dr. Sabine Oberst; Prof. Wolfgang Villwock; Prof. Lothar Renwrantz
	ICLARM	:	Dr. Ambekar Eknath; Dr. Roger Pullin

Objectives

- To train scientific and technical IAB staff in biochemical and immunological techniques for documentation of tilapia genetic resources.
- To apply these techniques in Ghana and to identify genetic markers in wild populations of economically important, indigenous tilapia species.
- To use these markers to screen tilapias sampled from different waterbodies so as to discriminate among sympatric species.
- To disseminate the results within and outside Ghana by means of workshops, written reports and publications.

Results

Collections were continued from the estuaries of Ghanaian rivers. *Sarotherodon melanotheron* is the dominant tilapia. Results indicate that all tilapia populations along the coastline of Ghana are genetically very close. Inland sampling in the Volta system was started at sites on the Black Volta, White Volta, and in the rivers Oti and Pru, as well as at sites directly above and below the Volta dam at Akasombo. The dominant species in the Volta system are *Oreochromis niloticus* and *S. galilaeus*. *Tilapia zillii* and *T. guineensis* occur in smaller proportions.

Various genetic markers for these species and *S. melanotheron* were identified by application of different biochemical and immunological methods on muscle and humoral blood proteins.

Blood plasma proteins and muscle parvalbumins were studied by polyacrylamide gel electrophoresis. Identification of species-specific molecules in plasma protein profiles was improved after reduction of the protein content of plasma samples by heat or ethanol treatment prior to electrophoresis. investigations of muscle extracts demonstrated parvalbumins with known characteristics. Their band patterns and molecular weights were species-specific for *S. melanotheron* and *T. guineensis*, but were identical for *O. niloticus* and *S. galilaeus*. This might indicate genetic closeness of *O. niloticus* and *S. galilaeus*. Parallel work on the meristics and morphometrics of specimens collected was performed for input into FishBase (see p. 86).

Laboratory training of IAB staff was continued and the range of techniques taught was expanded.

In February, representatives of the project team from IAB, ICLARM and ZIM/UH met at ZIM/UH with fish population geneticists from several research groups in Europe to review relevant biochemical and immunological methods applicable to tilapias and to exchange information on ongoing activities and future plans. During the year, the project facilitated working visits of scientists from their home institutions to the collaborating institutions.

Results obtained since the commencement of the project were presented at a local workshop at IAB in July 1992, where representatives from a wide cross-section of agencies in Ghana, academics as well as fisheries and aquaculture practitioners and policymakers, were made aware of information on the genetic characteristics of tilapia populations studied so far.

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

Funding Institution : Deustche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Germany

Cooperating Institutions : Malawi Fisheries Department (FD); Bunda College of Agriculture and Chancellor College of the University of Malawi (UM); Malawi Department of Research and Environmental Affairs (DREA); Malawi/German Fisheries and Aquaculture Development Project (MAGFAD); Aquaculture for Local Community Development Programme/ Food and Agriculture Organization (ALCOM/FAO)

Key Personnel
DOF : Mr. Boniface Mkoko; Mr. Brian Rashidi; Mr. Jasion Mutambo; Mr. Charles Makawa; Mr. Sloans Chimatiro; Ms. Mayesero Kapalamula
DREA : Mr. Orton Msiska
UM : Dr. Elenemo Khonga; Dr. Leonard Kamwanja; Dr. Davis Ng'ong'ola; Dr. Timothy Ngwira; Dr. Emmanuel Fabiano; Dr. James Seyani; Dr. Sosten Chiota; Mr. Aggrey Ambali; Mr. Jeremy Likongwe
MAGFAD : Dr. Thomas Gloerfelt-Tarp; Mr. Chris Bauer; Mr. Achim Jancke; Mr. Steve Langston
ALCOM/FAO : Mr. Boyd Haight; Mr. Niklas Mattson
ICLARM : Dr. Barry Costa-Pierce; Dr. Randall Brummett; Dr. Reginald Noble; Mr. Anne van Dam; Ms. Chipo Jamu; Mr. Emmanuel Kaunda; Mr. Fredson Chikafumbwa; Mr. Daniel Jamu; Ms Emma Mafuleka; Dr. Roger Pullin; Dr. Clive Lightfoot; Dr. Rainer Froese; Dr. Ma. Lourdes Palomares

Objectives

- To develop, through collaborative research with African scientists in biological and social sciences, aquaculture technologies appropriate to the prevailing conditions in rural Africa, with Malawi as a case study.
- To strengthen aquaculture research, training and education and information exchange among African and Asian institutions.
- To train African research and teaching personnel for supporting aquaculture research and development.
- To conduct research at Malawi's National Aquaculture Centre (NAC) on fish species and aquaculture systems, using bioresidues widely available on smallholder farms in rural Africa.
- To conduct on-farm participatory research on fish species and integrated crop-fish-pond systems using methods which improve farmer skills in resource management.
- To develop farmer-participatory monitoring tools for measuring impact of adoption of aquaculture on smallholder farming systems.

Results

On-Station Biological Research

The project continued research at the National Aquaculture Centre (NAC), Domasi, on use of on-farm resources and combinations of these as pond inputs for smallholder aquaculture. However, research was curtailed by a severe drought which started in January and reduced water supply to the ponds. As a consequence, pond experiments halted from May onwards. Conditions were made worse by deterioration of the water input channel to the NAC which is now under repair.

Despite these problems, some experiments were carried out in concrete tanks to investigate the effects of input type (grass vs. inorganic fertilizers) and fish (*Tilapia rendalli*) on the pond ecosystem. Fish in grass-fed tanks grew twice as fast as those in fertilized tanks. Detritus, derived from grass, was the predominant food item in the fish stomachs. There were significant differences in detrital biomass both between fish and nonfish treatments (fish reduced the detrital biomass) as well as between grass and fertilizer treatments (more grass, more detritus). Fish had a significant negative effect on numbers and biomass of benthic invertebrates. Phytoplankton biomass (chlorophyll *a*) was not significantly different between treatments. The experiments suggested that *T. rendalli* depended mainly on detritus and benthic food production and is not an exclusive macrophytic feeder.

Experiments were conducted to assess the effect of napier grass and maize bran input on *T. rendalli* and *Oreochromis shiranus* growth in 5 m^3 tanks. Alkalinity levels in all tanks were maintained at 40 mg/l. Fish were stocked at 2 fish/m^2. Grass was presented in a variety of ways: whole, chopped and ground. The highest fish productivity (2.6 t/ha/year) was achieved with napier grass and maize bran as a combined input, irrespective of how the grass was presented. The lowest productivity (1.7 t/ha/year) occurred where only napier grass was presented as a feed/fertilizer input. These experiments illustrate that farmers need not expend labor on processing grass for pond inputs but can simply throw whole leaves in. The experiments further underline that farmers can use readily available onfarm materials for pond inputs and achieve a reasonable fish production without resort to expensive off-farm inputs.

"Aqua-forestry" integrated systems research, initiated in 1991 as a pilot study to investigate if incorporating nitrogen-fixing trees into crop-fish systems would improve overall production of these systems, was continued. On the experimental site, total nitrogen yield increased by 22.5% to 1.4 t/ha/year nitrogen with the introduction of *Leucaena* trees. Other subsystems contributed the following to the total nitrogen yields: maize, 73%; mustard cabbage, 0.5%; fish, 4%. *Leucaena* leaves were not inputs to any of the subsystems except accidentally as natural leaf fall. The fishponds gave yields equivalent to 0.9 t/ha/year using fallow land grasses and waste vegetables as inputs. However, natural leaf fall from *Leucaena* contributed significantly to the proportion of dry matter in pond detritus. Even so, only 0.3% of the nitrogen entering ponds as direct inputs or as leaf litter was harvested as fish. This work is still preliminary and in 1993, a study is to be undertaken to fully investigate nitrogen recycling in tree-crop-fish systems more fully.

Farmer Participatory Research

a) Evaluation of impact of integrated aquaculture-agriculture on farming systems

A farmer-participatory research program was continued for testing aquaculture technologies and measuring the impact of integrated crop- and livestock-fish systems on the total farm environment. This program was conducted in collaboration with MAGFAD and the Malawi Fisheries Department (FD).

The main thrust of the impact assessment of aquaculture on small-scale farming systems involves a process of farmer drawing and modeling of their farm resource systems to capture the ecological transformations which occur due to the adoption of aquaculture. The modeling process provides feedback to the farmer on the effect of integrating aquaculture on the whole farming system. Thus hopefully, this participatory evaluation in farm evolution will provide farmers with a management tool for honing their resource management skills and more efficiently integrating aquaculture into the farming system. At present, 30 farmers are involved in the process but it is hoped to expand the number to 200-300 in collaboration with MAGFAD, FD and local NGOs.

Farm maps redrawn from a farmer's original drawings are demonstrated in Fig. 11. The two maps of the farm illustrate the arrangement of resource systems and bioresource flows before and after adoption of aquaculture. One year after adoption of aquaculture,

gross cash income to the farm has increased, marginal dambo land has been rehabilitated and recycling of bioresources and integration of resource systems has improved. This is not an isolated situation and transformation of the farming system can be even more dramatic in terms of improving cash and noncash incomes. This situation reflects the success of the collaborative effort of MAGFAD/FD extension and ICLARM's research effort in the study area.

This collaborative effort has led to increasing adoption of rice-fish and vegetable-fish integration. Assessment of 14 rice-fish ponds demonstrated rice production equivalent to 2.6 t/ha/year (std.dev. 0.8; range 1.3-4.2) and fish production equivalent to 1.4 t/ha/year (std.dev. 0.6; range 1.2-2.2). These yields of fish and rice compare favorably with those achieved on-station at the NAC with on-farm fish yields averaging just over twice those of on-station (range: 0.5-0.9 t/ha/year) and one cycle of rice achieving 50% of on-station yields (range: 5.2-6.7 t/ha/year). If farmers had run two cycles of rice then on-farm yields would have been very close to those on-station. On-farm yields of rice and fish certainly were reasonable when one considers that farm ponds were not fertilized, whereas on-station both diammonium phosphate and urea fertilizer were applied to ponds to maximize rice and fish yields.

The average rice area in ponds was 124 m^2 which had an estimated value in rice production of US$16 per year. The average size of pond is 211 m^2 which has the potential to earn on average US$23 per year for the farmer. In total, the rice-fish system can provide up to $39/year for the farmer irrespective of income from other resource systems. This is for a single cycle of rice and fish. Many farmers are starting to operate two cycles of rice and fish per year which will have the potential to increase total income up to $60 or $70/year. Considering that the average income for small-scale farmers in the research area is approximately $150-$200, then rice-fish can make a large contribution to improving income status and hopefully nutritional status of a farming household.

Impact assessment of aquaculture is just in its preliminary stages but there are already indications that small-scale aquaculture integrated into smallholder farming systems does have a positive effect on the farming environment, both biophysical and socioeconomic. Ponds seem to have many intrinsic beneficial effects because they trap water on the land and hence alter the water relations in adjacent resource systems. Table 5 demonstrates the range of effects of ponds on the farming systems of 21 farms which have put in ponds recently (i.e., the past 2-4 years).

An initial survey of farmers' perceptions of the relative importance of resource systems to the farming household's well being is also being carried out with farmers engaged in

Table 5. Effect of ponds on the farming environment of 21 smallholder farms in the Chingale-Chinseu Area, Zomba District, Malawi.

Effect of pond on farming system	Number	Per cent
Marginal land brought into production	7	33
Vegetable garden adjacent to pond expands due to pond improving soil-water relations in adjacent soils	4	19
New vegetable garden starts in association with pond	2	10
Vegetable garden soil fertility improved with pond mud	5	24
Household uses pond as domestic water supply	7	33
Recycling of crop/animal wastes starts or increases due to use as pond inputs	21	100
Rice-fish integration starts	5	24
Household cash income increases due to sales of fish and/or increased sales of vegetables, rice, etc., from gardens adjacent to ponds	15	71
Food supply for farming family improves	18	86

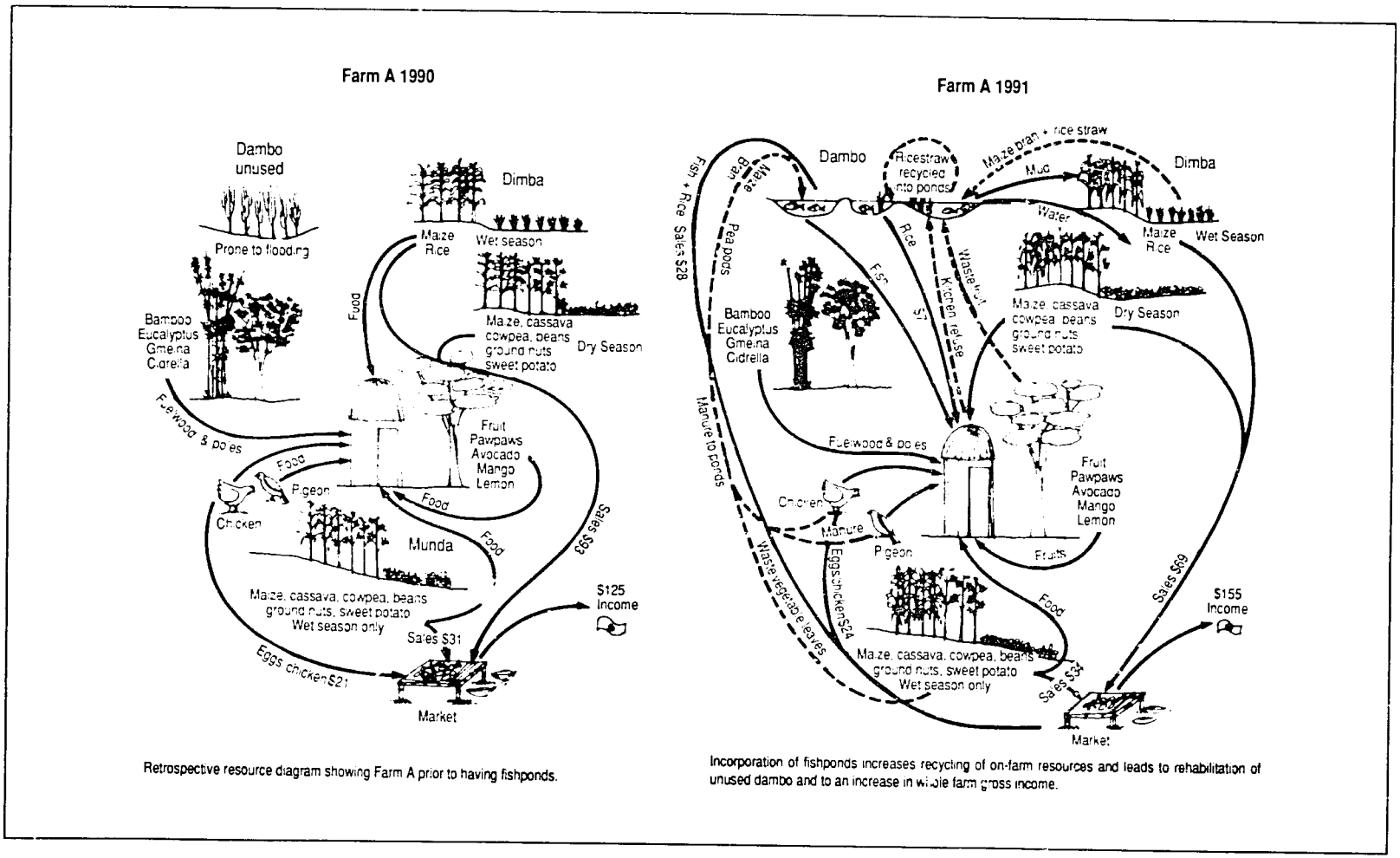


Fig. 11. A farmer's diagrams of a farming system before and after adoption of aquaculture.

aquaculture. An initial matrix analysis carried out with 11 farmers is shown in Table 6. Ponds as multipurpose resource systems scored highest without any prompting by researchers. Ponds scored well because they not only provide fish, but water and pond mud which can be recycled to other resource systems. To verify these findings, further matrix analyses are being done with larger numbers of farmers.

Table 6. Farmers' scoring for the relative importance different resource systems or enterprises make to cash income, food production, etc., of farming households.

Resource system/Enterprise	1. Cash income	2. Food	3. Use for household	4. Use for recycling	Total score for 1-4 (a)	Possible total (b)	A as % of B
a) Cropland (munda)							
Maize	5	4	2	3	14		
Intercrop veg.	5	3	0	2	10	40	60
b) Market garden (dimba)	5	4	0	2	11	20	55
c) Orchard	3	2	3	0	8	20	40
d) Woodlot	2	0	4	0	6	20	30
e) Fishpond	5	3	4	2	14	20	70
f) Livestock	5	2	1	4	12	20	60

Sample size = 11 farmers; Scoring was from 1-5, 1 = minor importance, 5 = very important. Household use = importance of material for either fuel, building, water supply, etc. Recycling = importance for use as compost and/or manure for recycling to other resource systems. (a) Cropland (munda) is farmland where crops can be only grown in wet season. (b) Market garden (dimba) is land where crops and vegetables can be grown almost throughout the year. Livestock is the only enterprise separated on its own because farmers were better able to score its importance this way. Maize and intercropped vegetables were also easier for farmers to score separately when assessing the cropland. For analysis, the scores for wet season cropland were summed to give a total for the munda resource system.

Detailed mapping and modeling with 18 farmers have enabled estimates to be made of the relative contribution different resource systems make to the gross cash income of a farming household practicing aquaculture. The pond-dimba system which are strongly integrated on all farms accounts for approximately 41% of the gross cash income on the 18 farms surveyed as shown in Tables 7 and 8.

Ponds contributed US$0-344/year in gross income to farming households. The zero cash income gives a false impression because this analysis does not take into account noncash income from ponds which is considerable. Farmers are using ponds for fish as food for their households, to provide fish for bartering and as gifts to maintain social contracts with family and friends. Detailed evaluation work is in progress to establish both cash and noncash income from resource systems before and after adoption of aquaculture to assess more accurately the effects of integrated aquaculture-agriculture systems on rural African households.

Table 7. Mean % contribution each resource system makes to gross cash income of 18 farms in Chinseu, Zomba District, Malawi.

Resource system	Munda	Dimba	Pond	Woodlot	Orchard	Livestock	Totals
Mean	49	25	16	3	1	5	100
Standard deviation	30	23	15	12	3	8	

Table 8. Mean gross cash income (US dollars) from each resource system summarized for 18 farms in Chinseu, Zomba District, Malawi

Resource system	Munda	Dimba	Pond	Woodlot	Orchard	Livestock	Totals
Mean	177	92	56	12	4	20	341
Standard deviation	175	87	84	32	5	34	383

All of this participatory impact assessment and on-going monitoring and evaluation is being done with the help of MAGFAD and FD in their extension areas.

b) On-farm experiments to test a new fish species for small-scale aquaculture - collaborative MAGFAD/FD/ICLARM project

On-farm monitoring of the performance of *Oreochromis saka/karongae* (a new species to aquaculture) and *Tilapia rendalli* polyculture was completed in five farmers' club ponds. Farmers determined the input regime, pond design and length of the experiment. The results are presented in Table 9.

Table 9. Production of *Oreochromis saka/karongae* and *Tilapia rendalli* in polyculture receiving low-quality on-farm inputs.

Quantity	*T. rendalli*		*O. saka*		Total	
kg/200 m^2/year	10.6	(3.3)	2.7	(1.1)	13.3	(4.2)
kg/ha/year	529	(165)	137	(55)	666	(211)

Figures in parentheses are standard deviations.

Overall production in the ponds was very low, particularly for *O. saka/karongae* which only contributed, on average, 20% to total fish production in the polyculture. The low production was probably related to the persistently low chlorophyll *a* levels in all ponds, *O. saka* being primarily a phytoplankton feeder. In contrast, *T. rendalli* production was over four times that of *O. saka*, reflecting the greater flexibility of the former in feeding, being able to utilize benthic invertebrate and detrital food chains. A contributory factor to total fish production being poor was probably the low input rates for crop and animal wastes. It seems that running farmer experiments at a club level is not effective as farmers are not prepared to take shared responsibility for running the experiment. Further farmer experiments on testing fish growth will be conducted in 1993 but these will be with individual farmers to ensure individual responsibility for growth trials. From this initial experiment with *O. saka/karongae*, it appears that it is unlikely to perform well under low-quality input regimes and therefore may not be suitable for most small-scale fish farming operations. A joint MAGFAD/FD/ICLARM workshop was held for the farmers participating in the experiment in July 1992. The objective of the workshop was to allow farmers to see the results from all the ponds and be able to discuss the problems and general usefulness of the experimental approach. It proved very successful and will become normal practice for all farmer-led on-farm experiments.

Collaboration with University of Malawi (UM) and Department of Research and Environmental Affairs (DREA)

ICLARM is currently supporting a UM Ph.D. research student who is a Principal Scientific Officer with DREA. This research is focusing on the aquaculture potential of indigenous fish species from Lake Malawi and will be completed early in 1993.

Three senior faculty of Chancellor College Biology and Chemistry Departments (UM) have received a joint ICLARM research grant of 12,500 Malawi Kwacha (approx. US$3,000) to study plants suitable for irradicating molluscs which transmit bilharzia in fishponds. This study entitled "Plant Molluscides and Piscicides" is now close to completion and will be published in 1993.

Three ICLARM sponsored M.Sc. students successfully completed their aquaculture research studies at UM in 1992. The students concerned all now have positions within the FD as Officer-in-Charge of the NAC (Mr. E. Kaunda), Women's Development Officer at FD

HQ (Ms. Mayesero Kapalamula) and Officer-in-Charge of aquaculture extension for Southern Region in Malawi (Mr. S. Chimatiro).

At Bunda College of Agriculture, ICLARM successfully completed construction of 21 experimental ponds to support the college's aquaculture program which is being designed to serve the SADCC countries in southern Africa.

Mr. E. Kaunda, while still with ICLARM, did part-time teaching at Bunda College of Agriculture and Chancellor College, University of Malawi in aquaculture (Bunda), freshwater biology (Chancellor) and fish biology (Chancellor) as part of ICLARM's collaboration with UM.

Collaboration with IARCs

ICLARM supervised an FD M.Sc. student who was doing his field research at NAC but was registered on the Aquaculture Master's Program at Kuopio University, Finland. The project concerned the effect on fish growth of a variety of locally designed pelleted feeds. The student concerned successfully completed his M.Sc. in 1992 and is a research officer on the EEC-funded Northern and Central Regions Aquaculture Project in Mzuzu, Northern Malawi.

ICLARM supervised three M.Sc. students from Wageningen Agricultural University, The Netherlands, who came to Malawi to obtain practical training in aquaculture and farming systems research as part of their master's program. This collaboration is continuing and hopefully further students will be coming in 1993.

ALCOM/FAO/ICLARM/FD Collaboration on Small Waterbodies

The ALCOM/FAO project based in Harare placed a research officer at NAC to work in collaboration with ICLARM and FD on assessment of fish stocks in small waterbodies in Malawi. ICLARM has provided research facilities and transport for ALCOM to carry out its research. The work has proved very successful and publications will be forthcoming in 1993.

Information

The project helped the flow of aquaculture, farming systems and general aquatic information to subSaharan Africa through the project library at the NAC. The library has now 1,003 books, 118 serial titles and 791 processed reprints as well as a further 650 reprints under process. All library holdings are logged on CDS/ISIS version 3.0 for easy access by staff and visitors. The library has 49 local members from Malawi but there is a much wider indirect access for users via links with other Malawi National libraries. There were 287 library transactions, 50 library requests and 22 aquatic and fisheries abstract searches during the year; 66% of requests were from within Malawi, 25% from other parts of Africa and 8% from outside Africa.

Staff Additions

In November 1992, Ms. Emma Mafuleka, a Bunda College graduate, joined the project as a research assistant on the farming systems research program. Ms. Mafuleka will be carrying out research on the effects of farming system transformation on intrahousehold dynamics, hopefully for a master's degree.

Project Title : Giant Clam Mariculture Project

Funding Institutions : United Kingdom Overseas Development Administration (UK-ODA); International Centre for Ocean Development (ICOD); Voluntary Service Overseas (VSO); United States Peace Corps (USPC)

Cooperating Institutions : Fisheries Division, Government of Solomon Islands (GSI); Centre for Development Studies, University of Bergen (CDS); University of Ghent, Belgium (UG)

Duration : Indefinite

Key Personnel ICLARM : Dr. John L. Munro; Dr. John B. Hambrey; Mr. Mark H. Gervis; Dr. Patricia E. Munro; Mr. Hugh Govan; Ms. Lucy Gilkes; Mr. Idris Lane; Mr. Cletus Oengpepa; Mr. Toata Molea; Mr. Thomas Shearer; Mr. Stephan Soule; Mr. F. Lasi; Mr. P. Timmy

GSI : Mr. Hugo Tafea; Mr. Francis Tofuakalo; Mr. Sylvester Diake

CDS : Dr. Edvard Hviding; Ms. K. Lievestad

UG : Dr. Patrick Sorgeloos; Mr. Peter Coutteau

Objectives

- To test, develop and demonstrate economically viable systems for the cultivation of various species of giant clams.
- To enhance the productivity of giant clams by selective breeding for improved growth or survival or other desirable characteristics.
- To investigate economic, social and legal factors which affect giant clam culture in the South Pacific Region.

Results

Hatchery and Nursery Systems

Good progress was made on many fronts in this project, from improved hatchery and ocean nursery systems to completion of the first economic analyses.

However, a most untoward event was an outbreak of an unknown affliction which selectively attacked *Tridacna gigas* and *Hippopus hippopus*. Other species were entirely unaffected. Mortalities were first reported in May in the eastern Solomon Islands, with subsequent reports indicating that the causative agent was spreading towards the northwest of the archipelago.

Some village ocean nursery trials in Makira, Guadalcanal and Nggela suffered reductions from total stocks of over 5,000 to a handful of clams, ranging in shell length from 35 to 400 mm. Initial reports from Marau Sound in eastern Guadalcanal indicated that *H. hippopus* and *T. gigas* were the only species to be affected.

At the CAC, deaths of *T. gigas* began in August. Losses included 63 mature wild *T. gigas* and 22 *H. hippopus* broodstock and approximately 10,000 35-mm *T. gigas* and 3,500 *H. hippopus* juveniles. At the end of October, *H. hippopus* broodstock began to die. Other species (*T. derasa, T. crocea, T. squamosa* and *T. maxima*) appeared healthy despite having previously been in close proximity to the dying clams.

The majority of ICLARM's cultured stocks are held at Nusa Tupe Field Station in the Western Province, where no mortalities were observed. The problem appeared to have run its course by November, coincident with the onset of the monsoon.

A similar sequence of events was seen in all clams affected by the malaise. The initial indication of ill health was a slight retraction of the mantle from the edge of the shell. Within 24 hours clams showing such symptoms had died. Antibiotic treatments were tried on adult *Tridacna gigas*, but chloramphenicol injected into the body cavity at a dose of 5 mg/kg body weight, streptomycin injected at a dose of 15 mg/kg body weight, and 50 ppm streptomycin baths were all unsuccessful.

Samples of tissues from all organs of clams of various sizes were sent to the Oonoonba Veterinary Laboratory in Australia. No cell necrosis or inflammatory lesions were found, nor evidence of viral inclusions, parasite damage or infection by *Perkinsus* sp. The symptoms were thought by the pathologists to suggest the presence of a toxin in the environment. However, it seems highly unlikely that a pollutant could spread over such a wide area and selectively kill only two out of six species of giant clams. There was also no indication of the presence of algal blooms or other possible biological sources of a toxin.

The incidence of the mass mortalities was associated with a pronounced "El Niño" event and observed environmental peculiarities included:

a) Tidal levels which were about 20 cm lower than predicted levels from April 1992 to October 1992. The low tide levels caused considerable mortality of corals and invertebrates on reef flats and reef crests in many areas of the Solomon Islands;

b) Between June and October 1992, abnormally strong currents were intermittently observed. Whilst in full flood they would drag a series of three floating ocean nursery rafts underwater to a depth of approximately 3 m.

c) The seawater temperature at the CAC has been declining since June 1991. Prior to that the average temperature was 30°C. By March 1992, the mean temperature was 27.5°C, but increased to 29°C in April and then dropped to 26.5°C in August, at the height of the die-off, and rose to 27.5°C by the end of the year.

Spawning and Hatchery Production

During the year, 20 cohorts of tridacnids were successfully reared; 1 of *T. gigas*, 5 of *T. maxima*, 4 of *T. crocea*, 1 of *T. derasa*, 2 of *T. squamosa* and 7 of *H. hippopus*, all using CAC's standard protocols.

Toward the end of the year, the static larval rearing system was compared with a flowthrough system, which would obviate the need for water changes on alternate days and the use of antibiotics. Output of spat appeared to be comparable with that obtained from the static tanks.

Larval feeding with the standard 50:50 mix of freeze-dried *Tetraselmis suecica* and Frippak Booster continued, additional supplies of *T. suecica* having been secured.

A total of 344,000 4-10-mm spat were harvested from the hatchery tanks during the year (Fig. 12) and stocked into floating ocean nurseries. Cumulative annual production peaked at 624,000 in August 1992. The decline in the production rate towards the end of the year resulted from the collapse of successive larval batches around mid-year and because spat were retained in the land-based tanks until the disease had abated. However, by the end of the year hatchery tanks were filled with large numbers of spat and no sustained decline in production was anticipated.

Experimental work on improvements of the output of the land-based nursery tank system focused on estimating the assimilation rate of ammonia by juvenile giant clams. The aim of the work was to set a baseline for establishing what concentrations of fertilizer are appropriate for different size juvenile clams. It was confirmed that the biomasses of clams harvested from tanks dosed with ammonium sulfate fertilizer were significantly higher than in unfertilized tanks.

The tanks that had fertilizer applied to them showed a different pattern of algal growth, with the most problematic algal types, the blue-greens, being more rapidly succeeded by green algae in tanks that had fertilizer applied to them.

Following from this work, the settlement tanks are now routinely fertilized with a daily 20 mm "spike" of ammonium sulfate, once the clams have become visible.

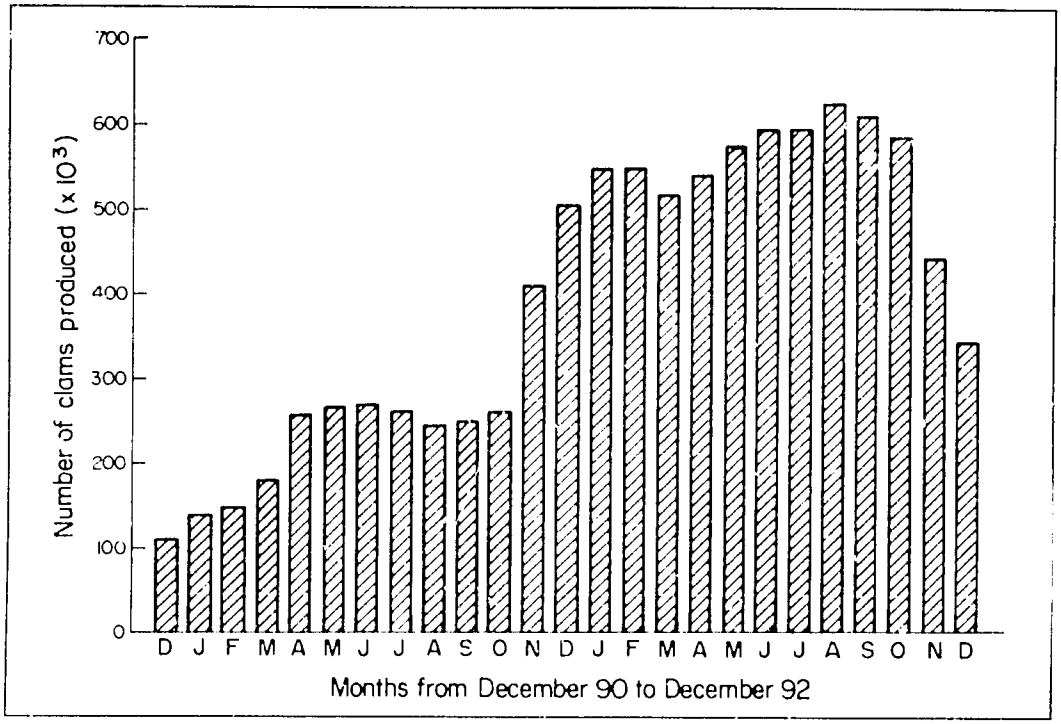


Fig. 12. Cumulative annual output of giant clam spat (4-25 mm) to the ocean nursery system at the Coastal Aquaculture Centre.

Ocean Nursery System

Output of 35-mm juveniles from the floating nurseries fell to 43,100 clams compared with 64,600 in 1991. This reduction in output was, in part, ascribable to the almost total loss of a large cohort of *T. gigas* and of two cohorts of *H. hippopus* as a result of the disease which struck these species in mid-year. Losses of *T. maxima* and *T. crocea* caused by their high mobility and propensity to crawl out of the ocean nursery trays reduced the apparent survival of these species.

The original designs used in floating ocean nurseries (FONs) at the CAC continued to be modified. Changes were effected in the system for support of the ocean nursery trays, in the composition of the float units and the attachment methods. All wood and bolts have been removed, shackles are fixed into galvanized pipes and splicing is used instead of rope clips. Anchors and anchor lines have also been modified, resulting in a system which is stronger and requires less maintenance. Costs were unchanged.

A different type of FON system using buoys rather than PVC pipes to suspend the platforms and trays was tested. This system is much less complex than the catamaran system and the cost is 27% less. Maintenance requirements are also lower. The system will be further tested next year.

A series of experiments on technology choice which began in December 1990 was completed in June 1992. These experiments were executed at the ocean nursery in Nusa Tupe. A total of 34,000 clams in the 6-80-mm size range were used. The major results were as follows:

- Survival of clams was found to be significantly better in ocean nursery cages on trestles in comparison with cages resting on the seabed. Growth was not significantly different.
- Survival was significantly higher in the trays of FONs than in trestle mounted cages; with differences being more marked for smaller clams. Growth rates were also superior in the FONs.

- Both growth and survival rates were superior in benthic or trestle-mounted cages in the subtidal zone compared with those in the intertidal zone.
- There were no significant differences in growth or survival rates with increased stocking densities.

It was concluded from this study that FONs were the most cost-effective choice of rearing system for clams from 3 to 60 mm, after which trestle cages are cheaper until the clams reach 100 mm, at which time they can be stocked into exclosures.

Forty-two thousand tridacnids (25-35 mm) were shipped from the CAC to the Nusa Tupe Field Station for rearing on site or for distribution to village-based ocean nursery trials. Annual survival of *T. gigas* was variable but averaged 50% (range 40-85%), for those clams retained at the station for a full year. There were marked differences between species and in particular, a cohort of *H. hippopus* exhibited a survival rate of 73% over a year, increasing in size at 6 mm/month. Growth rate of *T. gigas* was quite consistent and, in terms of shell length, nearly linear at 3.5 mm/month.

At the end of the year, nearly 29,000 *T. gigas* were in stock at Nusa Tupe plus 5,300 *H. hippopus*. More than 50% of the stock at Nusa Tupe is reared on a production basis, which involves counting and measuring at six-monthly intervals, rather than the more regular checks that are the norm for clams which are being used for experimental purposes. The Nusa Tupe facility consists of over 200 cages or trays placed either on trestles or in floating ocean nurseries. There are also two exclosures containing clams with a shell length of over 100 mm.

Village Trials

An additional 15 village trials were developed in the Western Solomons during the year, bringing the total number of village sites to 32, of which 17 are in the Western Province, managed from Nusa Tupe Field Station. In the eastern portion of the country, one additional site was activated, bringing the total number to 15. This additional site was established in the Marau Sound to act as a demonstration site and to oversee all trial sites in the area. By the end of the year a total of 7,700 clams were in the care of villagers, including a significant number of stock older than three years.

Survival rates of *T. gigas* at village sites were highly variable, as were growth rates, reflecting the varying suitability of available habitat and the relative diligence which was applied to the maintenance of the ocean nurseries. In the village trials in the Western Solomons, survival of *T. gigas* was around 55% per year, while *H. hippopus* had a survival rate of 86% per year.

Two of the village trials in Marau, East Guadalcanal suffered almost complete loss of their stock due to the unknown disease which afflicted both cultured and wild stocks in the area. However, other village trials within the same current stream suffered no usual losses, indicating that proximity is a major factor in transmission.

Economics

Estimates are available of production costs and output at each stage, based on the latest techniques being employed. From the work at Nusa Tupe it is estimated that over 50 ocean nursery trays or cages could be handled by one person.

Using a combination of land-based hatchery and a first stage floating ocean nursery with an annual production of 500,000 seed, the likely unit production cost in Solomon Islands for 35-mm giant clam seed was estimated at US$0.13.

Marketing costs, farm-gate prices, wholesale values, processing and shipping costs have been evaluated in a number of reports.

Survival rates achieved in the ocean nursery phase are the primary factor governing the economic viability of giant clam cultivation and this is directly related to the skills and motivation of the prospective farmer.

In addition to the known markets for adductor muscle and shells, there are developing markets in the aquarium and live seafood trades. The response from dealers in these

markets has been favorable and further investigations of these areas will be undertaken during 1993.

Genetics

A workshop was convened at ICLARM headquarters in June to examine genetic aspects of conservation and cultivation of giant clams. The workshop was particularly concerned with the genetic characteristics of surviving stocks and translocations of genetic material for commercial purposes or for the purpose of re-establishing wild stocks in regions where breeding populations are extinct. The workshop participants created an international consortium of their respective institutions with the objective of re-establishing stocks of giant clams in the Pacific Ocean in a manner which conforms with sound genetic principles.

Project Title		: Reef Ranching Research Project
Funding Institution		: South Pacific Regional Environmental Programme (SPREP)
Cooperating Institution		: South Pacific Regional Environmental Programme (SPREP)
Duration		: 1989 to 31 December 1992
Key Personnel	ICLARM	: Dr. John L. Munro; Ms. Lucy Gilkes
	SPREP	: Dr. Paul Holthus

Objectives

- To investigate the feasibility of ranching systems for coral reef fish and invertebrates, based upon the release or transplantation of juveniles of selected species to reef systems.
- To enhance the fisheries productivity of coral reef systems clams by artificial means
- To investigate economic, social and legal factors which affect reef ranching or replenishment systems in the South Pacific Region.

Results

No further work was done on the CAC's protected reef during this year. Ms Gilkes' assignment with ICLARM was completed in May and in addition to completing her reports on the preceding years' work she monitored the landings of an EEC-funded fisheries station in Santa Ysabel, Solomon Islands, for eight weeks, to assess the relative importance of various species in the small-scale fishery supplying the station. The results suggested that lutjanids, lethrinids and serranids were, as expected, of particular importance and appear to warrant further investigation in relation to reef ranching systems.

Some preparatory work was undertaken in anticipation of a new research project on the feasibility of ranching sea cucumbers.

This project will be absorbed into a new project on "New species for aquaculture and fisheries enhancement" in 1993.

Project Title		:	Status of Cultivation of Pearl Oysters in the Indo-Pacific Region: A Review
Funding Institution		:	United Kingdom Overseas Development Administration (UK-ODA)
Cooperating Institutions		:	Various
Duration		:	October 1990 to April 1992
Key Personnel	ICLARM	:	Mr. M.H. Gervis; Dr. J.L. Munro Mr. N.A. Sims

Objectives

- To review the present status of research in the culture of larvae of tropical bivalves, with particular reference to pearl oysters.
- To compile a comprehensive bibliography of the pearl oysters.
- To arrange for key documents to be translated from Japanese or Chinese.
- To prepare a research plan for the hatchery propagation of *Pinctada* sp., particularly *P. maxima* including various protocols for testing methods for spawning induction, larval rearing and settlement and maintenance of pearl oyster spat, juveniles and adults.

Results

This project was completed with the publication by ICLARM of the review by M.H. Gervis and N.A. Sims entitled "The biology and culture of pearl oysters (Bivalvia: Pteriidae)" in the ICLARM Studies and Reviews series.

A research plan for future work was drawn up, in anticipation of funding for a major research effort in 1993.

No translations were arranged as there was insufficient funding for this purpose.

Project Title		:	Coastal Aquaculture Network
Cooperating Institutions		:	James Cook University of North Queensland, Townsville, Australia; Fisheries Division, Ministry of Agriculture and Fisheries, Suva, Fiji; Center for Oceanological Research and Development, Jakarta, Indonesia; Fisheries Division, Tarawa, Kiribati; Silliman University, Durnaguete, Philippines; Marine Sciences Institute, University of the Philippines, Quezon City, Philippines; Fisheries Division, Honiara, Solomon Islands; Natural Resources Institute, Chatham, UK; University of Newcastle-upon-Tyne, UK; Fisheries Division, Apia, Western Samoa, National Aquaculture Centre, Kosrae, Federated States of Micronesia, and the Australian Institute of Marine Science, Townsville, Australia
Duration		:	1987 to December 1992
Key Personnel	ICLARM	:	Dr. John L. Munro; Dr. Patricia E. Munro

Objectives

- To enhance and promote international collaboration in coastal aquaculture by creating networks of interested institutions and individuals.

- To develop participating research groups concerned with specific organisms or aquaculture techniques and facilitate the rapid ex-change of information and results by newsletters and meetings.
- To promote exchange visits between participating institutions.

Results

Two issues of *Clamlines*, the newsletter of the Giant Clam Research Group, were published, edited by Dr. P.E. Munro.

Trainees from the South Pacific Region included Mr. Mason Timothy and Mr. Roland Sigrah from the National Aquaculture Centre and the Aquaculture Research Programme respectively in the Federated States of Micronesia and Mr. Aisake Batibasaga, Manager of the giant clam project in Fiji. Their travel costs were met by the Japan/FAO South Pacific Regional Aquaculture Development Project. Mr. Steve Lindsay, the aquaculture extension agent in Micronesia and who is also responsible for the hatchery in Kosrae, visited the CAC and Nusa Tupe for three weeks.

Project Title : A Collaborative Investigation of Predation on Cultivated Giant Clams (Tridacnidae: Bivalvia)

Funding Institution : Australian Centre for International Agricultural Research (ACIAR)

Cooperating Institutions : James Cook University of North Queensland, Australia; University of the South Pacific, Suva, Fiji; Silliman University, Dumaguete, Philippines; Marine Sciences Institute, University of the Philippines, Quezon City, Philippines; and Fisheries Division, Western Samoa.

Duration : Two years to November 1992

Key Personnel
ICLARM : Mr. Hugh Govan; Dr. John L. Munro
JCU : Dr. J.S. Lucas
USP : Dr. Alison Haynes
MSI : Dr. Edgardo D. Gomez
SU : Dr. Hilconida Calumpong

Objectives

- To collect and identify predators on juvenile giant clams
- To establish the identities of giant clam predators occurring in the widest possible range of Indo-Pacific habitats.
- To investigate the predatory behavior, predation rates and species and size selection by the predators.
- To elucidate the basic biology and ecology of the major predators.
- To utilize the results of these investigations for the formulation of recommendations concerning habitat selection for giant clam ocean nursery and growout areas and for the design and construction of ocean nurseries.
- To formulate recommendations for the control of giant clam predators.
- To compile a handbook for identification of giant clam predators.

Results

This project terminated on schedule in November. Accomplishments included the compilation of a list of animals that prey on juvenile tridacnids, based on observations at the CAC and collaborating institutions and reports in the scientific literature.

Data collected on the habitat preferences of various predators suggest that most clam predators seem to enjoy the same habitats which favor clam farming. Exceptions are the absence of the ranellid gastropods, *Cymatium* spp., from the Orpheus Island ocean nursery on the Great Barrier Reef and the absence of stylochid flatworms from benthic cages.

Ranellid gastropods are serious predators of juvenile clams at most clam farms and have been the focus of research at the CAC, where clams are preyed on mostly by *Cymatium muricinum* but also by *C. aquatile*, *C. pileare* and *C. nicobaricum*. Ranellids enter clam cages either by crawling into the cage or by settling on the clam cages as planktonic larvae.

Medium to full-sized ranellids attack small *T. gigas* up to about 100-150 mm SL either by climbing up the outside of the clams' valves and very rapidly everting its long extensible proboscis and stabbing the bivalve through the mantle between the gaping valves. The clam reacts by closing its valves, sometimes repeatedly, and often trapping the proboscis which rarely appears to trouble the predator, but soon the clam relaxes and dies. The internal organs are generally consumed before the mantle. The time taken to paralyze and eat the clam depends on the relative sizes of the predator and prey. In cases where even a small snail was removed from its prey immediately after the first successful stab, the clam has subsequently died. In the few unsuccessful attacks observed the gastropod has merely waited for the clam to re-open its valves and then proceeded to attack again in the same fashion.

It appears that the snails use toxic salivary secretions to kill or at least paralyze their prey. Judging by the angle of attack and rapid immobilization of the clam prey it appears that the target is the heart.

Where there is a marked disparity between the size of the ranellid and the size of the clam, the snails feed on the clam either through the valve gape or byssal orifice without attempting, or managing, to kill the clam outright. The snail may actually crawl into the clam and feed under the mantle edges or even inside the body cavity. This is the method favored by recently settled juvenile snails but all sizes of ranellids have been observed attacking large clams in this fashion. Adults have been observed feeding on a 40-cm *T. gigas* broodstock. The attack results in the death of the clam only if the size of snail is sufficiently large in relation to the clam size.

Growth of *C. muricinum* was studied from the stage of recently metamorphosed juveniles (protoconch) to maturity. Nothing is known about the larval growth and size at settlement of these snails. They show an early period of rapid and virtually linear shell growth which slows when a certain size is reached and a thickening of the shell lip known as a varix is formed. Two or three varices may be formed, but the first major one signals the end of the period of rapid, linear growth. The varix is formed in less than two weeks and growth then proceeds at a rate conforming to one of the standard growth functions such as von Bertalanffy's. Another varix is formed which may be the last, or occasionally growth may commence again with the formation of a third and final varix.

Ranellids which settle onto ocean nursery cages or trays, and are thus trapped with an abundant food supply, appear to show the type of growth observed in aquaria. But snails in benthic cages may have crawled in from the surrounding habitat and can be expected to have suffered periods of starvation or reduced food intake. These circumstances are thought to modify the snail's growth patterns by reducing size at the formation of varices, reducing the maximum snail size, increasing shell thickness and increasing the length of the periods of no growth. These characteristics can help to distinguish snails that have settled in cages as planktonic larvae from snails entering cages from the surrounding reef.

Predation rates of *C. muricinum* were measured and the biomass (dry weight) of the clams plotted against time and snail size. During the period of rapid, linear, growth *C. muricinum* consume 20-33 mg dry weight of clam per day. This is equivalent to about one 12-mm SL *T. gigas* per day or one 30-mm SL *T. gigas* every 2-3 days. Consumption

generally increases with snail size but becomes more variable when maximum snail size is reached. Larger adult snails consumed as many as ten 30-mm SL *T. gigas* per week. It is probable that scavengers such as other gastropods, fish and crustaceans increase these consumption rates in the field.

All four species laid egg capsules in aquaria. The capsules were arranged in a characteristic hemispherical shape and incubated by the parent snail for 2-3 weeks, before the planktonic veligers emerged through the top of the egg capsules. Veligers were maintained in aquaria for up to two weeks but none could be reared through to settlement.

Peaks in recruitment of ranellids appear sporadic and so far have not been correlated with climatological or hydrographical data.

Ranellids are capable of attacking and consuming *H. hippopus* but prefer *T. gigas*. This preference is more marked in the case of juveniles. When ranellids were only offered *H. hippopus*, these were consumed at only slightly inferior rates to those expected for *T. gigas*.

Muricid gastropods were found mostly in exclosures, benthic cages and trestle cages. Very few were found in floating cages. The large muricid, *Chicoreus ramosus*, can kill specimens of *T. gigas* and *T. squamosa* up to 30 cm in shell length. These gastropods are relatively rare and easily detected but may have contributed to high mortalities of growout clams at one site. A small muricid, *Muricodrupa fiscella*, was found to be associated with significant juvenile clam mortalities at five ocean nursery sites typified by rocky or rubble habitats. Predation can be easily controlled by regular checks on ocean nurseries (every 2-4 days). Snails can then be easily spotted and removed before clams have been adversely affected. It is important that the clams not be placed directly on the substrate, nor should cages be designed in such a way as to afford shelter to these snails, e.g., gravel substrate, rough and uneven cement work.

Three species of polyclad flatworm are commonly found in trestle and floating cages, one of which (*Stylochus (Imogene) matatasi* n sp.) appears to be a significant cause of clam mortality. The new species has been described in collaboration with staff from the Queensland Museum.

S. matatasi attack at night and are presumed to kill their prey by simple external digestion of their tissues. Mortality rates of two species of juvenile giant clam and of a pearl oyster increased significantly in the presence of these flatworms. The mortality rates of clams in experimental aquaria were sufficient to account for the mortality observed in ocean nurseries with heavy infestations of these worms. Consumption of bivalve tissue averaged around 10 mg dry weight per day or about one 30 mm SL *T. gigas* per week. Large and small juvenile *T. gigas*, *H. hippopus* and pearl oysters appeared equally vulnerable to the activities of these worms.

Eggs of *S. matatasi* are laid as frequently as every 7 days over one-month observation periods. Egg mass size varied proportionally to the size of flatworms and were laid in single, tightly packed layers on smooth surfaces over a 1-2 day period. The parent often broods the egg masses until the eggs hatch after 2-6 days. The four-lobed Göttes larvae are capable of metamorphosing into juveniles and settling 1-2 days later, but were also observed swimming for more than 8 days in some cases. The smallest observed juvenile was 400 x 60 mm. Juveniles are very active and appear to ingest particles from detritus.

Work on shell-boring organisms was limited to determining their incidence, identity and methods of control. Up to 50% of the larger juvenile giant clams at the CAC had infestations of one or more species of shell-borers. Shell-boring sponges, algae, fungi and polychaete worms are all capable of reducing shell strength, tissue condition or weight and in severe cases, cause death.

Control mechanisms for giant clam predators include checking ocean nurseries as frequently as possible; at least 2-3 times per week. Larger clams in exclosures and growout areas should also be checked regularly.

Infestations of flatworms can be controlled by manual removal of the worms along with debris and fouling organisms that may provide refuge and egg laying sites. The use of freshwater, hypersaline or chemical dips to control flatworms did not appear to hold much potential for the control of adult worms but may be of use in controlling eggs and recently

metamorphosed juveniles. The observed absence of flatworms in benthic cages provides an avenue for further research because environmental factors or predators may be responsible.

Most shell-borers die when treated with 1% formalin and exposed to air for one hour or more. Less toxic treatments such as the use of chlorine and freshwater are possibilities.

The prospects for the exclusion of larval ranellids are poor. Larger snails can be excluded from cages but the tenacity, agility and relatively small size of these animals have proven to be difficult characteristics to overcome and observations suggest that *Cymatium* spp. can get through any mesh aperture larger than the snail's diameter.

Mesh sizes of 20 mm and above are commonly used in ocean nurseries largely due to availability, ease of algal fouling control and efficiency in excluding most other predators. A plot of length versus diameter for all four species of *Cymatium* showed that all but exceptionally large snails can pass through 20-mm mesh. The use of 12.5-mm mesh would be expected to exclude a high proportion of the larger, more voracious and more mobile *Cymatium* spp. However, adoption of meshes of this size might involve unacceptable sacrifices in terms of increased maintenance, cost and weight. A compromise may be the use of rectangular meshes of, say, 25 x 12 mm.

Preliminary data from Solomon Islands and results from Western Samoa suggest that cages raised from the substratum on trestles reduce the incidence of large ranellids. Devices, dubbed "excluders", for preventing the climbing of trestle legs by ranellids have been tested. Designs that have failed include inverted cones of various materials, bundles of tangle mesh, bundles of sharp bristles, groups of horizontal disks at different spacings, cones with polythene skirts, suspension of cages or trays on fine wires, and combinations of the above.

These excluders all failed owing to the tenacity and agility of the snails. *Cymatium* spp. are all capable of extending their foot to a distance exceeding their shell length and gaining purchase with only a small proportion of the foot's tip. Snails were observed to experience difficulty crawling on vertical sheets of thin polythene (such as carrier bags) but the polythene soon fouled, stiffened or became detached, rendering the devices unreliable.

However, an excluder with various bends and curves which gave the snails many opportunities to take wrong turnings (Fig. 13) showed much promise and ranellids rarely managed to get past it and frequently remained trapped inside.

Relatively few organisms have been identified which might be used for biological control of predators. No animals have been found that consume the flatworm *S. matatasi*. Anecdotal evidence suggests that some species of fish may be able to consume polyclad flatworms. The absence of stylochids from benthic cages suggests biological or physical factors, which only prevail on the seabed, may be controlling these pests.

The hermit crab, *Dardanus lagpodes*, showed promise in aquarium trials when presented with pyramidellids and juvenile ranellids. Pyramidellids are easily killed by these crabs but ranellids are only killed when they have thin and relatively small shells (less than 15 mm in length).

The fasciolariid gastropod, *Pleuroploca filamentosa*, was observed to consume more than one ranellid per day in aquaria over four weeks. All sizes were attacked and the *P. filamentosa* showed no interest in clams, even when starved. Trials carried out in cages have given good results for large ranellids. Small ranellids were inclined to escape from the cages. Other fasciolariid species and cone shells are still to be screened.

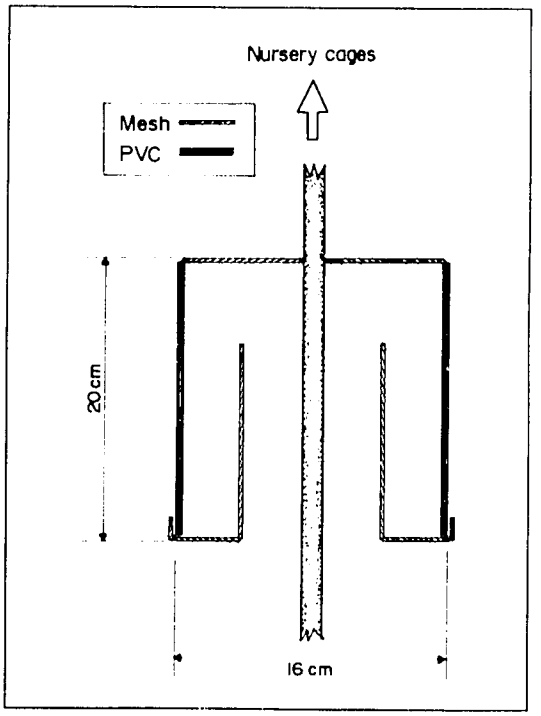


Fig. 13. PVC and wire mesh (10 mm) ranellid excluder, for attachment to legs of trestles bearing giant clam nursery cages.