ICLARM Report 1990

ICLARM

International Center for Living Aquatic Resources Management

ICLARM REPORT
1990

ICLARM STATEMENT OF PURPOSE

ICLARM is organized exclusively for charitable, educational, and scientific purposes; and in furtherance of these purposes, ICLARM is to establish, maintain, and operate an international aquatic resources center designed to pursue ... the following objectives:

To conduct directly and to assist others in conducting research on fish and other aquatic organisms, on all phases of fish production, management, preservation, distribution, and utilization with a view to assisting the peoples of the world in rationally developing their aquatic resources to meet their nutritive and economic needs;

To improve the efficiency and productivity of culture and capture fisheries through coordinated research, education and training, development and extension programs;

To upgrade the social, economic, and nutritional status of peoples in the less-developed areas of the world through improvement of small-scale rural subsistence and market fisheries;

To work toward the development of labor-intensive systems to aid employment and of low energy systems to minimize capital and cost requirements;

To publish and disseminate research findings and recommendations of the Center; and

To organize or hold periodic conferences, forums, and seminars, whether international, regional, local, or otherwise for the purposes of discussing current problems.

ICLARM Articles of Incorporation
1977, Manila, Philippines

PN-ABE-207

ICLARM REPORT 1990

Edited by

Jay L. Maclean
and
Leticia B. Dizon

1991

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

MC P.O. Box 1501, Makati, Metro Manila, Philippines
Telephones: 818-0466, 818-9283, 817-5255, 817-5163
Cable: ICLARM MANILA; Telex: (ETPI) 64794 ICLARM PN, 4900010376 ICL UI (USA)
FAX: (63-2) 816-3183; E-MAIL: (CGNET) ICLARM, (SCIENCENET) ICLARM.MANILA

ICLARM REPORT 1990

Edited by

JAY L. MACLEAN
AND
LETICIA B. DIZON

1991

Published by the International Center for Living Aquatic Resources Management, Manila, MC P.O. Box 1501, Makati, Metro Manila, Philippines

Printed in Manila, Philippines

Maclean, J.L. and L.B. Dizon, editors. 1991. ICLARM Report 1990. International Center for Living Aquatic Resources Management, Manila, Philippines. 152 p.

Cover: Increasing fishing pressure on declining openwater resources is evident in this photo of a fishing scene in Bangladesh by M.V. Gupta. See p. 105.

ISSN 0115-4494
ISBN 971-8709-06-1

ICLARM Contribution No. 708.

CONTENTS

Aquatic Foods: New Science Needed for a Blue Revolution• *R.S.V. Pullin* 1

Coastal Area Management Program

Progress of Work
ASEAN/US Coastal Resources Management Project 5
Asian Fisheries Social Science Research Network 11
Linkages 12
Advisory and Other Services 13
Program Plans 13
Meetings Attended, Papers Presented 14
Publications and Consultancy Reports 15
Coastal Area Management Program Project Summaries
ASEAN/US Coastal Resources Management Project 17
Asian Fisheries Social Science Research Network 25

Capture Fisheries Management Program

Background 29
Progress of Work
The Tropical Stock Assessment and ICLARM Software Projects 30
Multispecies and spatial modelling 31
The Network of Tropical Fisheries Scientists (NTFS) 33
FISHBASE 33
Women in fisheries 34
Education and Training 35
Advisory Services 36
Program Plans 36
Meetings Attended, Papers Presented 36
Publications and Consultancy Reports 38
Capture Fisheries Management Program Project Summaries
Tropical Fish Stock Assessment Project 42
Network of Tropical Fisheries Scientists (NTFS) 46

Management-Oriented Fisheries Research Project 48
Socioeconomic Valuation of Coastal Resources of Southwestern Latin America 53
The ICLARM Software Project 56
Global Comparisons of Aquatic Ecosystems 59
Interactive Database on Tropical Fisheries Resources Management (FISHBASE) 61

Aquaculture Program

Background 64
Progress of Work
Program-wide activities 65
Genetics 66
Integrated farming systems research 68
Education and Training 69
Training books 69
Advisory Services and Other Activities 70
Program Plans 70
Meetings Attended, Papers Presented 71
Publications and Consultancy Reports 74
Aquaculture Program Project Summaries
Network of Tropical Aquaculture Scientists (NTAS) 79
Genetic Improvement of Farmed Tilapias 81
Research for the Development of Tropical Aquaculture Technology Appropriate for Implementation in Rural Africa 93
Transfer of Asian Aquaculture Technologies to Africa 99
Integrated Rice-Fish Group 101
Agricultural Research Project II (Supplement) .. 105
Socioeconomic Impact of Fish Culture Extension on the Farming Systems of Bangladesh 108

Information Program

Progress of Work
Library 110
Publications 110
Research 111
Training 111
Meeting Attended, Papers Presented 111
Publications 112
Information Program Project Summary
Selective Fisheries Information Service (SFIS) Phase II: Project ADD (Analysis and Documentation) 113

South Pacific Office

Coastal Aquaculture Centre
Facilities 116
Giant clam culture 116
Recent Research 118
Reef ranching systems 120
Pearl oyster culture 121
Linkages 121
Education and Training 122
Program Plans 122
Meetings Attended, Papers Presented 123
Publications and Consultancy Reports 124
South Pacific Office Project Summaries
Giant Clam Mariculture Project 127
Reef Ranching Research Project 130
Status of Cultivation of Pearl Oysters in the Indo-Pacific Region: A Review 131
Coastal Aquaculture Network 132
A Collaborative Investigation of Predation on Cultivated Giant Clams (Tridacnidae: Bivalvia) 134

Administration and Finance

Board of Trustees 136
Board Membership 136
Board Officers and Committees, 1990-1991 139

1990 Sources of Support 142

Statement of Revenues and Expenses 145

ICLARM Staff 146

AQUATIC FOODS: NEW SCIENCE NEEDED FOR A BLUE REVOLUTION

R.S.V. Pullin
ICLARM

Humans have eaten fish, shellfish and aquatic plants since prehistoric times and aquatic foods have remained important in human nutrition and commerce, especially in Asia. Fish consumption was once much higher in the west also. Most European castles and monasteries kept carp ponds in the Middle Ages and British apprentices received a staple diet of salmon. Fish were consumed in large quantities in Roman Britain: even the bones were crunched, not discarded. Fish is widely recognized as a healthy, protein-rich food, but to most consumers in affluent developed countries it is now just one more expensive option in a wide range of convenience items.

The developing countries have no such choices. For many of the poorer nations, aquatic foods are an irreplaceable source of dietary protein and livelihood. Fish supplies up to 80% of the animal protein consumed by humans in some Asian developing countries and probably 25% on average in Africa. However, aquatic food production has not escaped the deepening crisis of rapid population growth and persistent poverty. Demand for aquatic produce has rocketed as have prices. Traders in international commodities, such as shrimp, have prospered. Traditional fishermen and poor consumers have not. Fishing methods have intensified to the point of destroying fish stocks and their habitats. Fishermen are caught in a desperate spiral of dwindling stocks and environmental degradation. Aquaculture, despite its ancient Chinese and Egyptian origins, has not filled the gap. It remains vastly underdeveloped in comparison with agriculture and fishing basically because of a general lack of knowledge on how to do it profitably and with confidence. Even in Asia, less than 1% of farmers and coastal dwellers farm fish at all.

There are, however, those who believe that a 'blue revolution' in aquatic food production is possible and can be largely based on low-technology systems by resource-poor farmers and fishermen: the most numerous and needy sector. Those who believe a blue revolution is possible - and ICLARM scientists are among them - point out that if fisheries were managed sensibly, by limiting fishing pressure, catches would actually increase substantially and be sustainable. They believe that aquaculture has vast scope for growth, particularly in the tropics and subtropics where organically fertilized fishponds do not need added feeds, as in integrated crop-livestock-fish farming, making the most of small-scale farm resources. They foresee enhancing fisheries by "ranching" hatchery-raised fish in open waters and improving fisheries by habitat conservation and modification. Above all they see that many of the developing countries have a comparative advantage to expand aquatic food production for domestic consumption and export.

To initiate and sustain a blue revolution in developing countries requires new science. Fisheries management and aquaculture must be put on a sound technical basis. Absence of this has perpetuated a frontier situation in which the fishing "cowboys" take their short-term gains and the ensuing boom-and-bust cycles leave communities and the natural environment in ever worse shape. Fishing has always been risky but poor fisheries science and bad management make it more so. Aquaculture is also risky. Whereas crops and livestock have been raised for centuries with confidence, most new fish farms are experimental. Farmed fish are scarcely domesticated. Pedigree fish are a future dream. Aquatic food webs are too poorly understood to be well managed. Aquaculture science is really only just beginning. Its further development is essential to attract new entrants.

ICLARM's Contributions

ICLARM has been working for fourteen years to help build some of the scientific foundations for a blue revolution. Its small international staff have worked without lavish laboratories and research vessels by establishing partnerships with developing-country scientists and institutions. It has kept researchers in touch with each other through fisheries and aquaculture research networks involving over 2,000 scientists throughout the developing world.

The Center's fisheries scientists are evolving a new range of computerized methods for evaluating and managing the multispecies fisheries of developing countries. Already versions of these new methods are now in use in many countries. They are also disseminated through individual training by the Center and through courses organized, e.g., by the Food and Agriculture Organization of the United Nations (FAO).

The best known of these are in the Compleat ELEFAN software, which consists of a battery of computerized methods for assessing the health of fish stocks. The main components were developed at ICLARM and refined over the past decade. Last year, FAO contracted the Center to merge the Compleat ELEFAN with stock assessment software developed by their Fishery Resource and Environment Division into a single package which will facilitate training in this field by FAO, ICLARM and other institutions. The merging work will be completed in 1991.

In 1990, two new projects, one focusing on ecosystems and the other on spatial modelling took over from the ELEFAN work. The ecosystem work has already yielded a software called ECOPATH II that measures the steady-state flow of nutrients through an ecosystem. It lets researchers see the ecological implications of exploiting components of an ecosystem. FAO is investigating its use in future fisheries training courses.

A simple, free, geographic information (GIS) was developed and applied to fisheries in Brunei Darussalam and Peru. This software both displays and provides biological and economic analyses and fisheries data.

In coastal area management, the Center has taken a holistic approach to the problems by bringing together senior politicians, policymakers, planners, local community leaders, farmers, fishermen and scientists to ensure their participation in issues related to mangrove deforestation, pollution, dynamite fishing, tourism, etc., and how to cope with multi-user needs in the coastal zone.

In March 1990, within an ASEAN/US Coastal Resources Management Project, a Policy Conference on Managing ASEAN's Coastal Resources for Sustainable Development was held, attended by top ASEAN government officials and representatives of donor agencies, NGOs and scientific institutions. During the meeting, a resolution with recommendations for initiatives by governments, donors and the media called the Baguio Resolution on Coastal Resources Management, was adopted. Also in 1990, the Project developed a graduate degree course in coastal management for the ASEAN region.

For aquaculture, ICLARM is pioneering a new international research effort towards low technology integrated farming systems appropriate for small-scale farmers in developing countries, while a major effort on genetic improvement of farmed fish is underway. ICLARM is keenly aware that a blue revolution must benefit the needy. For example, the Center's genetics work is aimed at developing better fish breeds for farming systems that do not require extensive inputs of feeds and fertilizers.

Continuing trials using Nile tilapia in 1990 confirmed that the test strains have the same relative performance in different environments. This means that for this species, a single strain can be selected which will be superior in a variety of different environments.

ICLARM's integrated farming systems research is being carried out in Bangladesh and Malawi and through an Integrated Rice-Fish Group, with current activities in a number of Asian countries and plans for expansion, including more linkages in Africa. Outreach teams in the various projects are looking into how aquaculture best fits into complete farming systems. They have had considerable success in farmer participation. The outreach projects are also providing data that are enabling the development of broadly applicable quantitative tools for analyzing farming systems' performance.

ICLARM's aquaculture focus ranges from pond fish such as the African tilapias (which we call the "aquatic chicken") and carps to the giant clams of the South Pacific; these clams are the world's only truly self-feeding animals, having green algal cells in their living tissues that "feed" on sunlight like plants.

The international nature of ICLARM's activities is evident in the table on p. 4, showing their nature and location.

CGIAR To Include Fish

In November 1990, the Consultative Group on International Agricultural Research (CGIAR) conditionally invited ICLARM to join the Group to carry out international research on aquaculture and aquatic resource management. A major condition for entry into the Group is acceptance by them of a strategic plan for international fisheries research.

In December 1990, ICLARM began such strategic planning activities for an international fisheries research institute. The plan will be presented to the Technical Advisory Committee (TAC) of the CGIAR in June 1991 and if approved, to the CGIAR itself in 1992, following an external review of ICLARM. It is expected that ICLARM will evolve into the new institute.

It is already clear that an international fisheries research institute would need to cover more subject matter over a broader disciplinary base,

especially in the social sciences, than the present ICLARM. It will also enable a closer focus on long-term strategic research. A feature of ICLARM's present projects is a large technical assistance component, the result of past donor-driven funding. Membership of the CGIAR would eventually mean more secure funding, needed for long-term research towards a blue revolution.

New Director General

ICLARM's Board of Trustees approved, in November 1990, the appointment of a new Director General, Canadian scientist Dr. Kenneth Tod MacKay, who will join ICLARM in April 1991, taking over from Jay Maclean, Acting Director General since November 1988. Dr. MacKay will take part in the Center's strategic planning and play a major role in its directions.

ICLARM Activities in 1990 at a Glance

Country	Program		
	Coastal Area Management	Capture Fisheries Management	Aquaculture
Bangladesh			● ● □
Brunei Darussalam	●	▲	
Chile		● ▲ △	
Denmark		□ *	
Ecuador	▲		
Germany		△	
India			
Indonesia	●		
Italy			□
Malaŵi			● □
Malaysia	●		
Mexico		●	
Peru		● ▲	
Philippines	● □	△	● ●
Puerto Rico		▲	
Singapore	● □		
Solomon Islands		● ● ●	
Thailand	●		●
Vietnam			●
USA		▲	
Regional	● ○ □	● ▲ **	● ○
Global		● ● ○	● ○ □

Key: ● Project implementation; ▲ Advisory service
□ Workshop/conference/training organized by ICLARM
○ Network; △ Theses supervision
* Poster sessions at ICES meeting
** African and Latin American missions of the Study on the International Fisheries Research Needs in Developing Countries.

COASTAL AREA MANAGEMENT PROGRAM

The Coastal Area Management Program's (CAMP) second year was marked by significant strides towards the promotion of the integrated area management approach in the management of the coastal zone. Although a relatively new field in ICLARM, the growing interest worldwide in this particular approach has gained the attention not only of resource managers, scientists and environmentalists but also of policymakers and national governments. Within the Southeast Asian region, CAMP has created some impacts on the regional political leadership and local communities to push for concrete action towards the sustainable utilization of renewable coastal resources and management of coastal ecosystems. Elsewhere, especially in some parts of Asia and Latin America, CAMP has touched base with experts who recognize the need for coastal area management in those regions. This may provide opportunities for mutual research and technical cooperation. CAMP is implementing two major projects: the ASEAN/US Coastal Resources Management Project (CRMP), since 1986 (when the project was part of the Capture Fisheries Management Program), and the Asian Fisheries Social Science Research Network (AFSSRN), since 1989.

The Program's main aims are:

1. promotion of the integrated management of coastal resources to ensure long-term sustainability of economic activities and the use of natural resources which are directly or indirectly linked to the coastal environment;
2. reduction of resource use conflicts through proper planning;
3. human resources development through training; and
4. creation of public awareness through information dissemination, workshops and seminars.

With increasing participation of all sectors (i.e., private and government) in these activities, the role of social sciences in research has become invaluable, especially in relation to fisheries resources management. This is where AFSSRN activities are focused.

Progress of Work

ASEAN/US Coastal Resources Management Project

The ASEAN/US CRMP has two components: (1) development of site-specific coastal resource management (CRM) plans in six ASEAN pilot sites, and (2) training and information dissemination. Elements under component 1 include cooperative research and planning activities. Activities started in 1986 with four countries participating. Malaysia and Brunei Darussalam formally joined in 1987. Component 1 activities are being implemented by 47 institutions involving over 200 scientists from the six participating

ASEAN countries. The involvement of these institutions in the project has strengthened existing capabilities in the region to develop multidisciplinary and environmentally sustainable coastal resources management plans. The organizational chart of the ASEAN/US CRMP is shown in Fig. 1.

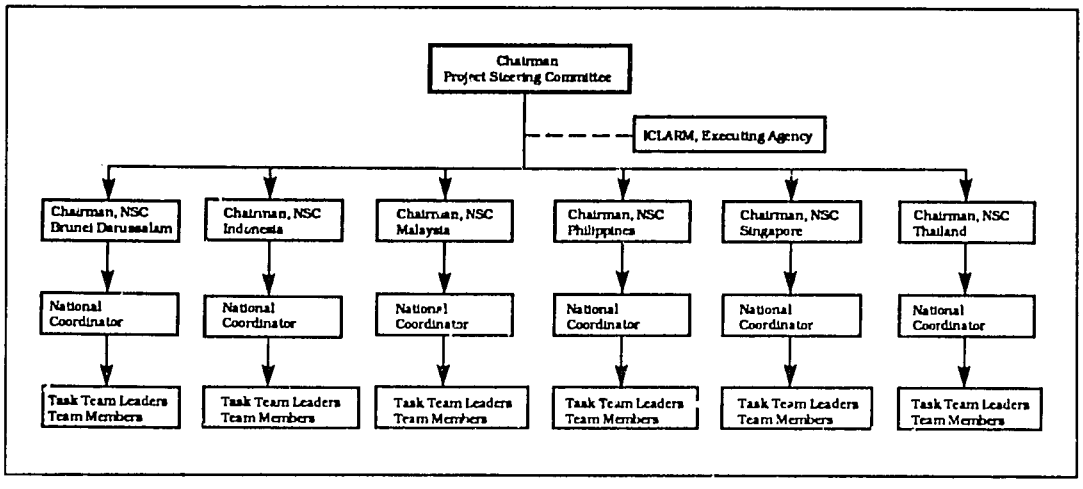


Fig. 1. ASEAN/US Coastal Resources Management Project organizational chart.

Research Activities. Research activities by national teams involved gathering of data relevant to the formulation of site-specific management plans and covered biogeographical, socioeconomic, legal and institutional studies on coastal resources, their utilization and management. Most of these activities were completed between 1988 and 1990, except those of Singapore which are expected to end by March 1991.

Under biogeographical studies, major areas of study were on mangroves, coral reefs, water quality, capture fisheries and aquaculture. Studies involved resource inventories, assessment of coastal resources utilization patterns, identification of resource use constraints, quantification of physical output or indicators (e.g., production and water quality parameters) and modelling, etc. Table 1 shows the biogeographical research activities of CRMP.

In addition, socioeconomic, legal and institutional studies were also carried out. The thrusts of socioeconomic studies were on the identification and quantification of social and economic factors affecting coastal communities with respect to coastal resource utilization and management. For the legal and institutional studies, activities were focused on assessment of laws and regulations relevant to CRM with the aim of determining how the management plans can be effectively implemented (Table 2).

Plan Formulation. With the completion of most research activities, in-country activities focused on the formulation of management plans for each of the pilot sites in late 1988. Fig. 2 shows the process of coastal resources management plan formulation. Site-specific plans consist of an integrated management plan and a number of action plans. The formulation of the management plans is aimed at sustainable development of coastal resources and includes projects that will demonstrate this concern as well as a zonation scheme to minimize resource use conflicts and adverse environmental impacts that may be generated from various activities in the coastal area.

Table 1. Biogeographical research activities.

General activities	Task code	Output (title of report)/ status by country
Mangrove Resources		
Resource assessment: mangrove forest inventory (plant community structure by line transect), utilization patterns and current status	240-B	Mangrove timber resources inventory in Brunei Darussalam
	210-I	Mangrove management plan for Brunei General coastal area management zones for Segara Anakan and surrounding areas; General policy and guidelines for zonation scheme of Segara Anakan Assessment of mangrove degradation and zoning for development (Segara Anakan)
	210-M	Developing a management scheme for mangrove forests in South Johore
	270-T	Evaluation of mangrove development potential of Phangnga and Ban Don Bays for coastal zone management
Coral Reef Resources		
Assessment of reef community structure by line transect, fish census, hydrographic parameters, reef lifeform distribution including resource use characteristics	510-B	(see entry on Artificial reefs)
	210-P	Resources inventory survey and natural resource mapping of coral reefs (Lingayen Gulf)
Fish and Shrimp Resources		
Assessment of fish and shrimp resources: production, catch by various gear types, CPUE, MSY, MEY, seasonality, etc. for artisanal and trawl fisheries (demersal and pelagic stocks)	220-B	Brunei Darussalam - reports still in preparation
	240-I	Lagoon and culture fisheries (terminal report - Indonesia)
	250-M	Prawn resource exploitation (South Johore)
	210-P	Fish resource assessment of Lingayen Gulf
	230-T	Management plan for fishery resources in Ban Don Bay, Surat Thani (draft)
Aquaculture		
Assessment of aquaculture: status, production, farming system and management, potentials, constraints including water and soil quality for brackishwater ponds (fish and shrimp culture), netcage (fish), culture of molluscs and seaweeds	240-I	See entry on Fish and Shrimp Resources
	260-M	An economic analysis of coastal aquaculture practices in South Johore Present status of aquaculture practices and potential areas for their development in South Johore, Malaysia
	230-P	Aquaculture potential in Lingayen Gulf
	240-P 250-P	Farm testing of appropriate aquaculture technology (Lingayen Gulf)
	210-S	Singapore - report in preparation (netcage farming)
	210-T 220-T	Final report on coastal aquaculture (Thailand)

Table 1 continued.

General activities	Task code	Output (title of report)/ status by country
Artificial Reefs		
Artificial reefs assessment by line transect, fish census, benthic communities, etc. vs. natural reefs; construction, installation and monitoring	510-B	An assessment of the productivity of artificial reef structures in the seas of Brunei Darussalam
	510-S	Role of artificial reefs in living resource enrichment - site surveys for possible establishment of artificial reefs (Singapore); terminal report for Task 510-S in preparation
Environmental Quality		
Assessment of: water and soil quality, hydrographic patterns, sedimentation process, water pollution, coastal erosion process, red tides, oil spill including impact of land use changes, demographic and industrial activities; modelling; related activities like evaluation of research facilities, manpower and constraints	230-B	Benthos in the coastal waters of Brunei Darussalam
		A composite sensitivity index for the coastal zones of Brunei Darussalam
		Water quality study for Brunei Darussalam
	220-I	The water quality of Segara Anakan
	230-I	Dynamics of water movement and sedimentation patterns of Cilacap/Segara Anakan Lagoon
	220-M	Water quality management scheme (South Johore)
	240-M	Transport and dispersion of pollutants
	220-P	Water quality baseline study of Lingayen Gulf
	240-T	Final technical report on coastal environment of Phangnga Bay
	250-T	Land-based pollution study/pollution for coastal zone development
	260-T	Final sectoral report
	280-T	Assessment of the coastal environment of Ban Don Bay
Wildlife Resources		
Wildlife assessment: inventory (e.g., threatened or rare species), community structure, management and constraints	280-T	Final report on wildlife resources of Ban Don Bay
		Final report on wildlife resources of Phangnga Bay
Land Use Capability		
Mapping and characterization of existing land use patterns, land use opportunity and impact of various activities	290-T	Evaluation of land use capability and development potentials
Geographic Information System		
The application of geographic information system in coastal resources assessment, planning and management	230-M	Geographic information system for coastal resources management

Table 2. Socioeconomic, legal and institutional research activities.

General activities	Task code	Output (title of report)/ status by country
Socioeconomic Studies		
Socioeconomic studies of the coastal communities including survey of demographic and economic activities, especially fishing, tourism; valuation of coastal resources, understanding social and cultural characteristics, etc.	310-B	Valuation and evaluation of coastal resources of Brunei Darussalam
	310-I	Socioeconomic study of three fishing villages of Segara Anakan
	320-I	Lagoon-Cilacap in relation to coastal resources management
	310-M	Final report of Task 310-M: socioeconomic studies
	320-M	CRM for tourism and recreation in South Johore, Malaysia
	310-P	The people of the coastal communities of Lingayen Gulf: profiles and conditions
	320-P	The economics of municipal fisheries-the case of Lingayen Gulf
	330-P	Marketing studies of selected commodities in Lingayen Gulf
	410-P	See entry on Legal and Institutional Studies
	420-P	
	310-T	Research study on administration and management of the Upper Southern region coastal resources associated with
	320-T	tourism: a case study of Surat Thani Province
	420-T	Research report on the knowledge, attitudes and behavior of villagers and business people on natural resource conservation and the government program for tourism promotion, Samui Island district, Surat Thani Province; anthropological evaluation of the socioeconomic consideration in coastal resource use in Phangnga and Ban Don Bays, Thailand; management of coastal tourism resources at Ban Don Bay (Final report)
Legal and Institutional Studies		
Assessment of the legal and institutional characteristics of coastal socioeconomic activities through survey, evaluation of policies, regulations and laws on coastal resources utilization and development including implementability of coastal area management plans	410-B	The legal and institutional environment for the management of coastal resources in Brunei Darussalam
	410-I	Assessing the feasibility of successfully implementing coastal area management
	420-I	plans in Malaysia, Indonesia, Philippines and Thailand
	430-I	Proceedings of the 3rd in-country
	410-M	meeting for the development of coastal area management plans for South Johore, Malaysia
	440-P	Political and sociocultural context of coastal area management in Lingayen Gulf
	410-T	Final report still in preparation (Thailand)

Note: B: Brunei Darussalam, I: Indonesia, M: Malaysia, P: Philippines, S: Singapore, T: Thailand.

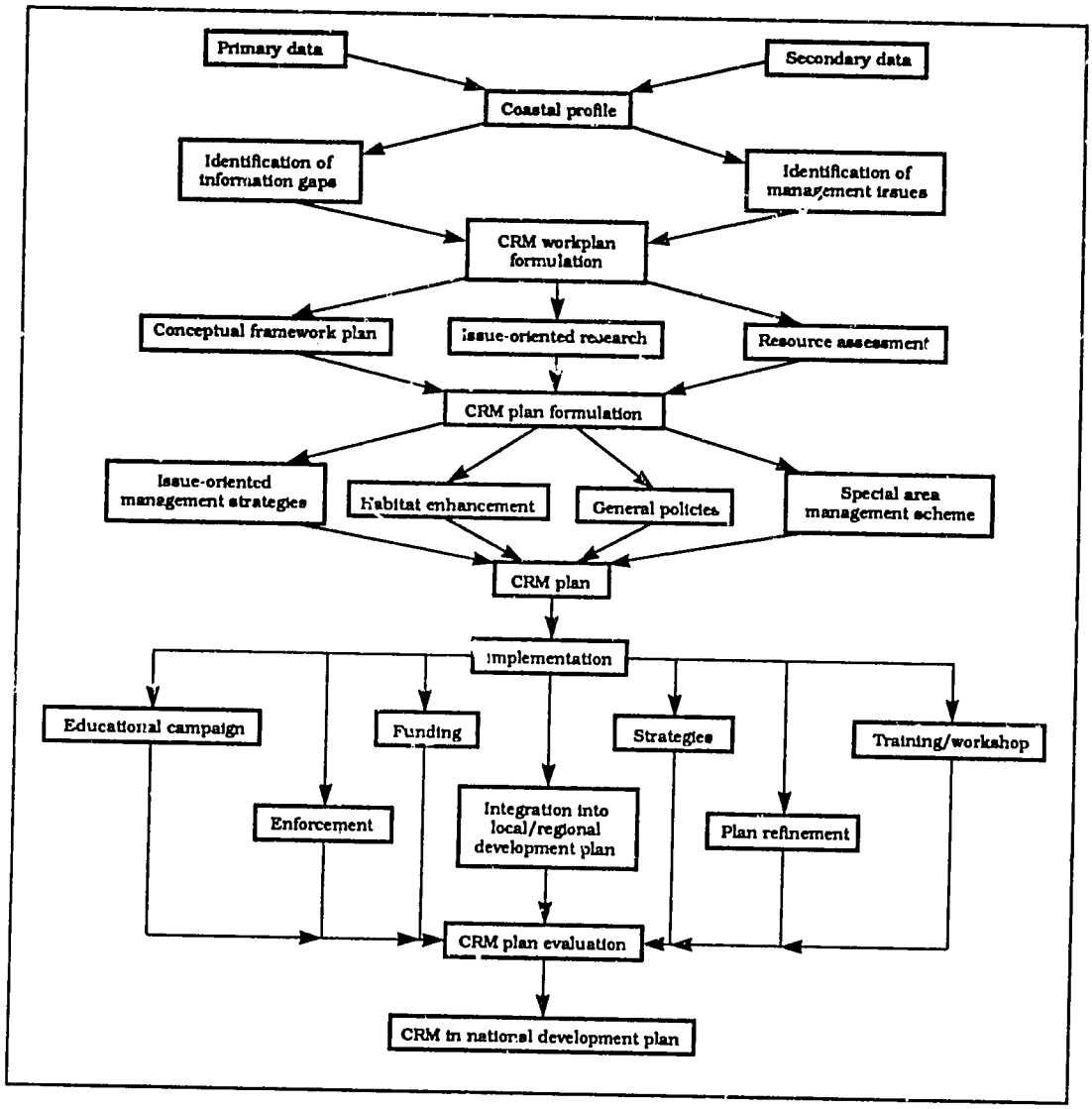


Fig. 2. The process of CRM plan development.

Currently, all six countries have completed preliminary drafts of the management plans (Table 3). Despite being in draft stage, some of the recommendations of the plans have been adopted by the respective governments. In Malaysia, a part of the recommendation in the CRM plan has been incorporated in the structural plan of the State of Johore by the Town and Country Planning Department. In Thailand, the plans have provided information for developing the basis of environmental impact assessment guidelines for development projects. Further refinement is being undertaken for all the management plans before they are published by the end of 1991.

Training and Information. In 1990, the project conducted two short-term training courses, organized four on-the-job training courses, arranged for one medium-term academic training in the US and organized and sponsored one major policy conference and one regional workshop on

Table 3. Site-specific plans.

Pilot site	Integrated management plan	Action plan
Brunei Darussalam	Coastal area management plan for Brunei Darussalam	Water quality management plan for Brunei Darussalam Island management strategy for Brunei Darussalam Mangrove management plan Fisheries management plan Red tides response scheme Oil spill contingency plan
Indonesia Segara Anakan - Cilacap southern Central Java	Integrated management plan for the coastal resources and land uses of Segara Anakan - Cilacap, Central Java, Indonesia	
Malaysia South Johore	South Johore coastal resources management plan	
Philippines Lingayen Gulf	The integrated management plan for Lingayen Gulf, Philippines	Fisheries management in Lingayen Gulf, Philippines Aquaculture management in Lingayen Gulf, Philippines Coral reefs and marine parks management in Lingayen Gulf, Philippines Environmental quality management in Lingayen Gulf, Philippines Alternative livelihood in Lingayen Gulf, Philippines
Singapore	Singapore's urban coastal area: strategies for management	
Thailand Phangnga and Ban Don Bays, Upper South	The Upper South coastal resources management plan	An issue-based action plan for the Upper South subregion's coastal zone: a contribution towards regional sustainable development

education and training. To date, nine short-term training courses, eight on-the-job training courses and six medium-term academic courses, three regional workshops and one major conference have been organized. These bring the total of project and national staff trained to 126 (Table 4).

Under Information, the project has published four technical reports; three booklets, a poster and three comics under the education series; four conference proceedings; and a directory. The project also publishes the *Tropical Coastal Area Management Newsletter* three times a year.

Asian Fisheries Social Science Research Network

The year 1990 was a very productive one for the network as most of the planned activities were successfully carried out. With Dr. Louise A. Fallon as Network Coordinator, the crucial holding of the AFSSRN Team Leaders' Meeting in Manila in February 1990 paved the way for the setting up of the network's overall plans and directions. Most of the activities of 1990 were centered on three network thrusts:

1. making available small grants to support the formulation and implementation of selected sector-related research projects;

Table 4. Number of training participants in CRMP training activities.

Training program	Country						Total
	Brunei Darussalam	Indonesia	Malaysia	Philippines	Singapore	Thailand	
Short-term							
1. Information research and management		2	2	5	2	2	13
2. Principles of CAM							
a. Thailand	1	2	3	2	2	5	15
b. Malaysia		3	4	2	2	2	13
c. Indonesia	2	3	2	2	1	2	12
3. Socioeconomic analysis	1	2	2	2	4	3	14
4. GIS/remote sensing (Singapore)	2	2	4	3	5	2	18
5. Economic valuation		2	2	6	1	2	13
6. GIS/remote sensing (Manila)		2	2	4	2	2	12
Academic		1	2	1	1	1	6
On-the-job	2	3	2		2	2	11
Total	8	22	25	27	22	23	127

* Note: Some project staff participated in more than one training course/activity.

2. sponsoring workshops and training courses primarily intended to develop and strengthen the research skills and capacity of members; and
3. encouraging interdisciplinary interface for purposes of instilling cooperation and fellowship between and among scientists/researchers in fisheries sector-related disciplines within, among and outside the countries covered by the Network.

Linkages

Whenever and wherever possible, CAMP has sought the cooperation of national and international agencies in the areas of technical assistance, cooperative research, planning and implementation of projects, training and educational activities, publications/information exchange and participation in meetings, conferences, seminars and workshops. The organizations and linkages are:

1. Asian Development Bank. Consultancy services of two experts for the forthcoming Waste Management Conference in 1991 under the CRMP. Total estimated financial support is about US$100,000.
2. Asian Wetland Bureau. Publications exchange.
3. Association of Southeast Asian Marine Scientists. Newsletter exchange and participation in meetings, conferences, seminars and workshops.
4. Canada-ASEAN Centre. Financial support is being sought for the survey on manpower requirements and training needs of CAM in the ASEAN—one of the recommendations at the workshop on coastal

area management education in the ASEAN region held in Singapore in October; financial support to cosponsor the waste management workshop in Singapore, 28-30 June 1991.

5. Food and Agriculture Organization of the United Nations (FAO). Close linkage is maintained in the field of coastal area management. FAO representatives attended the coastal area management education workshop in Singapore in October 1990.
6. The International Federation of Institutes for Advanced Study (IFIAS). Publications exchange and training/research cooperation.
7. University of Rhode Island. Training and research cooperation and publications/information exchange.
8. United Nations Environment Programme (UNEP) and United Nations Educational, Scientific and Cultural Organization (UNESCO). Publications/information exchange and participation in meetings, seminars, workshops and conferences.

Advisory and Other Services

In addition to serving activities in the CAMP, the Program Director continues to serve as President of the Asian Fisheries Society (AFS) until 1992. Dr. Chua Thia-Eng is also Research Director of the International Development Research Centre-Asian Fisheries Society (IDRC-AFS) Small Grant Program. He is a member of the Board of Directors of the International Coastal and Ocean Organization. He and Dr. Fallon are members of the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) of FAO. He is a scientific advisor of the International Foundation for Science (IFS) and Chairman of the Advisory Council of the World Fisheries Congress 1991. Dr. Chua was also consultant to the University of Rhode Island (URI) in 1990 for its project in Ecuador on the diversification of coastal aquaculture.

Program Plans

CAMP will continue to implement the scheduled activities of the ASEAN/US CRMP and AFSSRN for 1991. In addition, the program expects to start work on the following projects:

1. Santiago Island Project, Bolinao, Philippines. This project has served as a pilot project for a consortium of collaborating agencies. It attempts to integrate five components: population, health and nutrition, education, alternative livelihood and protected area management. The Swedish Agency for Research Cooperation with Developing Countries (SAREC) in cooperation with the Swedish International Development Agency (SIDA) through the intercession of the Dutch Embassy in Manila has expressed interest in the development of marine parks, education and alternative livelihood components. Local participation will include the National Economic and Development Authority (NEDA)-Region I and the University of the Philippines Marine Science Institute. The United Nations Fund for Population Activities (UNFPA) will address the population, health and nutrition components with the possible collaboration of

Plan International, a nongovernment organization. However, these activities have yet to be finalized.

2. Geographic Information Systems for Coastal Area Management and Planning (GISCAMP). The International Development Research Centre (IDRC) of Canada, with the participation of the National Economic and Development Authority (NEDA)-Region I, has agreed in principle to undertake the project. The main goal is to establish a planning and management capability on coastal areas using GIS. The use of GIS will allow the computerized storage and retrieval of spatial and attribute data on coastal resources including analyses which can be periodically refined and improved as the need arises. A proposal has been submitted for funding consideration.
3. Batangas Bay Project. In anticipation of the project's implementation in March 1990, the program started preliminary work by hiring technical staff and purchasing a GIS software and hardware needed to carry out the activities. However, implementation has been considerably delayed as the primary sponsor, Pilipinas Shell Foundation, is seeking to include other companies operating in the Batangas Bay area and the provincial government. This led to the formation of the Batangas Bay Development Foundation (BBDF) which has as its members the largest firms representing the major industries around Batangas Bay. This project is expected to be finalized in 1991.
4. Puttalam Lagoon Project, Sri Lanka. The Swedish Agency for Research Cooperation with Developing Countries (SAREC) is jointly implementing a marine science cooperation program in Sri Lanka with the National Aquatic Resources Research and Development Agency (NARA) of the Government of Sri Lanka. The program includes a comprehensive study of the Puttalam/Mundal estuarine system. CAMP committed to provide an advisory mission in March 1991 to assist the program. The mission, which will be composed of Dr. Chua, Dr. Fallon and Mr. G. Silvestre, will help develop appropriate research designs for undertaking the following studies in the Puttalam Lagoon: (1) resource inventory; (2) socioeconomic valuation of lagoonal resources such as coral, seagrass and mangrove resources; (3) assessment of fish stocks and the migratory pattern of key fish species; (4) reassessment of its aquaculture development potential in the context of sustainability; (5) legal and institutional framework; and (6) training needs of national staff, in particular on methodologies and planning tools.

Meetings Attended, Papers Presented

Final In-Country Meeting for Coastal Resources Management Plan Development Langkawi, Malaysia, 9-11 January. (T.-E. Chua and L.A. Fallon)

AFSSRN Annual Team Leaders' Meeting, Manila, Philippines, 1-2 February. (L.A. Fallon)

Fifth Project Steering Committee Meeting, Manila, Philippines, 2-3 March. (ASEAN/US CRMP Staff)

Policy Conference on Managing ASEAN's Coastal Resources for Sustainable

Development, Manila and Baguio, Philippines, 4-7 March. (ASEAN/US CRMP and ICLARM Staff)

Third Meeting of the Research Award Review Committee of the Asian Fisheries Society, Singapore, 17-18 April. (T.-E. Chua)

Special Asian Fisheries Society Council Meeting, Singapore, 19 April. (T.-E. Chua)

IDRC Workshop on Resource Allocation for Fisheries Research, Singapore, 20-21 April. (T.-E. Chua)

IDRC Asian Fisheries Research Priorities Meeting, Singapore, 23-24 April. (T.-E. Chua and L.A. Fallon)

Twentieth Session of the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), Geneva, Switzerland, 7-11 May. (T.-E. Chua)

Second Indian Fisheries Forum, Mangalore, India, 27-31 May. (T.-E. Chua)

International Conference on the Environmental Management of Enclosed Coastal Seas '90, Kobe, Japan, 3-6 August. (J.N. Paw and F.Y. Guarin)

Paper presented:

Guarin, F.Y. Water quality management issues in Lingayen Gulf, Philippines, and some proposed solutions.

Poster presented:

Paw, J.N. Managing coastal resources in Cilacap, Indonesia and Lingayen Gulf, Philippines—an ASEAN initiative.

In-House Workshop on the Ecological History of Pak Phanang (Coastal Resources Institute, Prince of Songkla University), Koh Samui, Thailand, 4-5 August. (L.A. Fallon)

Regional Conference on ASEAN's Scholarly Publishing, Universiti Kebangsaan Malaysia, Bangi, and Ming Court Hotel, Kuala Lumpur, Malaysia, 27 to 29 August. (M.S.M. Sadorra)

711th Conference on Environmental Issues in Third World Aquaculture Development, Bellagio, Italy, 17-22 September. (T.-E. Chua)

Paper presented:

Chua T.-E. Environmental management of coastal aquaculture development.

Ad-hoc Meeting of the GESAMP Steering Group on Environmental Impact of Coastal Aquaculture, Rome, Italy, 24-25 September. (T.-E. Chua)

Workshop on Coastal Area Management Education in the ASEAN Region, Singapore, 8-11 October. (T.-E. Chua, L.A. Fallon and S.C. Guerrero)

Seminar on the Contribution of Social Anthropology to Fisheries Development, Manila, Philippines, 19 October. (AFSSRN and ICLARM Senior and Mid-level Professional Staff)

9th Asian Fisheries Society Council Meeting, Beijing, China, 20-21 October. (T.-E. Chua)

Second Resource Allocation Workshop, Beijing, China, 21-23 October. (T.-E. Chua)

Asian Fisheries Society Review Committee Meeting, Beijing, China, 24-26 October. (T.-E. Chua)

AFSSRN-Thailand Workshop on Joint Project Development, Bangkok, Thailand, 1-2 November. (L.A. Fallon)

Publications and Consultancy Reports

Christie, P., A.T. White and D. Buhat. 1990. San Salvador Island Marine Conservation Project: some lessons for community-based resource management. Trop. Coast. Area Manage. 5(1/2): 7-11.

Chua T.-E. and P. Kungvankij. 1990. An assessment of shrimp culture in Ecuador and policy strategy for its development and mariculture diversification. A consultancy report submitted to the University of Rhode Island/USAID Coastal Resources Management Project.

Fallon, L.A. 1990. The Baguio Conference: a regional commitment to coastal area management. Trop. Coast. Area Manage. 5(1/2): 1, 3.

Fallon, L.A. and T.-E. Chua. 1990. Towards strengthening policy and strategic orientation for fisheries resources management: the role of coastal area management. Trop. Coast. Area Manage. 5(3): 1, 3-5.

The Policy Conference on Managing ASEAN's Coastal Resources for Sustainable Development. 1990. Baguio resolution on coastal resources management. ICLARM Conf. Proc. 23, 11 p.

Coastal Area Management Program Project Summaries

Project Title : ASEAN/US Coastal Resources Management Project

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 the 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 Energy (coordinating 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

Key Personnel

Brunei Darussalam	: Haji Matdanan bin Haji Jaafar; Pengiran Sharifuddin Pengiran Haji Yusof; Dr. M.W.R.N. De Silva
Indonesia	: Mr. Sukotjo Adisukresno, Dr. Kasijan Romimohtarto, Mr. Ben Abdul Malik, Dr. Subagjo Soemodihardjo, Dr. Mulia Purba, Dr. Nurzali Naamin, Mr. Agus Brotosusilo, Mr. Subhat Nurhakim, Dr. Soerjono Soekanto, Mr. Budirahardjo, Mr. Koesoebiono, Ir. Agustinus W. Taufik, Mr. Edi M. Amin and Mr. Zen Omar Purba
Malaysia	: Dr. Abu Bakar Jaafar, Ms. Ch'ng Kim Looi, Dr. Chan Hung Tuck, Dr. Lim Poh Eng, Dr. Kam Suan Pheng, Ir. Sieh Koh Chi, Dr. Koh Hock Lye, Mr. Mohd. Zaki bin Mohd. Saad, Mr. Hambal Hanafi, Dr. Jahara Yahaya, Dr. Wong Poh Kam, Dr. Shaharuddin bin Mohd. Said, Ir. Zamali Midun, En. Ahmad Tajuddin Hj. Kechik and En. Redzuan Yusof
Philippines	: Dr. Rafael D. Guerrero III, Dr. Edgardo D. Gomez, Dr. Liana T. McManus, Ms. Adelaida Palma, Mr. Nygiel Armada, Prof. Elmer M. Ferrer, Mr. Joseph M. Alabanza, Mr. Leonardo Quitos and Dr. Roberto A. de los Reyes

Singapore	: Mr. Leslie Cheong, Dr. Chou Loke Ming and Dr. Chia Lien Sien
Thailand	: Mr. Arthorn Suphapodok, Mr. Chalermsak Wanichsombat, Dr. Saksit Tridech, Dr. Sirikul Bunpapong, Dr. Teerayut Poopetch, Mr. Yodchai Karnasuta, Mr. Somporn Lohsawadikul, Dr. Manuwadi Hungspreugs, Mr. Prawin Limpsaichol, Mrs. Nisakorn Kositratana, Dr. Sanit Aksornkoae, Dr. Vijarnsorn, Dr. Subarn Panvisavas, Mr. Robert Dobias, Ms. Chandhana Indhapanya and Mr. Ilyas Baker
ICLARM	: Dr. Chua Thia-Eng (Project Coordinator), Dr. Alan T. White (Technical Advisor), Dr. Heng L. Thung (Coastal Zone Planner), Prof. Rogelio O. Juliano (Coastal Zone Planner - Brunei Darussalam), Mr. James N. Paw (Project Specialist), Mrs. Flordeliz Y. Guarin (Project Specialist), Mrs. Madeleine L. Dalusung (Project Specialist - Economist), Mr. Len Garces (Project Specialist), Mr. Oliver G. Coroza (Research Associate) and Mr. Geronimo T. Silvestre (Stock Assessment Expert)

Objectives

To increase existing capabilities within the Southeast Asian region to develop and implement comprehensive, multidisciplinary and environmentally sustainable coastal resources management strategies through:

- analysis, documentation and dissemination of information on trends in coastal resources development;
- increasing awareness of the importance of coastal resources management policies and identification and, where possible, strengthening of management capabilities;
- provision of technical solutions to coastal resources use conflicts; and
- promotion of institutional arrangements that bring multisectoral planning to coastal resources development.

Results

In-country projects

Brunei Darussalam. Several biogeographic studies were undertaken in 1990 with the hiring of technical consultants from Malaysia, Singapore

and the Philippines. The studies were on water quality, mangroves, coral reefs and fish stocks. In addition, a socioeconomic study was conducted.

Reports on water quality management were completed. These reports were based on available data gathered by the Department of Fisheries on studies undertaken for waste management in Kampong Ayer and on the analysis of water samples made during a month-long field study. The reports, which include a water quality management plan, classified the country's waters for various beneficial uses.

An oil contingency plan was also completed which includes the ecological features of the coastal areas (specifically in Brunei Bay) that will be vulnerable to an oil spill event and vegetation cover, species abundance, distribution, diversity index as well as oil spill trajectories. A composite sensitivity report of the coastal habitats to oil spill was also completed.

The task group on mangrove management adopted some of the recommendations cited in the *Coastal Environmental Profile of Brunei Darussalam* produced in 1987 and carried out a reassessment/inventory of the mangrove resources. A draft mangrove management scheme for the optimal use of this resource in Brunei Darussalam has been formulated by Dr. Prescillano M. Zamora (UP). A silvicultural management plan for the mangrove areas designated for wood production was also prepared based on primary and secondary data collected by Mr. Dexter Cabahug.

In April, Dr. Fallon visited Brunei Darussalam to determine the physical scope required for a socioeconomic survey and to draw up a detailed workplan for developing a database quantifying the socioeconomic importance of its coastal resources and activities. Fieldwork was carried out from June to August by Ms. Madeleine L. Dalusung.

In May, a team of researchers from the National University of Singapore's Department of Zoology, led by Prof. Chou Loke Ming, conducted studies on marine communities around oil pipelines and coral reefs to assess reef status in terms of fisheries productivity, diversity and abundance. The final report contains recommendations on the formulation of an artificial reef habitat management and action plans necessary to study/monitor artificial habitats in relation to fisheries conservation and management including islands.

In August 1990, Mr. Geronimo T. Silvestre completed his field surveys for shrimp and fish stock assessment. Three reports on the task have been prepared: (1) The capture fisheries of Brunei Darussalam: resources exploitation and management; (2) Results of demersal resource investigations in coastal waters of Brunei Darussalam; and (3) Negara Brunei Darussalam capture fisheries management plan.

The results of the above-mentioned studies were incorporated into the draft integrated management plan. These activities are also closely integrated with those of relevant government agencies, departments and institutions.

Indonesia. The draft "Integrated management plan for the coastal resources and land uses of Segara Anakan lagoon and vicinity" was approved by the *Bupati* (district head) of Cilacap in late February. It addresses the main issues of land use, mangrove forest, fisheries management and socioeconomics.

Based on the recommendations in the draft management plan, the following activities were undertaken to assess the constraints towards plan implementation and the delineation of a zonation scheme:

- The Segara Anakan Task Force (SATF) was established to coordinate plan activities, evaluate the recommendations of the plan and develop new policies to solve conflicts.
- Zonation boundaries for the Segara Anakan mangrove and land areas were assessed and delineated. Boundary markers around the coast of the intensive zone, or the urban industrial zone, were placed.
- Kampung Laut residents were trained in the culture of crab, fish and related aquatic species.

Dr. Purwito Martosubroto, National Steering Committee Chairman, left the project earlier this year to assume a post at FAO, Rome. He was replaced by Mr. Sukotjo Adisukresno, formerly Regional Director of Fisheries for Central Java.

Malaysia. The draft coastal area management plan for South Johore has been completed. Its implementation under the Sixth Malaysian Economic Development Plan (1991-1995) has been ensured with the active interest, support and participation of both the federal and state governments, especially the Chief Minister and the State Director of the Economic Planning Unit of Johore. Already, some of the recommendations of the plan have been incorporated into the state structural plan of Johore.

The eight specific action plans of the integrated coastal area management plan of South Johore cover coastal forest, mangrove forest, agriculture, sand mining, coastal erosion, water quality, tourism and fisheries. The plans were reviewed by the participating departments, authorities and agencies.

Several briefings on the project have been given to a number of agencies to encourage the implementation of similar projects in coastal areas, state by state on a national level.

Philippines. Drafts of seven action plans and an integrated coastal area management plan were produced by separate task groups under the coordination of a project team from NEDA-Region I. These action plans deal with the management in Lingayen Gulf of coral reefs and marine reserves, environmental quality, fisheries, alternative livelihood projects, aquaculture, and recreation and tourism, as well as community mobilization and an alternative livelihood scheme. These plans are being refined following a technical review conducted around the second quarter of 1990.

The aquaculture task was completed. This covered identification of existing and potential aquaculture sites and farm testing. Cadastral maps of scales 1:1,000, 1:2,000 and 1:4,000 were submitted by the team from the Bureau of Fisheries and Aquatic Resources as part of the mapping of land-based aquaculture activities. These maps indicate the commodity cultured in each fishpond and identify those fishponds with potential for increased production. Separate resource maps on oysters, cage culture and seaweeds were also produced.

As originally planned, improved techniques of milkfish monoculture and shrimp-milkfish polyculture were to be field-tested in the ponds of participating fishfarmers. However, a survey showed that the fishfarmers were reluctant to participate for various reasons. Hence, the application of techniques was consequently abandoned.

Singapore. Under the artificial reefs (AR) project, rapid colonization by sessile organisms and fish was observed following the establishment of the AR in August 1989 in one of the southern islands. Monitoring is ongoing.

The task group on rehabilitation of a section of Singapore River released another 4,300 seabass fry/fingerlings into the river in the first quarter of 1990. Further releases were discontinued as plans were drawn up for a national 10-year project encompassing the stocking of fish in a larger body of water (200 ha) that includes Marina Bay and Kallang River Basin.

A study on floating deep netcage culture of seabass at a maximum stocking density of 300 fish/m^3 was not successful due to a number of factors. Incidence of tailrot and protozoan ectoparasite (*Cryptocaryon* sp.) severely reduced the stock. The study is ongoing and aims to demonstrate the viability of deep netcage culture.

The use of artificial seagrass (AS) in the restocking program along the Singapore River showed that it is suitable for the initial first two months after installation. Subsequently, the strands of the AS tend to become heavily fouled and get weighed down in the water, making them less effective as fish aggregating devices.

The draft management plan is essentially completed and the recommendations of a national workshop in 1989 are being incorporated to refine further the plan. Other action plans for inclusion in the plan are those on marine pollution control and marine conservation which will be completed by June 1991.

Thailand. Activities concentrated on the refinement and completion of the sectoral plans and public education on coastal resource conservation. To ensure the successful completion of Thailand's integrated coastal area management plan, a technical working group, composed of all task leaders assisted by a technical advisor/coordinator, was formed. The outline/summary of the management plan has already been approved by the planning team.

Three technical seminars on natural resources and environment, administration and management in Phangnga and Surat Thani were conducted. The purpose of the seminars was to present information and recommendations to local agencies for better understanding, coordination and awareness of coastal area management in the provinces.

Educational materials on coastal resources and environmental conservation have been produced and distributed. These materials (all in Thai) included posters, stickers, booklets and books.

The project also led a mangrove planting activity at the coastal area of Surat Thani to promote public awareness on mangrove conservation.

Training and information

The project conducted two short-term training courses, organized four on-the-job training courses; arranged for one medium-term academic training at the University of Rhode Island under the one-year Master in Marine Affairs program; and organized and sponsored one major policy conference and one regional workshop.

The two short-term training courses conducted were the Principles of Economic Valuation of Coastal Resources (7-19 May) and Remote Sensing and GIS for Coastal Zone Planning and Management (3-14 December). It was participated in by 25 project and national staff.

The Policy Conference on Managing ASEAN's Coastal Resources for Sustainable Development held on 4-7 March was the project's major activity in 1990. It was viewed as a concrete reaffirmation of ASEAN governments' commitment to coastal area management efforts. A significant output of this conference was the adoption of the Baguio Resolution on Coastal Resources Management which lays out the rationale for managing coastal resources as viewed by the participants and provides recommendations for initiatives to be taken by governments in the region, donor agencies and the media to protect and manage coastal resources. There were 96 participants, including top government officials from throughout Southeast Asia.

Philippine Executive Secretary Catalino Macaraig giving the keynote address during the Policy Conference on Managing ASEAN'S Coastal Resources for Sustainable Development opening ceremonies at the Manila Hotel. (Left to right): Tan Sri Haji Muhyiddin bin Mohd. Yasin, Chief Minister of the State, Government of Jahore; Minister Stephen K.T. Yong, Minister of Science, Technology and the Environment, Malaysia; H.E. Chuan Leekpai, Deputy Prime Minister of Thailand; Secretary Ceferino L. Follosco, Philippine Department of Science and Technology; Minister Ahmad Mattar, Ministry of the Environment, Singapore; Mr. M.S. Kismadi, Special Assistant to the State Minister for Environment, State Ministry for Population and Environment, Indonesia; and Dato Haji Mohd. Salleh Haji Hidup, Permanent Secretary of Brunei Darussalam's Ministry of Development.

Table 1. ASEAN/US CRMP working papers, 1990.

90/1	Brunei Darussalam: Progress Report 1989
90/2	Brunei Darussalam: Annual Workplan 1990
90/3	Indonesia: Annual Report 1989
90/4	Indonesia: Annual Workplan 1990
90/5	Malaysia: Annual Report 1989 Vols. 1 and 2
90/6	Malaysia: Annual Workplan 1990
90/7	Philippines: Annual Report 1989
90/8	Philippines: Annual Workplan 1990
90/9	Singapore: Annual Report 1989
90/10	Singapore: Annual Workplan 1990
90/11	Thailand: Annual Report 1989
90/12	Thailand: Annual Workplan 1990
90/13	White, A.T. and R.J. Dobias. 1990. Community Marine Tourism in the Philippines and Thailand: A Boon or Bane to Conservation
90/14	Tarnas, D.A. Sustainable Development in Marine Tourism for South Johore, Malaysia: The ASEAN-USAID Coastal Resources Management Project
90/15	Chou, L.M., G.S.Y. Lim and C.B. Leng. An Assessment of the Productivity of Artificial Reef Structures in the Seas of Brunei Darussalam
90/16	Lai, H.C., B. Ong and A.O. Kessler. Benthos in the Coastal Waters of Brunei Darussalam
90/17	Lai, H.C., B. Ong, A.O. Kessler and M.W.R.N. de Silva. A Composite Sensitivity Index for the Coastal Zones of Brunei Darussalam
90/18	Koh, H.L., P.E. Lim and Z. Midun. Management and Control of Pollution in Inner Johore Strait
90/19	Annotated Bibliography on the Coastal Resources and Coastal Area Management of Brunei Darussalam
90/20	Progress Report of the Project Coordinator, 1990

The Workshop on Coastal Area Management Education in the ASEAN Region was held on 8-11 October in Singapore with 16 participants. Presented papers summarized the capabilities and constraints which currently exist in educational institutions in the region relative to a graduate degree course in coastal area management. The highlight of the workshop was the formation of a postgraduate curriculum for a one-year master's degree. The curriculum aims to train resource managers in various disciplines such as natural, environmental and social sciences, economics and law.

The project produced one technical report, five conference proceedings, two educational booklets and 20 working papers (Table 1). The triannual newsletter, *Tropical Coastal Area Management*, continues to be published.

Project Title : Asian Fisheries Social Science Research Network

Cooperating Institutions : INDONESIA - Faculty of Economics, Universitas Diponegoro (UNDIP); Research Institute for Coastal Aquaculture (RICA); The Research Group on Agro-Ecosystems (KEPAS), Agency for Agricultural Research and Development; Research Institute for Marine Fisheries (RIMF); MALAYSIA - Institute of Advanced Studies, 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); 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, 1989-1991

Key Personnel

Indonesia : UNDIP - Drs. Wiratno (Team Leader), Drs. Mudiantono, Drs. Dwisetia Poerwono, Drs. Syafrudin B. Suharto, Drs. Salrid, Drs. Basuki Suwardo, Drs. Edy Yusuf, Drs. Amier Kusnamawardani, Drs. Indah Susilowai, Ir. Yolianes Husabarat, and Ir. Argo; RICA - Dr. Fuad Cholik (Team Leader), Drs. Ali Pasaribu; Drs. Hasseng Padda, and Dr. Adi Hanafi; KEPAS - Dr. Kedi Suradisastra (Team Leader), Dr. Ibrahim Manwan, Ir. Asep Saefuddin, and Ir. Muchamad Yusron; RIMF - Mr. Victor P.H. Nikijuluw (Team Leader), Dr. Nurzali Naamin, Mr. Riyanto Basuki,

Mr. Manadiyanto, Mr. Bambang Sadhatomo, Mr. Sarjana, and Ms. Tuti Susilowati

Malaysia : UM - Dr. Jahara Yahaya (Team Leader), Anurddin Abdul Ghani and Azmah Binti Othman; UPM - Dr. Nik Mustapha Raja Abdullah (Team Leader), Dr. Mohd. Ariff Hussein, Dr. Syed Kadir Alsagoff, Dr. Ishak Hj. Omar, and Mr. Kusairi Mohd. Noh

Philippines : BFAR - Mr. Nelson A. Lopez (Team Leader), Ms. Marissa Albaladejo, Mr. Nemencio B. Arevalo, Mr. Severo D.B. Balane, Jr., Mr. Abundio M. Galicia, Jr., Mr. Cesar V. Guerrero, Ms. Emerita S. Lapasaran, Ms. Leonora O. Signey and Ms. Carmencita D. Tocino; CLSU - Mr. Ruben C. Sevilleja (Team Leader), Dr. Eduardo G. Marzan, Jr. and Ms. Ma. Excelsis M. Orden; SEAFDEC AQD - Mr. Renato Agbayani (Team Leader), Mr. Romeo D. Caturao, Ms. Giselle P.B. Samonte, Ms. Susana V. Siar and Mr. Reuel E. Tumaliuan

Thailand : DOF - Mr. Pongpat Boonchuwong (Team Leader), Ms. Panipa Hanvivatanakit, Ms. Somying Piumsombun, Ms. Pensri Julnimit, Mr. Pornsak Supavivat, Ms. Amporn Lawapong, Mr. Prayot Techapeowlert and Ms. Kulapa Mingmeag; KU - Dr. Ruangrai Tokrisna (Team Leader), Dr. Thanwa Jitsanguan, Dr. Sarun Wattanutchariya, Mr. Somkit Tugsinavisuitti, Mr. Somporn Isvilanondha, Ms. Fenporn Janekarnkij Mr. Piti Kantangkul, Mr. Banlu Puttikorn and Mr. Sanit Kao-ian; PSU - Dr. Somsak Baromthanarat

ICLARM : Dr. Louise A. Fallon (Network Coordinator); Mr. Herminigildo M. Montalvo (Research Associate); and Ma. Angelina A. Agulto (Project Assistant)

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; and
- To promote the use of the AFSSRN research results through effective dissemination.

Results

Membership. The Universiti Malaya (UM) in Kuala Lumpur, Malaysia became the 14th AFSSRN member institution in March 1990. The Network now has 88 member-researchers in 14 institutions in four Southeast Asian countries.

Research. A total of 13 research proposals has been received for funding consideration under Phase III in 1990. These proposals, which came from nine member institutions, deal with some of the current, most urgent, sensitive and relevant issues in the region. One of these proposals, a one-year project entitled, "Financial feasibility of rice-fish farming system", has been approved with initial funding already released. The research is to be conducted by the Freshwater Aquaculture Center of the Central Luzon State University in Muñoz, Nueva Ecija, Philippines, starting 1 December 1990.

All proposals passed through a thorough screening process. The AFSSRN Coordinator, upon receipt of the proposal, conducts a "proposal desirability" test using set criteria as well as an initial technical review. Then, an external technical review is pursued involving experts within and outside ICLARM. Proposals which require revisions/modifications as a result of the screening process are then returned to the proponent for their proper action.

Training and education. The Network sponsored the participation of four Network members to the FAO-Bay of Bengal Programme Regional Workshop on Fisheries Bioeconomics in Penang, Malaysia, on 2-12 October 1990. The purpose of the workshop was to introduce BEAM IV (Bioeconomic analytical model), a software developed by FAO which integrates the biological and economic aspects into the analysis of fisheries. As the four participants were selected to represent each country, they are expected to conduct similar workshops in their respective country for the benefit of their fellow Network members. The holding of these country-specific workshops will be sponsored by the Network.

The Network also sponsored a series of one-day seminars on "The Contribution of Social Anthropology to Fisheries Development" in member institutions in the Philippines, Indonesia, Malaysia and Thailand in the same year. Primarily aimed at promoting the importance of the socio-anthropological dimension of fishery development, the seminars were conducted by Prof. Yvan Breton, an economic anthropologist from Université Laval in Quebec, Canada.

A training course on The Principles of Bioeconomic Analysis in Fisheries was held on 5-7 November at ICLARM for Philippine AFSSRN members. The course, sponsored by the Network, was attended by 12 researchers from Network teams in UPV, UPLB, CLSU, SEAFDEC and BFAR. The course was

mainly intended to introduce concepts on the use of bioeconomics in the analysis of fisheries problems. The main discussant in the course was Prof. Parzival Copes, Director of the Institute of Fisheries Analysis at the Simon Fraser University (SFU) in Canada. An introduction to the BEAM IV program was given by Ms. Chona Iturralde, the Philippine participant in the BEAM IV course (in Penang, Malaysia in November 1990) and the AFSSRN-UPV team leader.

A collaborative agreement has been reached with SFU to enable AFSSRN members to pursue graduate studies there in fisheries economics. Initial consultative work was undertaken by Prof. Copes with Network members on possible scholarship slots, which will be financed by IDRC.

In preparation for the planned Economic Valuation Training Course in 1991, a compilation of selected literature on valuation techniques including the basic references has been put up in the form of a book called "The Reference Book". This book will serve as the primary hand-out to the participants in the training course on economic valuation.

Publications. The maiden issue of *AFSSRNews* came out as a pull-out section in the December 1990 (Vol. 5 No. 3) issue of the *Tropical Coastal Area Management* (TCAM) Newsletter.

Professional interaction. Continuing efforts were being made to organize an Advisory Committee, the primary perceived function of which is to review specific proposals that have been submitted to the Network for funding. This Committee will be composed of experts from various disciplines.

Coordination and administration. The AFSSRN Coordinator visited member institutions in the four Southeast Asian countries where discussions/consultations on current and future activities, possible scholarship opportunities open to members, and probable research areas for future funding were made.

As part of the agreed working arrangement, ICLARM hired a full-time research associate in September 1990 to assist the Network Coordinator. A project assistant is likewise assigned to the Network to provide administrative and secretarial support to the Coordinator.

AFSSRN Work Plan for 1991

Some of the research proposals submitted have already hurdled the critical technical review and are expected to be approved in due time while the remaining proposals will still have to be revised/modified. Proposals from other member institutions are likewise expected to come in. Strict monitoring of ongoing projects will be undertaken.

The Network's team leaders are scheduled to meet again in early 1991 for the purpose of assessing what has transpired during the previous year, determining the status of ongoing projects and laying out the Network activities for the remaining period.

Holding of seminars and workshops within the area of economic valuation and bioeconomic modelling in aquaculture will be pursued. Members will be encouraged to avail of opportunities being offered as part of the AFSSRN-SFU Collaborative Agreement.

CAPTURE FISHERIES MANAGEMENT PROGRAM

Background

The Capture Fisheries Management Program (CFMP) was created in December 1988 by ICLARM's Board of Trustees to focus on research relevant to the management of tropical and subtropical capture fisheries, and previously conducted as part of a larger program, the Resource Assessment and Management Program.

ICLARM's emphasis, through the CFMP, is on fish stocks as resources that should be managed based on the best science available to ensure sustainability of harvests. By addressing the various fisheries management issues and concerns, ICLARM is consciously, if indirectly, helping to solve the problems of millions of poor small-scale fishermen in tropical developing countries. By developing management tools and methods based on its research, ICLARM works to equip developing-country fisheries scientists and managers with the means to assess properly and effectively manage the fisheries resources for which they are responsible. This is the emphasis, e.g., of a newly launched joint project with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), in which linear programming software is being developed for managing fisheries as a part of a continuum of coastal resources (p. 53).

Modelling of exploited fish stocks has been a significant activity of this program for many years. The emphasis is now gradually changing from single-species models to (i) multispecies models and (ii) geographically structured approaches, since both of these approaches lead to more accurate assessments. This is done in the former case by explicitly accounting for biological interactions; in the latter case, this is achieved by explicitly accounting for the spatial distribution of the resource(s) within the ecosystems being analyzed. As an offshoot of this work, ICLARM continues to develop management software for use by fisheries researchers and managers on standard personal microcomputers.

For the CFMP, the main achievement in 1990 has been the launching of two major activities - in addition to that involving ECLAC - the FISHBASE Project, executed in cooperation with FAO and funded by the Commission of the European Communities (CEC) and the DANIDA-funded project on Global Comparisons of Aquatic Ecosystems.

Both of these activities involved recruiting new professional staff: Dr. Rainer Froese, the FISHBASE team leader, previously with the Institut für Meereskunde, Kiel, Germany, and our consultant during the initial phase of that activity, and Mr. Villy Christensen, previously with the Danish Institute for Fisheries and Marine Research, Hirtshals, Denmark.

Both activities involve a strong element of intensive work at ICLARM headquarters, one of documentation in the case of FISHBASE, the other concentrated on development of new approaches to the multispecies modelling of exploited aquatic ecosystems. Both activities rely on extensive development of new software, and both depend crucially on extensive contacts with fisheries scientists in developing as well as in developed countries institutions. Finally, both activities detailed further below (p. 59 and 61) involve a massive transfer of information and/or methodologies from developed-country libraries and/or laboratories to their sister institutions in developing countries.

Progress of Work

The Tropical Stock Assessment and ICLARM Software Projects

Research on improving the available methodology for assessing and managing tropical and subtropical fish stocks continued, and several new methods were developed which can be expected to find wide applicability, either directly, or as routines of the Compleat ELEFAN software, still the most popular software developed at ICLARM (Fig. 1).

Of the latter methods, one, recently published in Fishbyte, removes a source of bias in length-converted catch curves, one of the major methods for stock assessment in the tropics (Fig. 2). This method, along with a number of other related approaches is presently being incorporated into a new FAO-ICLARM software, under development at ICLARM, which will include all routines of ICLARM's Compleat ELEFAN and of FAO's software for length-based fisheries stock assessment (LFSA).

Related activities included further work on estimating the food consumption of fishes in nature, as required for multispecies models of fish populations. Much of this work was conducted by Ms. Astrid Jarre until her departure from ICLARM on 31 July to work on her doctorate thesis in Germany. A number of contributions resulting from this work

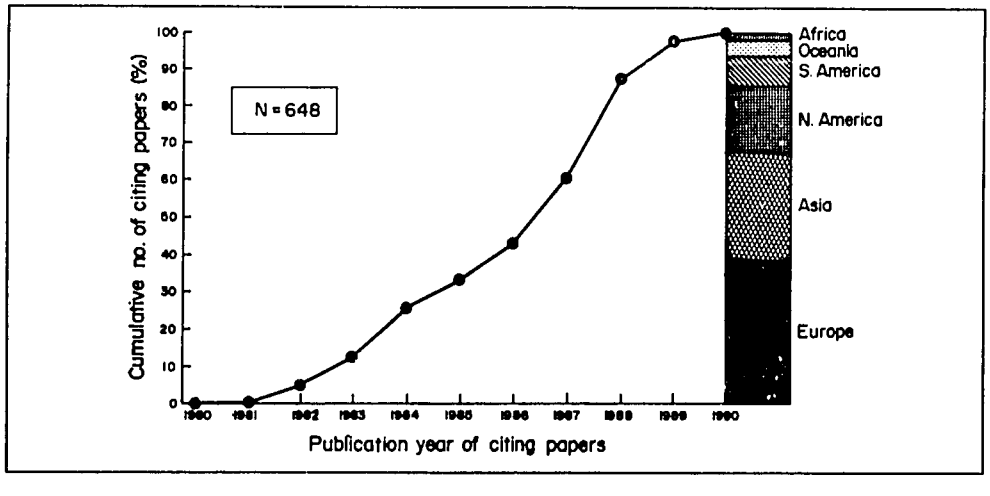


Fig. 1. Citations received by ICLARM publications describing the ELEFAN software, or routines included therein, for the decade from January 1981 to December 1990. Note the large number of citations, indicative of a large number of users from Europe and Asia.

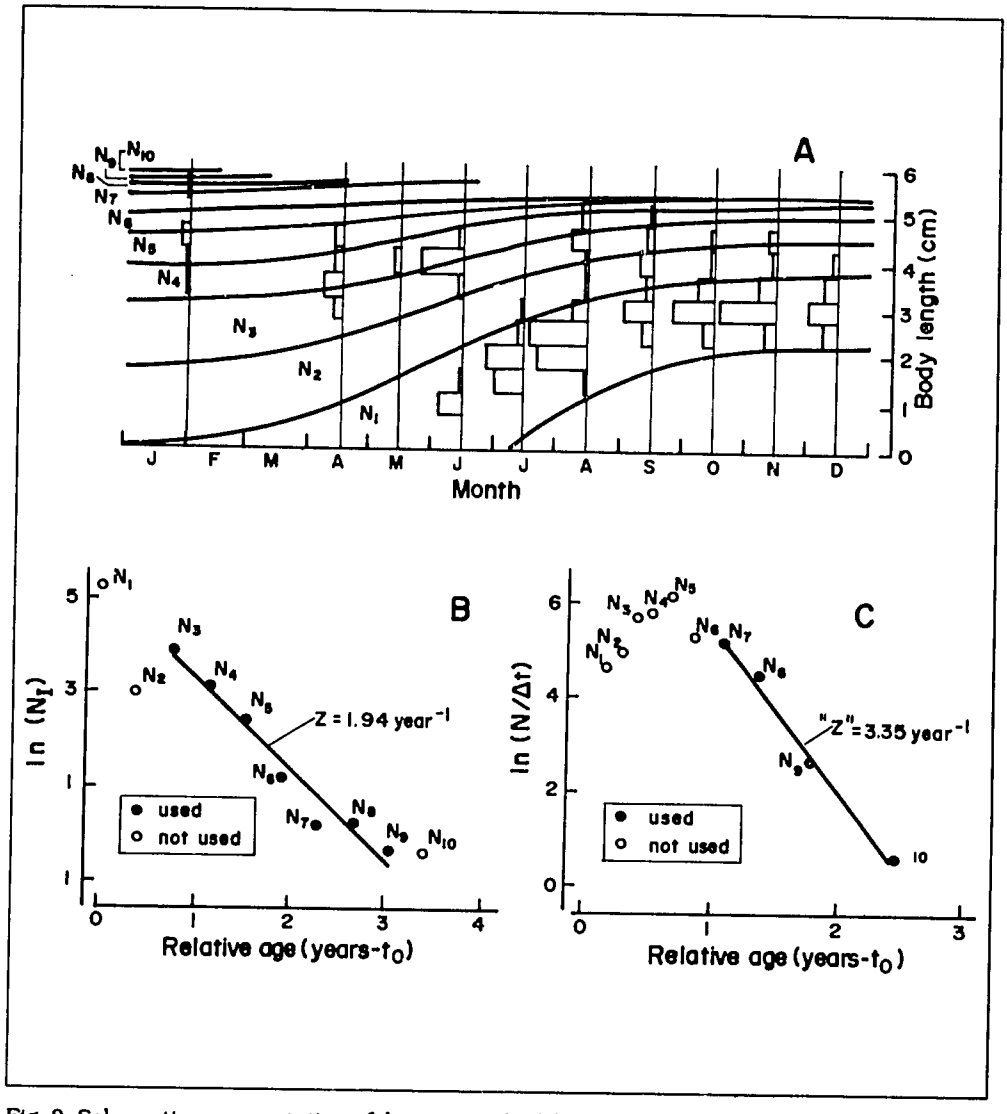


Fig. 2. Schematic representation of the new method for construction of length-converted catch curves for estimation of mortality (Z), accounting for seasonality of growth.

A. The first operation is using the parameters of a seasonally oscillating growth curve to identify a number (I) of (pseudo) cohorts, i.e., fish between two successive growth curves; the next step is adding fish belonging to different samples, but to the same (pseudo) cohort to obtain successive values of N_I.

B. Construction of catch curve as a plot of $\ln(N_I)$ *vs.* relative ages, and estimation of Z from straight descending arm of curve.

C. Standard length-converted catch curve, also based on data in A, but not accounting for seasonal growth; note overestimation of Z.

were submitted and/or published in 1990, and a test version of a software package called "MAXIMS" was released. This program will be used by, among others, the numerous scientists who also use the ECOPATH II software (see p. 59) for construction of ecosystem models.

Multispecies and spatial modelling

Fishes are usually not seen, counted nor weighed before they are caught, and yet we want to know how numerous they are, and how to

manage them. To do this, fisheries science has from the very onset, a century ago, depended on indirect inferences for quantifying vital statistics of fish populations; this involved the development of quantitative models of exploited fish populations.

The most important step in this development was the book of R. Beverton and S. Holt "On the dynamics of exploited fish populations", published in 1957, which presents the basic concepts of single-species fisheries assessment. The single-species model now most generally used is the virtual population analysis (VPA), a single-species method developed, based on the Beverton and Holt theory, to reconstruct fish population size from catch data. VPA has been applied to a large number of temperate stocks, and the main conclusion that can be drawn from these exercises is that VPA can generally be applied to exploited populations if the management options considered do not have much influence on the biological interactions between species. In other cases, the use of single-species models usually leads to erroneous management advice.

To circumvent these problems, various extensions of the Beverton and Holt model have been suggested, which explicitly take species interaction into account. The most advanced example of this is the multispecies VPA (MSVPA) model of the North Sea developed and maintained by the Multispecies Working Group of the International Council for the Exploration of the Sea (ICES). Applying this and similar approaches to tropical/subtropical conditions is not straightforward, however, and ICLARM's work in this area can be viewed as setting a methodological basis for the eventual application of MSVPA and related approaches to tropical/subtropical fisheries. To date, this work emphasized:

- length-based models for the rapid estimation of vital statistics required for model parametrization (especially growth and mortality rates, as estimated using ELEFAN and feeding rates as estimated using MAXIMS); and
- development of software for construction of steady-state trophic models, i.e., the ECOPATH II model, discussed further below.

In February 1990, renewed emphasis was given to the ECOPATH II program, of which a preliminary version was developed in 1986, when Mr. Villy Christensen initiated the project on Global Comparisons of Aquatic Ecosystems. He revised the initial version of the ECOPATH II program and in May 1990, a new version of the software and a draft manual were issued in the ICLARM software series.

Simultaneously, contacts were established with various colleagues throughout the world, who were invited to contribute applications of ECOPATH II to various aquatic ecosystems in the form of posters to be presented at the October 1990 annual meeting of the International Council for the Exploration of the Sea, in Copenhagen, Denmark.

The response was very positive and at this poster session, 37 posters were presented. Particularly interesting was the wide diversity of ecosystems covered, which ranged from Southeast Asian inshore waters, exploited mainly by trawlers, to aquaculture ponds in Malaŵi and southern China, and from coral reefs to the Antarctic shelf (Fig. 3).

We interpret the wide acceptability of the ECOPATH II software, and of the modelling approach it represents, as proof of their timeliness. The

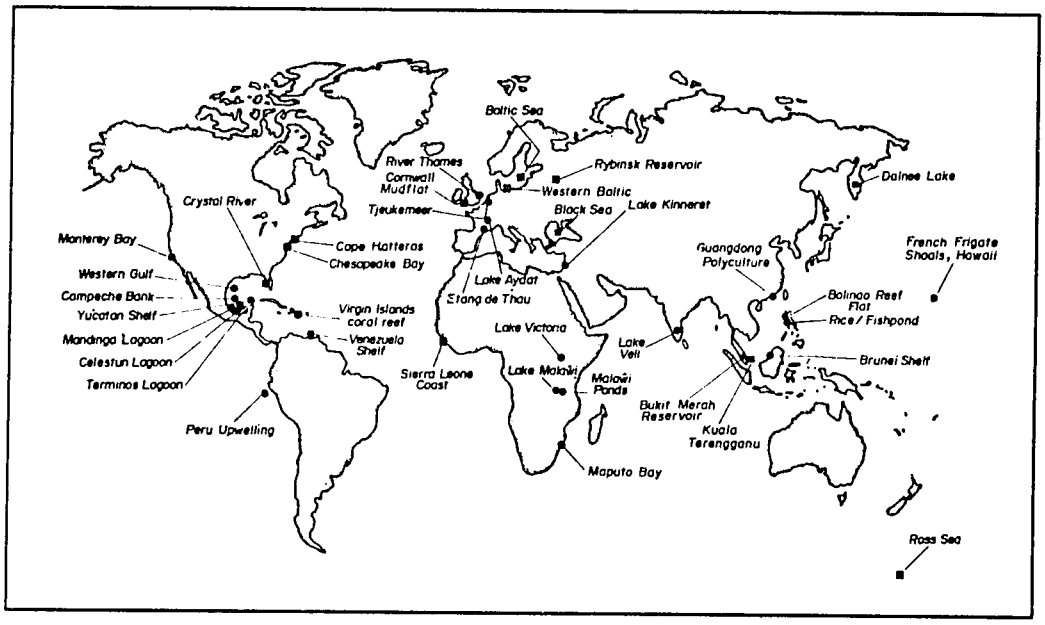


Fig. 3. Location of some of the ecosystems for which models constructed with ICLARM's ECOPATH II software exist. The dots refer to ecosystems documented in posters presented at the ICES meeting in October 1990 (see text); the squares refer to models constructed "in-house" by V. Christensen, based on published information.

high acceptability of this model was also evident during a series of lectures on this topic, given by Daniel Pauly in Europe and the Caribbean, in June-August 1990.

Finally, spatial modelling of fish resources was also given emphasis in 1990, resulting in a novel concept for simple geographic information systems (GIS) for use in fisheries research. Prototype software based on this concept was developed for documenting the coastal fisheries of Brunei Darussalam and for the Peruvian upwelling system and the pelagic fisheries it supports.

The Network of Tropical Fisheries Scientists (NTFS)

In 1990, the membership of the Network of Tropical Fisheries Scientists (NTFS), went above 1,000 for the first time, and the largest issue of Fishbyte was produced (April 1990: 56 pages) as one of the 3 issues produced yearly. The main problem for this successful information network, now in its eighth year, is thus *stabilization*. This can be achieved by updating the membership list, so as to identify non-active members, and by redirecting some of the manuscripts submitted to Fishbyte to international journals, more appropriate for the output of the more experienced members of the NTFS.

FISHBASE

The FISHBASE project, i.e., the elaboration of a computerized database on fish, began in October 1988 as a smaller project between FAO and ICLARM, and with the support of a small grant from the

Commission of the European Communities (CEC). This allowed the design of the FISHBASE software by project consultant, Dr. Rainer Froese, as well as the initial phase of data entry.

In mid-1990, a substantial grant was awarded to ICLARM by the CEC which enabled hiring of a full-time project leader (Dr. Froese) and more inputters, as well as the creation of two additional inputting stations in subSaharan Africa and one in the Philippines.

With this increased level of funding, the FISHBASE project staff have been able to advance much faster than previously. The various topics to be covered by FISHBASE for each species entered have not been covered evenly (Fig. 4) but it can now be confidently expected that the project's aim will be reached by providing key information on the identity, biology, ecology and status of basically all commercially important tropical and subtropical fish species of the world (see also Project Summary on p. 61).

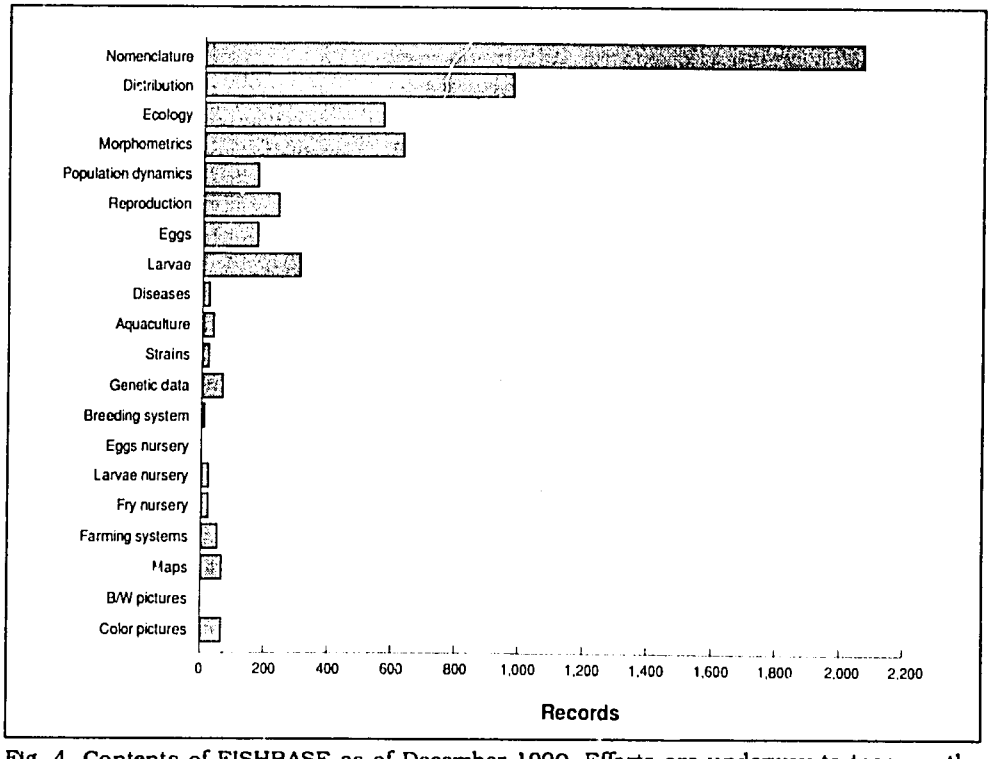


Fig. 4. Contents of FISHBASE as of December 1990. Efforts are underway to increase the information contained in the various areas presently not well covered, notably the aquaculture section.

Women in fisheries

Several versions of an elaborate proposal were submitted in 1990 to a major funding agency. This was to initiate a project aimed at addressing gender issues in fisheries and investigating the often negative impact of typical fisheries "development" projects on women's incomes. Further, gender roles and equity issues in fisherfolk communities in developing countries were to be investigated. This proposal was not funded. However, the Center is continuing to seek funding for work in this important area.

Education and Training

The year 1990 saw three graduate students of Dr. Daniel Pauly complete their studies. These were:

- Ms. Miriam Balgos, who completed her MS thesis entitled "Age and growth of the squid *Sepiotheuthis lessoniana* Lesson (1830) in Bolinao, Pangasinan, by statolith observation and length-frequency analysis" (Marine Science Institute, University of the Philippines, Diliman, Quezon City, 78 p.);
- Dr. Mark Prein, who completed his doctorate thesis entitled, "Multivariate analysis of tilapia growth experiments in ponds: case studies from the Philippines, Israel, Zambia and Peru". (Math-nat wiss. Fakultät, University of Kiel, Germany, 125 p.); and
- Dr. J.M. Vakily, whose thesis was on "Determination and comparison of growth in bivalves, with emphasis on the tropics and Thailand" (Math-nat. wiss. Fakultät, University of Kiel, Germany, 115 p + appendices).

Also, Mr. Victor Sambilay, Jr., a CFMP staff member, submitted in December 1990 to the College of Fisheries, University of the Philippines in the Visayas, Miag-ao, an MS thesis entitled "Depth distribution patterns of demersal fishes of the Samar Sea, Philippines, and their use for estimation of mortality", written, under the direction of Dr. Pauly, in the course of his research work.

Dr. Pauly was codirector and senior lecturer of the FAO/DANIDA Course in Fish Stock Assessment held from 3 to 28 September at the Instituto del Mar del Perú, Callao, Peru. He also gave an impromptu three-day course on fish stock assessment on the use of the Compleat ELEFAN software to staff of various institutions in the Caribbean, at Mayagüez, Puerto Rico, 30 July to 1 August 1990. This was followed by a two-day lecture/workshop visit (2-3 August 1990) at the Southwest Fisheries Center, Miami, Florida, at the invitation of its Director, Dr. Bradford Brown, and devoted to the assessment of predation by fish stocks and construction of multispecies models. These topics were also the themes of a formal lecture given on the last day of a visit at the Laboratoire d'Ichtyologie Appliquée, Ecole Nationale Supérieure Agronomique de Toulouse, France, on 2-6 July. This visit occurred in the context of ICLARM's Memorandum of Understanding with that institution to coordinate various joint publications with Prof. J. Moreau, and to advise Ms. M.L. Palomares, formerly of ICLARM, and now completing there a doctorate thesis on the food consumption of freshwater fishes.

Dr. Max Agüero has been nominated Adjunct Professor of the University of Rhode Island and member of the Advisory Committee of the Master's Thesis on Fisheries Economics of a graduate student of that faculty. Dr. Agüero also conducted a training course on "Fisheries Economics and Management" for fishery sector representatives and staff of fisheries research centers in Chile at the School of Marine Sciences, Universidad Católica, Valparaiso, Chile, from 19 to 21 December 1990, and gave formal lectures on related topics at the Université du Quebec, Montreal, Canada and in at the Universidad Nacional Agraria "La Molina", Lima, Peru.

Advisory Services

Dr. Daniel Pauly acted as team leader of a four-person World Bank mission to Kenya, Malaŵi, Mozambique and Zimbabwe, performed from 7 to 26 January in the frame of the World Bank-coordinated Study of International Fisheries Research. The report based on this mission discussed in depth some factors affecting the effectiveness of fisheries research in the countries visited, and more generally, in subSaharan Africa, and presented some nonconventional schemes which, if implemented, may lead to a reduction of the effects of these constraints.

Dr. Max Agüero assisted staff members of the Pan American Center for Sanitary Engineering and Environmental Sciences (CEPIS) in the social and economic evaluation of its "Waste-fed Experimental Project" in Lima, Peru, conducted with the support from the World Bank and GTZ. For this purpose, Dr. Agüero went twice to Lima, in mid-July and October 1990. A final report has been prepared and a series of templates for the estimation and analysis of costs and returns in waste-fed fish production systems have been elaborated using the Lotus 1-2-3 software package.

In December 1990, Dr. Agüero and the Directors of the Schools of Fisheries and Economics of the Universidad Austral of Valdivia, had several meetings in Santiago to plan the initiation of a curriculum for an academic degree in Fisheries Management/Environmental Economics, in collaboration with staff of the Faculty of Resource Economics, University of Rhode Island.

Program Plans

With three new projects launched in 1990, the program plans for 1991 do not involve any new initiative. Rather, our emphasis will be to reach the goals set for each of the activities described in the various Project summaries starting on p. 42.

Also, emphasis will be given to gradual adjustments towards the mode of operation required of the members of the Consultative Group on International Agricultural Research, into which ICLARM presently seeks membership.

Meetings Attended, Papers Presented

Workshop on Coastal Fisheries, sponsored by the Philippine Council for Marine and Aquatic Resources Research and Development (PCMARRD), Cebu City, 23-25 January. (A. Jarre).

Policy Conference on Managing ASEAN's Coastal Resources for Sustainable Development, Manila and Baguio, Philippines, 4-7 March 1990. (D. Pauly).

Meeting on Asian Fisheries Research Priorities, International Development Research Center, Singapore, 23-24 April. (D. Pauly).

First National Symposium on Marine Science, Bolinao Marine

Laboratory, Marine Science Institute, University of the Philippines, 16-18 May. (V. Christensen, A. Jarre, D. Pauly and V. Sambilay, Jr.).

Paper presented:

Sambilay, V.C., Jr., M.L. Palomares, S. Opitz and D. Pauly. Towards modelling a coral reef ecosystem: relative food consumption estimates for some Bolinao reef fishes, Pangasinan, Philippines.

Second Marine Science Congress, Havana, Cuba, 18-22 June. (D. Pauly: keynote speaker and chairman of session on Fishery Biology, 22 June).

Paper presented:

Pauly, D. Fishery science: a new toolkit for dealing with new problems.

International Council for the Exploration of the Sea (ICES) Statutory Meeting, Copenhagen, Denmark, 4-9 October. (V. Christensen, R. Froese and D. Pauly).

Papers presented:

Degnbol, P., V. Christensen, J.G. Stöttrup, H. Paulsen and K.J. Staehr. Experimental estimation of food preference in cod - results of a pilot experiment.

Froese, R. Growth strategies of fish larvae.

Froese, R. Presentation of a biological data base for species of current or future importance to aquaculture or fisheries.

Froese, R., K.-G. Barthel, W. Welsch, M. Rolke, C. Schubert, B. Hermann, S. Mees, D. Schnack and J. Lenz. Development of an underwater video system for recording of ichthyoplankton and zooplankton.

Hernandez, H., P. Aliño and A. Jarre. The annual food consumption of *Siganus fuscescens*, a dominant herbivore in the reef flats of Bolinao, Pangasinan Province, Philippines.

Pauly, D., V. Christensen and V. Sambilay, Jr. Some features of fish food consumption estimates used by ecosystem modellers.

Soriano, M., J. Moreau, J. Hoenig and D. Pauly. New function for the analysis of two-phase growth of juvenile and adult fishes, with application to Nile perch.

Poster Session on "Construction and Comparison of Trophic Models of Ecosystem", International Council for the Exploration of the Sea, Copenhagen, Denmark, 4-9 October. (V. Christensen and D. Pauly, hosts).

Posters presented:

Christensen, V. and D. Pauly. The ECOPATH II model.

Christensen, V. and D. Pauly. Global comparisons of aquatic ecosystems.

Jarre, A. and D. Pauly. Seasonal changes in the Peruvian upwelling ecosystem.

Pauly, D. and V. Christensen. Three new approaches for the graphical representation of steady-state trophic ecosystem models.

Ruddle, K and V. Christensen. A quantitative energy flow model of the mulberry dike-carp pond integrated farming system of the Zhujiang delta, Guangdong Province, China.

Eighth Fishery Symposium, School of Marine Science, Universidad Católica de Valparaiso, Valparaiso, Chile, 15-17 October. (M.A. Arellano).

Paper presented:

Agüero, M. Sustainable resources management options in developing countries.

Regional Application of SPOT and ERS-1. Training course sponsored by the European Space Agency, Centre National des Etudes Spatiales (France) and Faculty of Engineering, Universidad Católica de Valparaiso, Valparaiso, Chile, 17-30 October. (M. Agüero and C. Olivares).

Fourth Quarterly Meeting of the Fish Stock Assessment Collaborative Research Support Program, MSI/URI/USAID, Marine Science Institute, University of the Philippines, Diliman, Quezon City, 7 November. (V. Christensen, R. Froese and D. Pauly).

Conference on Bioscience and Society, sponsored by the Senate of Berlin and Schering A.G., Berlin, 26-30 November. (D. Pauly).

Natural Resources Valuation and Management. A workshop sponsored by the Economic Research Corporation for Latin America (CIEPLAN) and the World Resources Institute, Santiago, Chile, 28 November. (M. Agüero).

International Conference on Natural Resources and Economic Development, sponsored by the Economic Research Corporation for Latin America (CIEPLAN), the Environmental Research and Planning Center (CIPMA) and the Faculty of Economics and Management, University of Concepcion, Concepcion, Chile, 29-30 November. (M. Agüero, panelist).

Fifth International Conference of the International Institute of Fisheries Economics and Trade, Fundacion Chile, Santiago, Chile, 3-6 December. (M. Agüero).

Paper presented:

Agüero, M. Social and economic benefits of mangroves, with emphasis on Ecuador.

Experts Meeting to Prepare a Regional Position on Sustainable Development of the Coastal/Marine Environments of the Southeast Pacific for the United Nations Conference on the Environment and Development, Permanent Commission for the South Pacific (CPPS), United Nations Environment Program (UNEP) and Escondida Mining Company (MINESC), Santiago; Chile, 11-12 December. (M. Agüero, observer).

Fourth Meeting of Experts on the East Asian Seas Action Plan, Quezon City, Philippines, 26 December. (D. Pauly, observer).

Publications and Consultancy Reports

Achenbach, I. and R. Froese. 1990. Presentation of a data base system for information on and diagnosis of fish diseases. ICES C.M. 1990/F:72 13 p.

Agüero, M. and M. Ahmed. 1990. Economic rationalization of fisheries exploitation through management: experience from the open-water inland fisheries management in Bangladesh, p. 747-750. *In* R. Hirano and I. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Brey, T., W.E. Arntz, D. Pauly and H. Rumohr. 1990. *Arctica (Cyprina) islandica* in Kiel Bay (Western Baltic): growth, production and ecological significance. J. Exp. Mar. Biol. Ecol. 136: 217-235.

Capili, J.B., S.M. Luna and M.L. Palomares. 1990. A multivariate analysis of the growth of three strains of tank-reared tilapia *Oreochromis niloticus*, p. 425-428. *In* R. Hirano and I. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Christensen, V. 1990. The ECOPATH II software and how we can gain from working together. Naga, ICLARM Q. 13(2): 9-10.

Christensen, V. and D. Pauly. 1990. A draft guide to the ECOPATH II program (ver. 1.0). ICLARM Software 6, 22 p.

Christensen, V. and D. Pauly. 1990. Global comparison of aquatic ecosystems. ICES C.M. 1990/L:69. 7 p.

Christensen, V. and D. Pauly. 1990. The ECOPATH II model. ICES C.M. 1990/L:68. 6 p.

Cruz-Trinidad, A.V. 1990. The use of surplus-yield models in the economic analysis of a fishery. Fishbyte 8(2): 20-24.

Cruz-Trinidad, A. and D. Pauly. 1990. The network of tropical fisheries scientists: bridging communication gaps, p.14-19. *In* J.L. Maclean and L.B. Dizon (eds.) ICLARM Report 1989, 167 p.

Cruz, A.V. and G. Silvestre. 1988. Economic analysis of medium trawlers in Lingayen Gulf. Fish. Res. J. Philipp. 13(1-2):1-14 (published in 1990).

Degnbol, P., V. Christensen, J.G. Stöttrup, H. Paulsen and K.J. Staehr. Experimental estimation of food preference in cod-results of a pilot experiment. ICES C.M. 1990/G:63. 10 p.

Del Norte, A.G.C. and D. Pauly. 1990. Virtual population estimates of monthly recruitment and biomass of rabbit fish, *Siganus canaliculatus* from Bolinao, northern Philippines, p. 851-854. *In* R. Hirano and I. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Froese, R. 1990. Growth strategies of fish larvae. ICES C.M. 1990/L:91. 20 p.

Froese, R. 1990. Presentation of a biological data base for species of current or future importance to aquaculture or fisheries. ICES C.M. 1990/L:92. 6 p.

Froese, R. 1990. FISHBASE: an information system to support fisheries and aquaculture research. Fishbyte 8(3): 21-24.

Froese, R. and C. Papasissi 1990. The use of modern relational databases for identification of fish larvae. J. Appl. Ichthyol. 6: 37-45.

Froese, R., I. Achenbach, and C. Papasissi. 1990. Computer-aided approaches to identification. III (Conclusion). Modern databases. Fishbyte 8(2): 25-27.

Gayanilo, F.C., Jr. 1990. CDS Assistant: utilities for the bibliographic software micro CDS/ISIS. Naga, ICLARM Q. 13(2): 17-18.

Gayanilo, F.C., Jr. 1990. Review of basic fishery science programs: a compendium of microcomputer program and manual of operation, by S.B. Saila, C.W. Recksiek and M.H. Prager. Naga, ICLARM Q. 13(2): 19.

Gayanilo, F., Jr. and D. Pauly. 1990. The Compleat ELEFAN version 1.1: post-release blues. Fishbyte 8(1): 47-49.

Hernandez, H., P. Aliño and A. Jarre. 1990. The annual food consumption of *Siganus fuscescens*, a dominant herbivore in the reef flats of Bolinao, Pangasinan Province, Philippines. ICES C.M.1990/G:18. 15 p.

Isaac, V. 1990. The accuracy of some length-based methods for fish population studies. ICLARM Tech. Rep. 27, 81 p.

Jarre, A. 1990. Estimating the food consumption of fishes: one step in linking a species with its ecosystem. Naga, ICLARM Q. 13(2): 3-4.

Jarre, A., M.L. Palomares, V.C. Sambilay, Jr. and D. Pauly. 1990. A user's guide to MAXIMS: estimating fish food consumption from diel stomach contents data and population parameters. ICLARM Software 4, 27 p. + two 5.25 360K program diskettes.

Jarre, A. and D. Pauly. Seasonal changes in the Peruvian upwelling ecosystem. ICES C.M. 1990/L:50.

McManus, J. and D. Pauly. 1990. Measuring ecological stress-variations on a theme by R.M. Warwick. Mar. Biol. 106(2): 305-309.

Papasissi, C. and R. Froese. 1990. Modern relational databases for the identification of fish larvae of the Mediterranean Sea. Rapp. Comm. int. Mer Médit. 32(1): 307.

Pauly, D. 1990. On Malthusian overfishing. Naga, ICLARM Q. 13(1): 3-4.

Pauly, D. 1990. John A. Gulland, FRS, 1923-1990. Fishbyte 8(2): 28-29.

Pauly, D. 1990. On holism, reductionism and working from 9 to 5. Naga, ICLARM Q. 13(2): 3-4.

Pauly, D. 1990. Length-converted catch curves and the seasonal growth of fishes. Fishbyte 8(3): 24-29.

Pauly, D. and V. Christensen. 1990. Three new approaches for the graphical representation of steady-state trophic ecosystem models. ICES C.M. 1990/L:67. 6 p.

Pauly, D. and F.C. Gayanilo, Jr. 1990. The growth of ELEFAN. Naga, ICLARM Q. 13(2): 14-16.

Pauly, D., V. Christensen and V. Sambilay, Jr. 1990. Some features of fish food consumption estimates used by ecosystem modellers ICES C.M. 1990/G. 17. 9 p.

Pauly, D., M. Small, R. Vore and M.L. Palomares. 1990. Fisheries yields and morphoedaphic index of Lake Mainit, Philippines, p. 835-838. *In* R. Hirano and I. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Pauly, D., T.O. Acere, C. Newton and M. Vincke. 1990. On research for fisheries and aquaculture in southeastern Africa; Report of a mission to Kenya, Malaŵi, Mozambique and Zimbabwe, 7-26 January 1990. Study of International Fisheries Research. SIFR/6. 58 p.

Regier, H.A., J.A. Holmes and D. Pauly. 1990. Influence of temperature changes on aquatic ecosystems: an interpretation of empirical data. Trans. Amer. Fish. Soc. 119: 374-389.

Ruddle, K. and V. Christensen. 1990. A quantitative energy flow model of the mulberry dike-carp pond integrated farming system of the Zhujiang delta, Guangdong Province, China. ICES C.M. 1990/L:35. 6 p.

Sambilay, V.C., Jr. 1990. Depth-distribution patterns of demersal fishes of the Samar Sea, Philippines, and their use for estimation of mortality. Institute of Marine Fisheries and Oceanology, University of the Philippines in the Visayas, Miag-ao, Iloilo. 65 p. MS thesis.

Sambilay, V.C., Jr. 1990. Interrelationships between swimming speed, caudal fin aspect ratio, and body length in fishes. Fishbyte 8(3): 15-20.

Sambilay, V.C. Jr., A.B. Corpuz and L.S. Reyes. 1990. Catch and length-frequency data sets of the R/V *Albacore* and the R/V *Sardinella* bottom trawl surveys in central Philippine waters, 1979 to 1982. Tech. Rep. Dept. Mar. Fish. 11. 180 p.

Soriano, M., J. Moreau, J. Hoenig and D. Pauly. 1990. New function for the analysis of two-phase growth of juvenile and adult fishes, with application to Nile perch. ICES C.M. 1990/D:16. 9 p.

Tandog-Edralin, D.D., E.C. Cortes-Zaragosa, P. Dalzell and D. Pauly. 1990. Some aspects of the biology of skipjack *(Katsuwonus pelamis)* in Philippine waters. Asian Mar. Biol. 7: 15-29.

Capture Fisheries Management Program
Project Summaries

Project Title	:	Tropical Fish Stock Assessment Project
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. Victor Sambilay, Jr. Ms. Mina Soriano (until 1 March) Ms. Astrid Jarre (until 31 July) Mr. Geronimo Silvestre Mr. Villy Christensen (from 1 February)

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

The project was extraordinarily successful in 1990 in that numerous new methods were developed which, in line with the objectives of that project, can be expected to find wide applicability throughout the tropics and subtropics and in temperate areas as well. Some of the highlights are:

(i) A set of new methods and related concepts were developed in conjunction with the ECOPATH II software and modelling approach, which range from the parametrization of trophic steady-state models to new modes for their graphical representation (see the Project Summary and the list of publications on p. 59 and 38, respectively).

(ii) Another set of new methods and concepts were developed in conjunction with the MAXIMS software, for estimation of the daily ration (i.e., food consumption of fishes), of which a test version was released in May 1990 (see Project Summary on p. 56).

(iii) Also, a new method was developed by J. McManus and D. Pauly, based on earlier work by R.M. Warwick, to quantify "stresses" (e.g., pollution or fishing pressure) affecting a multispecies community from the relative distribution of species

numbers and biomass per species. A program implementing this method will be issued as ICLARM software in 1991.

(iv) Various new methods were developed for the improved estimation of vital statistics of fish populations (growth, mortality rates, gear selection, etc.) from length-frequency data (see list of publications on p. 38). These will be implemented as routines of ICLARM's Compleat ELEFAN software package, and of a joint FAO-ICLARM package presently under development (see also Project Summary on p. 56).

Fig. 2, on p. 31 illustrates one of these new methods, related to the estimation of mortality. Fig. 5 illustrates the results drawn from the version published by ICLARM of a doctorate thesis by V. Isaac, supervised by Dr. D. Pauly, and devoted to a detailed analysis of the accuracy of the ELEFAN I program and two related methods, also to be introduced in the joint FAO-ICLARM package.

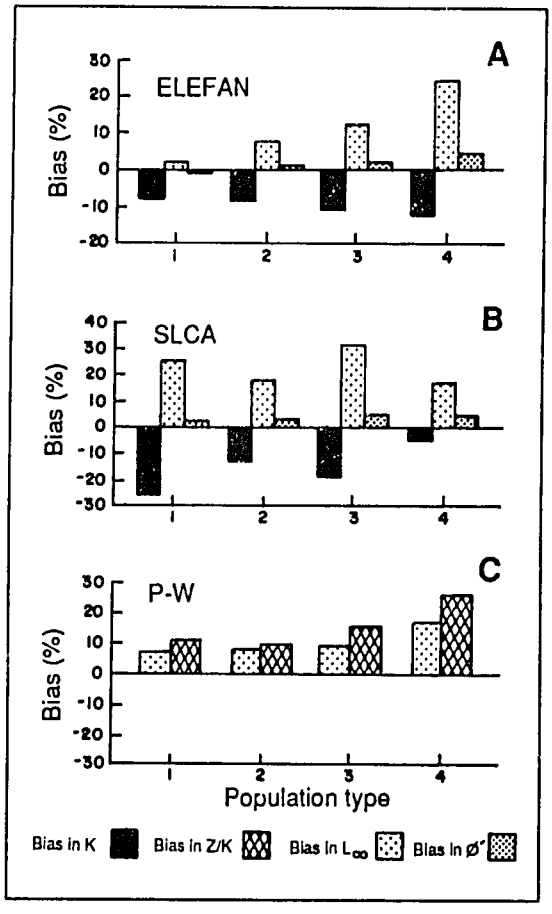


Fig. 5. Bias of fish growth parameter estimates (in %) obtained by three alternative methods for analysis of length-frequency data, as a function of increasing growth variability (populations 1 to 4). A: ELEFAN I; B: Shepherd's length composition analysis; and C: Powell-Wetherall method. Knowledge of these biases, derived from the computer simulations of V. Isaac (1990, ICLARM Tech. Rep. 27), leads to more reliable assessments of the fish stocks for which the estimates are made.

It is planned to devote in 1991 even more attention than previously to the development of methods for multispecies modelling and stock assessment. Particularly, effort will be directed towards development of a length-structured version of multispecies virtual population analysis (MSVPA), and to apply this to selected tropical datasets/fisheries, ranging from coral reefs to reservoirs. The extremely favorable reception of the CFMP's new ECOPATH II software and related method gives hope that length-structured MSVPA, a related, but even more powerful method, will also find wide acceptance and be used to develop multispecies fisheries management options throughout the intertropical belt.

Another line of research and methods development has been initiated, based on the observation that information of crucial importance for the management of fisheries, pertaining to the spatial distribution of catches, catch-per-effort (C/f), biomasses, etc., is lost when single

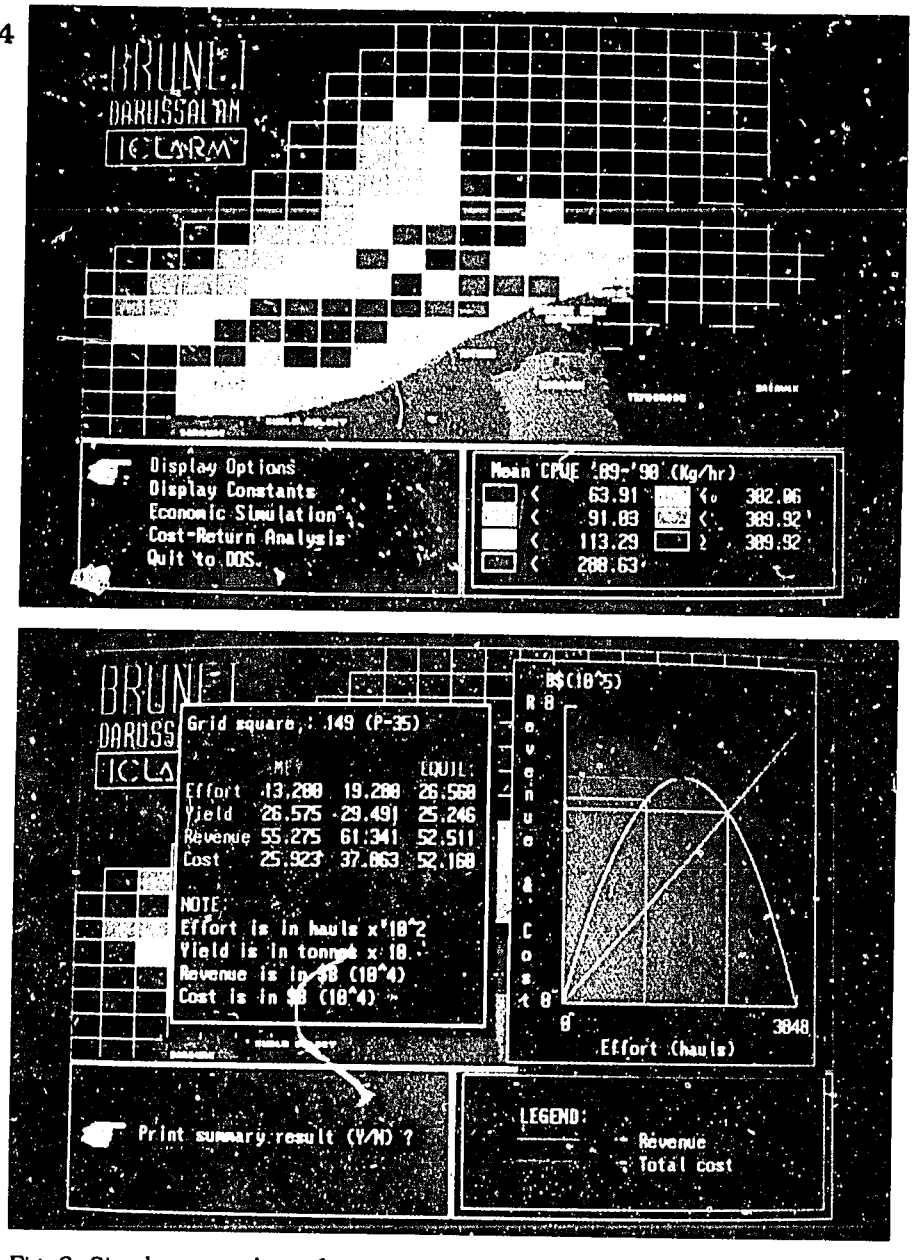


Fig. 6. Simple geographic information system (B:RUN) developed in 1990 for the display and analysis of trawl survey and related data from the coastal area of Brunei Darassalam. *Top*: Example of a map (here: distribution of catch-per-effort of trawlers) displayed by B:RUN; *Bottom*: Screen for documenting an elementary cost and return analysis, for a trawler based in Muara, Brunei Darussalam, and fishing, e.g., in one of the nearshore squares of the map (top).

numbers (e.g., total biomass or mean C/f) or time series thereof are accepted as the sole result of investigation at fish landing places, or of trawl surveys.

Clearly, one way to deal with this is to use Geographic Information System (GIS). However, commercial GIS are costly, hard-to-use software, requiring skilled personnel. This has resulted in a large number of research institutions in developing countries underutilizing their hard-to-obtain data.

To overcome this, the project has developed a concept for simple GIS, consisting of two basic routines:

(i) a map digitized in-house, programmed as a series of "data statements" (thus requiring no dedicated GIS software for display), and gridded such that the (aquatic) area of interest is split into 100-200 numbered squares, and

(ii) a routine to interface the squares in (i) with a commonly-used spreadsheet package (Lotus 1-2-3), whose cells are used for storing quantitative information on each of the map's squares.

This simple system, a low-cost, if low-resolution GIS, thus combines the computational versatility of a spreadsheet package with the visual impact of color computer graphics in a one-diskette software package.

To illustrate the potential of this approach, two packages were developed in 1990; They are:

- B:RUN, developed in cooperation between CFMP (F. Gayanilo, Jr. and D. Pauly) and CAMP (G. Silvestre) mainly to document and analyze the results of a demersal trawl survey conducted in 1989/1990 in the frame of the ASEAN/US Coastal Resources Management Project in Brunei Darussalam (Fig. 6), and
- GEOMARPE, developed by Mr. F. Gayanilo, Jr., Ms. C. Janagap and D. Pauly as an offshoot of a simulation model for the management of the Peruvian pelagic fisheries (see Project Summary, p. 51).

A third package covering the coastal area of Sierra Leone, West Africa, will be developed in 1991 as part of a two-year fishery management project to be undertaken in that country by ICLARM, with the Institute of Marine Biology, Freetown, and funding from the Commission of the European Communities.

Project Title	:	Network of Tropical Fisheries Scientists (NTFS)
Cooperating Institutions	:	FAO/DANIDA Training Course in Tropical Fish Stock Assessment
Duration	:	Continuous from April 1982
Key Personnel ICLARM	:	Ms. Abbie Cruz-Trinidad, Network Secretary Dr. Daniel Pauly, Fishbyte Editor

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. The technical focus is on the estimation of the biological, fisheries and socioeconomic parameters which determine the magnitude of harvests and the application of those parameters to models to arrive at scientifically sound management measures for tropical stocks.

Results

The Network of Tropical Fisheries Scientists continued in 1990 its successful operation. Membership totalled 1,060 by the end of 1990, which represents an increase of 100 members from the 1989 level. Most of the new members come from Latin America, especially Cuba and Peru. This results from Dr. Pauly's visit to Cuba in June 1990 and from the FAO/DANIDA-sponsored national training course in Fish Stock Assessment held in Callao, Peru, on 3-28 September 1990, respectively.

Three voluminous issues of Fishbyte were produced in 1990. Among the contributions were the last of eight papers written by scientists from the South Pacific on the applicability of the ELEFAN software to estimate population parameters of various reef fishes. This work resulted from a workshop on Length-Based Methods in Fish Analysis, sponsored by the Forum Fisheries Agency and held in the Solomon Islands on 5-17 December 1988. Other location-specific papers described fisheries in Africa (3), Latin America (2) and Europe (1). Eight papers dealt with new methods; of these, two dealt with computer software and one with the economic evaluation of fisheries.

In the future, an attempt will be made to redirect the high quality manuscripts submitted to Fishbyte towards international journals, where they belong, and to reemphasize the role of Fishbyte as an informal newsletter.

Three network members stayed at ICLARM for study stages in 1990, and Table 1 below provides details on these.

Table 1. Details on NTFS members who spent study stages with ICLARM's CFMP in 1990.

Visitor	Institution[a]	Duration of stage	Research area[b]
Mr. Hussain Mohammed	Mariculture and Fisheries Department, Kuwait Institute for Scientific Research (KISR), Salmiyah, Kuwait	23 Jan-16 Mar	Population dynamics of *Metapenaeus affinis* in Kuwait waters
Mr. U.S. Amarasinghe	National Aquatic Resources Agency (NARA), Colombo, Sri Lanka	12 Feb-9 Mar	Management of reservoir fisheries in Sri Lanka
Mr. Taweep Boonwanich	Department of Fisheries (DoF) Bangkok, Thailand	5-30 Nov	Population dynamics of Gulf of Thailand lizardfish *Saurida undosquamis* and *S. elongata*

[a]KISR and NARA-funded the stages of their staff members; the visitor from the Thai DoF was funded via the ASEAN-US Coastal Area Management Project.

[b]The papers based on work in Kuwait and Thailand will be published in Fishbyte; that from Sri Lanka was used for a Ph.D. thesis.

Project Title		: Management-Oriented Fisheries Research Project
Cooperating Institutions		: Instituto del Mar del Perú (IMARPE), Callao, Perú; Laboratory for Ichthyology and Coastal Systems (LICS), Limnology and Marine Science Institute, Universidad Nacional Autónoma de México (UNAM), Mexico City; Marine Science Institute, University of the Philippines, Quezon City, Philippines; Uganda Freshwater Fisheries Research Organization (UFFRO), Jinja, Uganda
Duration		: Continuous from April 1982
Key Personnel	UNAM	: Dr. Alejandro Yáñez-Arancibia[a]
	MSI	: Dr. Porfirio Aliño
	UFFRO	: Mr. Thaddeus O. Acere
	ICLARM	: Dr. Daniel Pauly
		Ms. Astrid Jarre (until 31 July)
		Dr. Peter Muck (c/o IMARPE)
		Mr. Villy Christensen (from 1 February)

Objectives

- To cooperate with fisheries scientists in national institutions on the interpretation of fishery data (especially in extracting a maximum of information from available data) and in formulating implementable management options for their fisheries;
- To help determine for the fisheries covered the basic information requirements for stock assessment and fisheries management;
- To produce well-documented reviews relevant to the management of the various fisheries investigated and original studies on tropical fisheries research.

Results

Uganda module

The only activity in the module occurred in 1990 during the joint trips of Dr. D. Pauly of ICLARM and Mr. T.O. Acere, conducted in the frame of a mission to Kenya, Malaŵi, Mozambique and Zimbabwe for the Study of International Fisheries Research, from 7 to 26 January 1990. This provided an opportunity for the joint elaboration of a report on

[a]Since mid-1990: Programa EPOMEX, Universidad Autónoma de Campeche, Apartado Postal 520, Campeche 24030, Mexico.

constraints to fisheries research in southeastern Africa and for some progress on several contributions that had been neglected in 1989, mainly for lack of time.

Mexico module

Activities of this module were limited in 1990 mainly because of the mid-year transfer of ICLARM's "partners", the scientific group of Prof. A. Yáñez-Arancibia from the Limnology and Marine Science Institute, UNAM, Mexico City, to the Universidad Autónoma de Campeche, Campeche, where they form the core of the EPOMEX Program (Programa de Ecologia Pesquerías y Oceanografía del Golfo de México).

During a brief visit by Dr. D. Pauly in Mexico City on 16-17 June, it was agreed that Dr. M. Agüero, Mr. V. Christensen and Dr. D. Pauly would contribute two chapters, on the economic value and the modelling of mangroves, respectively, to a book on mangroves to be issued by EPOMEX.

Also, Dr. Pauly was invited to join the Scientific Board of EPOMEX.

Philippine module

This "module" is not new, although it appears for the first time under the heading of the Management-Oriented Fisheries Research Project, because CFMP program staff here since the early 1980s interacted with scientists of the University of the Philippines, notably with MSI and its predecessor, the UP Marine Science Center.

However, these interactions have become rather close in 1990, justifying a separate account in this project summary.

i) Based on proposals by Ms. A. Jarre, the Embassy of the Federal Republic of Germany and the Center for International Migrations (CIM) donated in February 1990, a set of fifteen scientific books to the MSI library.

ii) Following up on her teaching of a biostatistics course at UPMSI in 1989, Ms. A. Jarre continued her study with Mr. H. Hernandez and Dr. P. Aliño, on the feeding of reef fishes, which led to a joint contribution on this topic, presented at the October Council Meeting of ICES, in Copenhagen.

iii) Also, Dr. Aliño and colleagues working for the MSI station at Bolinao, Pangasinan, in cooperation with Ms. Jarre and Mr. Christensen, developed a quantified trophic model of the Bolinao reef flats (Fig. 7) which was presented at the Poster session on trophic models discussed on p. 59 held in the frame of the abovementioned meeting of ICES. Dr. Aliño's trip to Copenhagen was made possible through a special travel grant from DANIDA through ICLARM's ECOPATH II project (see also p. 59).

iv) Cooperation on these two activities - estimating the food consumption of single-species population of reef fishes and modelling the entire reef - will continue. Indeed, it is expected that the results of these two lines of research will be integrated using a length-structured version of multispecies virtual population analysis (MSVPA), presently being developed by Mr.

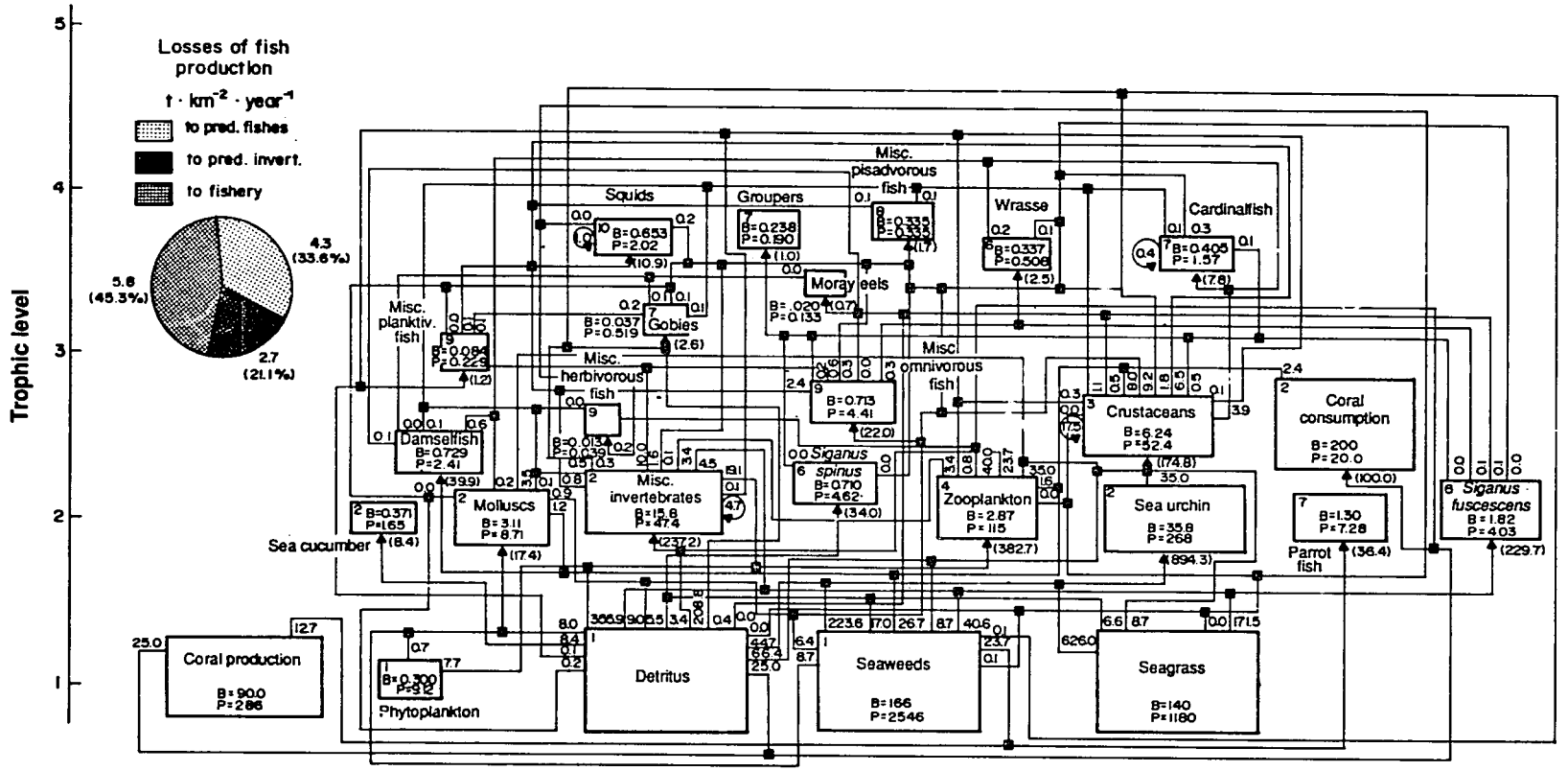


Fig. 7. Trophic model of a generalized South China Sea reef flat modified from a model from near Bolinao, Pangasinan, Philippines, as constructed using ICLARM's ECOPATH II software (modified from Aliño et al.; ICES CM 1990/L:55, Session Q). The surface area of the "boxes" is proportional to the logarithm of the biomass they represent; all flows are in tonnes/km².

Villy Christensen, and for which the Bolinao reef and the well-documented fishery that it supports offer an ideal test bed.

v) Cooperation of project staff with the USAID-funded Fish Stock Assessment Collaborative Research Program (CRSP), also based at MSI was strengthened. CRSP Staff used Naga, the ICLARM Quarterly and Fishbyte for papers and/or announcements concerning their project, and several joint papers were initiated, notably on the structure of Southeast Asian demersal fish communities, as well as software on measures of ecological stress, based on size distribution of aquatic organisms, and on a CRSP/ICLARM paper by J. McManus and Daniel Pauly, published in 1990 in "Marine Biology".

Peru module

Following the publication in 1989 of a second IMARPE/GTZ/ICLARM book on the Peruvian upwelling system, the joint activities with IMARPE were concentrated in 1990 on the elaboration of a simulation model of that system, ultimately aimed at supporting decisions concerning the development of the Peruvian pelagic fleet.

The bulk of this work was done by Dr. P. Muck, formerly of the Programa Peruano-Aleman de Investigacion Pesquera (PROCOPA) and hired for the task on the basis of a GTZ grant for the period from May 1989 to April 1990.

However, the time initially allocated for completing this model was underestimated, and a new schedule was elaborated, from 21 February to 4 March, during a visit of Dr. Muck to ICLARM Headquarters. This foresaw:

(i) continued development of the "oceanographic" and the "biological" components of model until the end of August 1990;
(ii) simultaneous development at ICLARM of a user-friendly graphic interface for these components;
(iii) presentation of items (i) and (ii) to an audience of Peruvian fisheries scientists during the FAO/DANIDA Training Course in Fish Stock Assessment held at IMARPE, 3-28 September 1990;
(iv) a visit of Dr. Muck to Dr. M. Agüero in Santiago, Chile, to advance the economic component of the model; and
(v) involvement of Ms. Astrid Jarre in the finalization of the model as a part of the work upon which her doctorate thesis, also on the Peruvian upwelling ecosystem, will be based.

The revised plan unfolded as anticipated; particularly, FAO hired Dr. Muck for one week of lecture and exercises in the frame of the training course in (iii). The software prepared by Programmer Mr. F. Gayanilo, Jr. to meet the requirement in (ii) and used at this course was, indeed, such a success that it was decided to issue it separately under the name "GEOMARPE" (Geografia del Mar Peruano) in the ICLARM Software Series in 1991 (see also Fig. 8). This is encouraging, in that it indicates that the notion of a simulation program structured around vivid representation of "living maps" would make our planned simulation model more interesting to scientists and acceptable to policymakers.

Dr. Muck's December visit to Dr. Agüero in Santiago, Chile, resulted in a marked improvement of the economic component of the model,

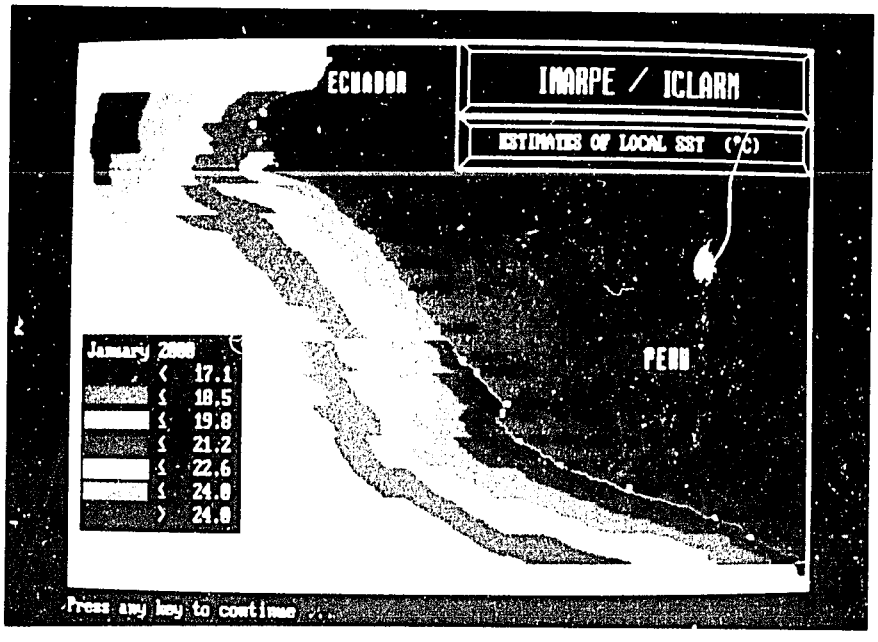


Fig. 8. Example of a screen output obtained with GEOMARPE, a program designed for displaying geographic information on the Peruvian upwelling system. This example shows the distribution of sea surface temperature in January 2000, as generated by a simulation model presently under development. Note the (cold) blue areas are optimal for the anchoveta *Engraulis ringens*.

which was presented along with "GEOMARPE" to staff of the United Nations Economic Commission for Latin America and the Caribbean where Dr. Agüero is now outposted.

It is anticipated that the involvement of Ms. Jarre in the finalization and documentation of the simulation model will begin in the first half of 1991, on the occasion of a visit to Peru, and will continue until the model is released.

Project Title	:	Socioeconomic Valuation of Coastal Resources of Southwestern Latin America
Cooperating Institutions	:	United Nations Economic Commission for Latin America and the Caribbean (ECLAC)
Duration	:	June 1990 to November 1991
Key Personnel ICLARM	:	Dr. Max Agüero

Objectives

- To identify the major processes, relationships and factors determining the dynamics of coastal resources uses;
- To identify existing data/information related to coastal resources use;
- To identify major data/information gaps and needs for monitoring, evaluation, management and modelling 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.

Mode of Operation

The project is directed by Dr. Max Agüero, who since June 1990 has been based at ECLAC, and works in collaboration with ECLAC staff, short-term consultants (both national and international) and research assistants, of whom several conduct their thesis work in the frame of the project. Also, a technical coordinator and a systems analyst participate on a full-time basis in the project to coordinate the work of the members of the research team and to prepare the computer software for the model, respectively.

Results

The coastal zone is a complex ecosystem where multiple elements interact with varying degrees of intensity and where impacts across and within sectors play an important role in the economic and social valuation of resources. Large and complex interrelated systems require, for their description, a considerable amount of information, especially on spatial and temporal distributions. Mathematical programming has proved to be an efficient and cost effective method for handling large amount of such information and for dealing with sectoral environmental and interactions.

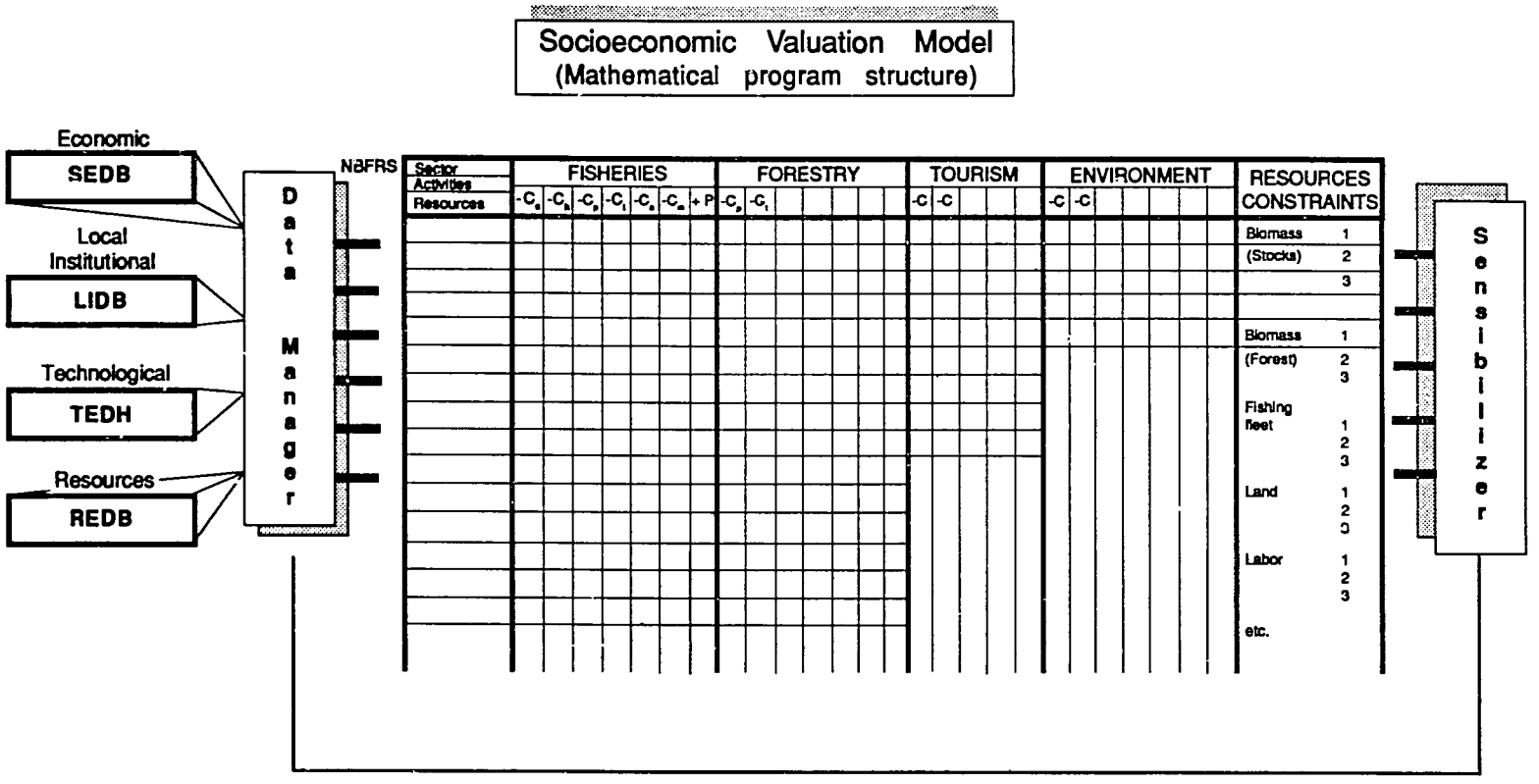


Fig. 9. Schematic representation of a socioeconomic valuation model showing the resources constraints (rows) and the sectors considered (columns).

A mathematical programming (simplex) model structured around a net benefit function from coastal resources use and exploitation has therefore been developed for the purpose of determining the economic and social value of important coastal resources and for facilitating the determination of social values (as distinct from market, i.e., observed economic values) via the computation of vector of shadow prices.

This socioeconomic valuation model requires interactive access to a set of databases especially designed to provide the necessary information on the state and dynamics of the various coastal resources, existing and alternative available technologies, socioeconomic conditions, legal and institutional constraints, and environmental impacts (Fig. 9).

In December 1990, a socioeconomic database for Region VIII of Chile, used as a case study, was completed. This provides detailed information on the economic performance of the various categories of social and economic units of the fishery, forestry and tourism sectors, with specific valuation of costs imposed on the environment.

The relevant resources, technology and legal/institutional databases have been designed and appropriate data are currently being entered.

Emphasis will be given in the finalization of the model (due in late 1991) to the development of a user-friendly interface to allow its use by non-specialized professionals and policymakers.

Project Title	:	The ICLARM Software Project
Cooperating Institutions	:	Predominantly in-house activity[a], with informal linkages with various individuals and research institutions.
Duration	:	Continuous from 1986
Key Personnel ICLARM	:	Dr. Daniel Pauly Mr. Felimon Gayanilo, Jr. Mr. Villy Christensen (from 1 February) Ms. Carmela Janagap (from 1 April) Ms. Mina Soriano (until 1 March) Ms. Astrid Jarre (until 31 July) Dr. Rainer Froese (from 1 September)

Objective

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

Results

Several new software were released in 1990; the table below lists the packages now available from the project.

Although a wide range of programs is covered by the above table, the bulk of the programming within the project, mainly by Mr. Felimon Gayanilo, Jr. working in collaboration with Dr. Pauly, was structured along two main areas:

- the development of a joint FAO-ICLARM software for length-based fish stock assessment; and
- the development of a simple geographic information system (GIS) for analysis and display of fisheries data.

Item (i), described in detail in the 1989 ICLARM Report, involves developing a new joint "shell" for and the merging of FAO's Length-Based Stock Assessment Package (LFSA) with ICLARM's Compleat ELEFAN, combined with a number of new improved routines, as described in the Project Summary, starting on p. 42. The joint package will be evaluated by an FAO staff who will visit ICLARM in early 1991. Testing and writing of the manual will be initiated in the second half of 1991 and release of the joint package, first in English and then in French and Spanish, will begin in early 1992.

Item (ii) implemented the simple GIS approach outlined on p. 44. To the end of December 1990, two systems, one for application to the coastal fisheries of Brunei Darussalam (Fig. 6) and the other, for the

[a]This was initiated by ICLARM Capture Fisheries Management Program, but will gradually involve all of ICLARM's programs.

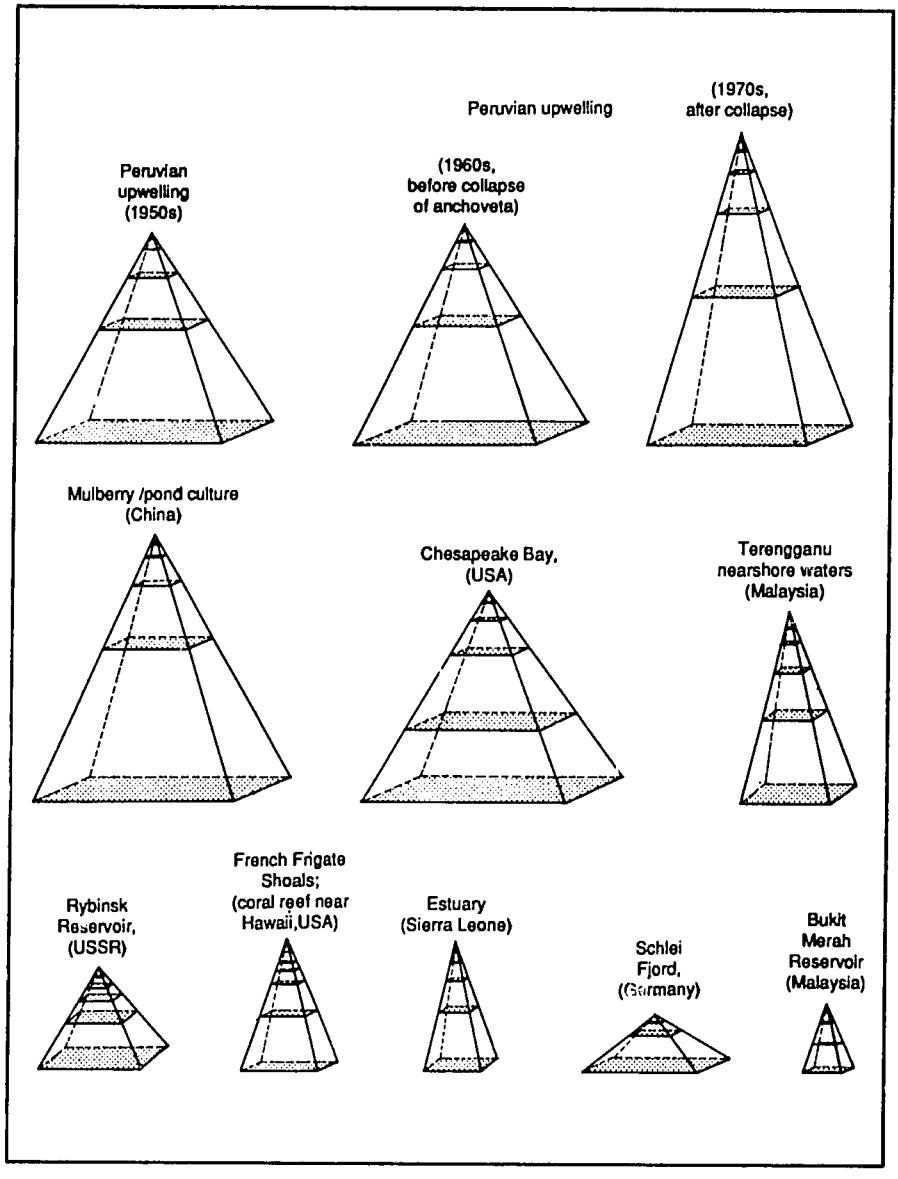


Fig. 10. A new type of trophic pyramids, developed in conjunction with the ECOPATH II software. Here, the volume within each trophic level is directly proportional to the amount of energy flowing through that level, while the topangle is inversely proportional to the mean transfer efficiency of the overall system. This new approach for the representation of flows within ecosystems allows direct comparison of systems as different as coral reefs and aquaculture ponds, as well as assessment of changes through time, as illustrated here for the Peruvian upwelling ecosystem whose overall "shape" changed radically following the collapse of the overexploited anchoveta in the early 1970s.

Peruvian upwelling system (see p. 51 and Fig. 10) were almost completed, while a third system, for the coastal fisheries of Sierra Leone in West Africa was being planned for release in 1991. It is expected that these systems will serve as a model for development of similar systems elsewhere, and indeed the programming of these systems is highly modular, allowing their easy adaptation to different areas.

Table 1. Summary of information on products of the ICLARM Software Project, as of December 1990.

ICLARM software no.	Title of manual	Month/year of release	Pages of program documentation/no. of 360 K diskettes	Number of packages shipped	Price (in US$)
1	User's Manual for the Fish Population Dynamics Plug-in Module for HP41CV Calculators	August 1987	5/n.a.	6	150
2	A Draft Guide to the Compleat ELEFAN	June 1988	65/12	350	75
3	Estimation and Comparison of Fish Growth Parameters from Pond Experiments: A Spreadsheet Solution	December 1988	3/1	40	15
4	MAXIM5: A Computer Program for Estimating the Food Consumption of Fishes from Diel Stomach Contents Data and Population Parameters	May 1990	27/2	20	20
5	CDS Assistant	May 1990	19/1	25	15
6	A Draft Guide to the ECOPATH II Program (ver. 1.0)	May 1990	22/1	53	20[b]

[a]Software for programmable calculators, not any longer supported by the project.
[b]Distributed free of cost for cooperators of the ICLARM Project "Global Comparisons of Aquatic Ecosystems".

To facilitate this and other program developments under this project, the plan has been made to use to the farthest extent possible the "C" programming languages, and the associated libraries of ready-made routines from mid-1991, and to strengthen under this project, the cooperation of the several programmers presently working in different ICLARM projects on development of various software such as ECOPATH II (see p. 59), FARMBASE (see p. 68) or FISHBASE (see p. 61).

Project Title	:	Global Comparisons of Aquatic Ecosystems
Cooperating Institution	:	Danish International Development Agency (DANIDA)
Duration	:	February 1990 to January 1992
Key Personnel ICLARM	:	Mr. Villy Christensen (since 1 February) Dr. Daniel Pauly Ms. Carmela Janagap (from 1 April) Ms. Sandra Gayosa (from 1 June) Ms. Mina Soriano (until 1 March)

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

During early 1990, the test version of ECOPATH II, a software package for construction and parametrization of steady-state trophic models of ecosystems, initially developed at ICLARM in 1986, was improved considerably and released as Version 1.0 in May 1990. Of this, over 50 copies were distributed to various scientists/groups, mainly in developing countries. As a result of this, these scientists/groups contributed some forty posters to a theme session devoted to the "Construction and Comparisons of Trophic Models of Aquatic Ecosystems" held from 4 to 9 October as a part of the annual meeting of ICES (see Fig. 3, p. 33). Few of the poster contributors had previous experience with ecosystem modelling, and their submission of posters to this theme session is thus particularly noteworthy. Also much appreciated were special travel grants from DANIDA for three of the poster presentors, Drs. Porfirio Aliño of the Marine Science Institute, University of the Philippines (see Fig. 7, p. 50), and R. Santhanam of Tamil Nadu Veterinary and Animal Sciences University, Tuticorin, India and to Ms. Maria Lourdes Palomares, formerly with ICLARM and now a doctorate student at the Ecole Nationale Supérieure d'Agronomique, Toulouse, France. The proceedings of this session, convened by Daniel Pauly and Villy Christensen, will be published in 1991 in the ICLARM Conference Proceedings Series as a copublication of ICLARM, ICES and DANIDA.

It appears that the release of ECOPATH II has helped to fill the need for readily available methods for assessing multispecies stock assemblages in the tropics (as well as for Aquaculture; see account on

FARMBASE on p. 68). The program is backed up by continuous support for the modelling efforts of various research groups on tropical/ subtropical fisheries resources. This will help the cooperating scientists, and also lead to the elaboration, by the project staff, of a comprehensive database for the global comparisons part of the project reported herein. To date, this effort has been rather successful; we have, thanks to the ECOPATH II model, now more than 50 new quantified models of aquatic ecosystems. Research work is also in progress in cooperation with leading theoretical ecologists to describe the various characteristics of energy flow in aquatic ecosystems (Fig. 10), with emphasis on the ecological implications of exploiting those systems.

Project Title		: Interactive Database on Tropical Fisheries Resources Management (FISHBASE)
Funding Institutions		: Commission of the European Communities (CEC); Food and Agriculture Organization of the United Nations (FAO)
Cooperating Institutions		: Food and Agriculture Organization of the United Nations (FAO); Institut für Meereskunde (IfM), Kiel University; Commission of the European Communities (CEC); Department of Biology, Patras University (PU)
Duration		: October 1988 to end 1992
Key Personnel	FAO	: Dr. Walter Fischer
	IfM	: Ms. Imke Achenbach
	Patras Univ.	: Ms. Christine Papasissi
	ICLARM	: Dr. Rainer Froese[a] Dr. Daniel Pauly Dr. Roger S.V. Pullin Ms. Susan Luna Ms. Crispina Binohlan Mr. Robbie Cada Mr. Dominic Tioseco

Objectives

- To develop, in cooperation with FAO and national institutions, a large biological database on marine and freshwater fishes, with emphasis on tropical and subtropical species, containing key information on nomenclature (especially as established by FAO), ecology, population dynamics, fisheries, aquaculture, genetics and diseases;
- To initiate and encourage the development of similar databases by other institutions by covering the important aquatic invertebrates, such as crustaceans and molluscs;
- To maintain and distribute the database to researchers, planners and managers in developing-country agencies and institutions.

Results

As of December 1990, substantial information on about 400 species of finfish and nomenclature and distribution for about 1,600 others have

[a]Since 1 September 1990, previously IfM.

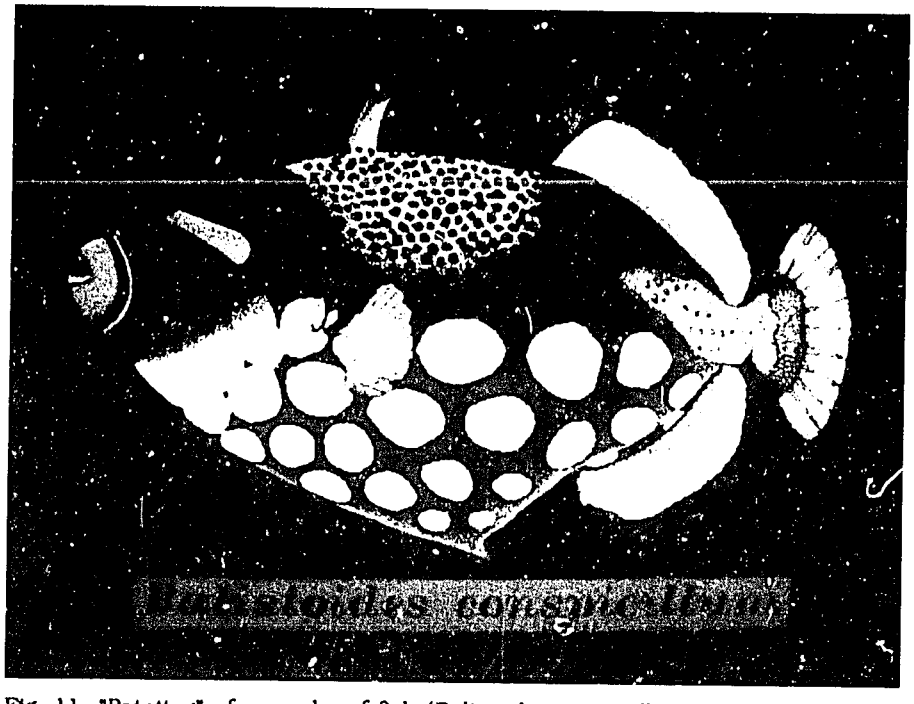


Fig. 11. "Painting" of a coral reef fish (*Balistoides conspicillum*) as incorporated in FISHBASE. Such figures are usually found only in expensive taxonomic books, often not available to developing-country libraries.

Fig. 12. Distribution of the shark mackerel (*Grammatorcynus bicarinatus*) as an example of a distribution map contained in FISHBASE.

been entered into FISHBASE (Fig. 4, p. 34). Information on the nomenclature, distribution and exploitation of about 500 crustacean species (mainly penaeid shrimps) has also been entered.

Additional funding by the CEC, starting in September 1990, allowed recruitment of Dr. Rainer Froese as FISHBASE project leader and of Mr. Robbie Cada as an artist, in charge of producing on-screen colored pictures of fish (Fig. 11) and distribution maps (Fig. 12). The grant will allow for the establishment in 1991 of three external inputting stations, one to be located in the Marine Science Institute, University of the Philippines, and two in Subsaharan Africa, probably in Malawi and Ghana. The cooperating institutions will be equipped with a computer and a two-year salary for a scientific inputter.

Ms. Imke Achenbach (IfM) has demonstrated in her master's thesis the ability of FISHBASE to diagnose fish diseases (Achenbach and Froese 1990)[a]. To date, complete descriptions of about 140 common fish diseases are contained in FISHBASE.

Ms. Christine Papasissi (PU) and Dr. Rainer Froese have demonstrated the usefulness of FISHBASE for identification of fish larvae (Froese and Papasissi 1990; Papasissi and Froese 1990). Because of their studies, complete descriptions of most fish larvae occurring in the Northeast Atlantic and in the Mediterranean are now contained in FISHBASE.

The integration of the FISHBASE project with ICLARM's Aquaculture Program involved: (i) entering information on the fishes (mainly tilapia) on which the Aquaculture Program concentrates, and (ii) first steps toward linking FISHBASE and FARMBASE, described on p. 68.

FISHBASE was presented during the 1990 Statutory Meeting of the International Council for the Exploration of the Sea (ICES) in Copenhagen. Dr. Rainer Froese was elected Chairman of a study group to: i) establish cooperation agreements between institutions in the ICES area and ICLARM on specific topics of FISHBASE, such as diseases or morphometrics, and ii) find ways to include the species of the ICES area into FISHBASE because inputting at ICLARM focuses on tropical and subtropical species. Distribution of a Beta version of FISHBASE to cooperating scientists is planned to occur at the end of 1991; FISHBASE should become generally available at the end of 1992 with annual updates.

[a] See p. 38, 39 and 40 for this and following references.

AQUACULTURE PROGRAM

Background

Aquaculture worldwide has shown respectable, even impressive, growth rates throughout the 1980s (about 5%/year overall and from 5 to 20%/year for freshwater aquaculture in a few Asian countries). These figures, however, conceal an unstable situation in which different operations wax and wane, some causing serious harm to the environment, and in which relatively small numbers of entrepreneurs, rather than the more numerous and needy small-scale farmers and coastal dwellers, take the risks and enjoy the benefits of aquaculture. There are still very few fish farmers in all developing countries compared to other types of farmers.

How can large numbers of new entrants, particularly those with low incomes, become fish farmers, confident that the risks they take will be manageable and will be outweighed by continuing benefits? Answers require thorough analyses of resources and trends not only in aquaculture but also in other related sectors (especially agriculture and fisheries) and sustained strategic research to develop appropriate fish breeds and farming systems.

Aquatic husbandry is presently based more on tradition and guesswork than on sound science. Most aquaculture enterprises therefore entail considerable risk and uncertainty. Aquaculture lags far behind agriculture in the development of well-proven breeds and farming systems. Domestication and genetic improvement of farmed aquatic organisms are only just beginning and aquatic farm environments are changing rapidly as new ideas emerge to improve breeding and feeding.

In this complex scenario of diverse needs and opportunities, ICLARM's Aquaculture Program focuses on research for the development of better breeds and better farming systems for organisms best suited to low input aquaculture by low income producers, raising produce mainly for low income consumers. This requires systems with high biological and resource use efficiency. It means working mainly on organisms that feed low in the foodchain (bivalve molluscs and herbivorous or microphagous finfish) and on simple non-intensive culture systems, particularly small fishponds.

ICLARM uses certain species groups and systems as research models (for example, herbivorous/omnivorous tilapias and carps in integrated agriculture-aquaculture) in order to devise approaches that can be applied by others to wider ranges of species and systems. This reflects the Center's long-term strategic role, complementary to the work of national institutions, which are better placed to solving farmers' problems in specific locations by disciplinary research in nutrition, pathology, reproduction and engineering.

Most of the Aquaculture Program's work in 1990 is reported below. The activities of ICLARM's Coastal Aquaculture Centre are reported separately (p. 116) as part of the South Pacific Office report.

Progress of Work

Program-wide activities

The Program's Network of Tropical Aquaculture Scientists completed its third year and continued to grow with over 450 members from 81 countries (see p. 79). There were numerous requests for its newsletter 'Aquabyte'.

Major events of the year in terms of meetings and workshops are reported below. However, one important event encompassed the whole scope of aquaculture research and development - the Bellagio Conference on Third-World Aquaculture Development and the Environment, held 17-22 September at the Rockfeller Foundation's Conference and Study Center, Bellagio, Como, Italy, with sponsorship from the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH. This was a high-level 'think-tank' on all aspects of the impact of aquaculture on the environment, ranging from aquatic pollution and genetic change in aquatic organisms to drug-resistance in fish pathogens and the public health aspects of farming fish and eating farmed aquatic produce. The proceedings and recommendations will be published by ICLARM and GTZ in 1991.

Three major publications in 1990 also included material across program themes: a large technical report, financed by the World Bank, on Reservoir Fisheries and Aquaculture Development for Resettlement in Indonesia (a case study for fisheries enhancement and management and aquaculture development in new tropical reservoirs); the summary proceedings of the ICLARM-GTZ-Malaŵi Department of Fisheries-University of Malaŵi International Conference on Aquaculture Research and Development in Rural Africa; and an ICLARM-GTZ book on the Context of Small-Scale Integrated Agriculture-Aquaculture Systems in Africa: A Case Study of Malaŵi. These last two publications contain a wealth of information on the biotechnical and sociocultural issues affecting African aquaculture development.

Program Director Dr. Roger Pullin co-edited with Dr. Peter Edwards of the Asian Institute of Technology (AIT), Bangkok, Thailand, the Proceedings of the International Seminar on Wastewater Reclamation and Reuse for Aquaculture, Calcutta, India, 6-9 December 1988. The proceedings volume entitled "Wastewater-fed Aquaculture" was published by AIT's Environmental Sanitation Information Center in 1990.

The Program continued its work on translation of key information from English to French to assist technical exchanges between Asia and francophone Africa for aquaculture research and development. This was supported by the French Ministry of Foreign Affairs (see p. 99). The major results of 1990 were the publication of a French translation by Catherine Lhomme Binudin of the ICLARM Review 'Research and Education for the Development of Integrated Crop-Livestock-Fish Farming Systems in the Tropics', and increased linkages with francophone African countries, especially Côte

d'Ivoire for the organization of the Third International Symposium on Tilapia in Aquaculture (ISTA III) (see Future Plans).

Genetics

Many working in aquaculture research and development for low-income producers and consumers have, until very recently, regarded aquaculture genetics research as being of low importance, believing that for relatively low-input, extensive or semi-intensive systems, any genetic gains would be masked by variations in farm environments. Genetic change is, however, inevitable in all aquaculture systems, particularly where the whole life cycle is closed in captivity. Even in the absence of breeding programs for genetic improvement, 'indirect' selection pressures, brought about by various management practices (breeding and harvesting strategies) lead to permanent changes in the cultured stocks.

The genetic consequences of such indirect selection pressures have been quantified for Indian carps, tilapias and freshwater prawns. Farm management practices have exerted strongly negative selection pressures on important economic traits such as growth and age at maturation. For Indian carps, the effect of 'indirect' selection on growth, exerted during routine breeding and fish seed production operations, ranges from minus 5% to minus 20% per year depending on the size of the hatcheries. For freshwater prawns and tilapias, it can be about minus 15% per year. Accumulation of inbreeding effects can be very high. Such trends bring progressively reduced performance, termed genetic deterioration.

As well as avoidance of genetic deterioration, there is large scope for genetic improvement in aquaculture. Wide genetic variance exists for important economic traits in many farmed aquatic organisms. Moreover, their high fecundity, relatively short generation times and the moderately high heritabilities estimated for some traits will facilitate high and relative rapid genetic gain.

Fortunately, the view that application of genetics in aquaculture is only worthwhile in intensive systems has now been superceded by awareness that the genetic characteristics of farmed aquatic organisms influence their performance in *all* aquaculture systems. Nevertheless, the application of genetics in aquaculture still remains at a very low level compared to its position in agriculture. Methods for the genetic improvement of farmed aquatic organisms are still being evaluated. These include:

1. additive, selective breeding (as well-proven for livestock; already used successfully to improve commercial traits in salmon; and showing early promise for improving tilapias);
2. genetic management techniques (hybridization, chromosome manipulations for polypoidy or sex control, and genetic engineering to produce 'transgenic fish'); and
3. combinations of selection and genetic management.

The technologies to be chosen for genetic improvement and the improvements to be sought (e.g., better growth, better product quality in appearance, composition, texture and taste, and disease resistance) have far-reaching social and economic consequences for low-income users who need guaranteed access at affordable prices to good 'seed' that will perform well in their current and future aquaculture systems.

Nile tilapia (*Oreochromis niloticus*).

ICLARM's Genetic Improvement of Farmed Tilapias (GIFT) project, funded by the United Nations Development Program and the Asian Development Bank (see p. 81) is the main Program activity. Nile tilapia (*Oreochromis niloticus*) is an ideal test species for studying model approaches to genetic improvement as it has a short generation time and can be bred year-round in the tropics. It is also a very important cultured fish in Africa and Asia.

In 1990, work continued under the GIFT project with Philippine and Norwegian collaborators. Following the earlier first generation trials, which compared the performance of new germplasm brought from Africa with 'Philippine' strains in different farm environments and showed large differences among strains and very low genotype x environment interaction, the second generation trials were made in 1990: a complete 8 x 8 diallele cross experiment, using 4 African and 4 'local' tilapia strains in eight low-input farm environments. Analysis of the large dataset was initiated during a Training Workshop in August. The results indicate low heterosis (<3%) and reconfirm low genotype x environment interaction. The dataset is perhaps the most complete of its kind and will help to provide guidelines for investigating important genetic parameters of farmed tilapias and approaches to be used with other species.

Collaboration continued with other groups researching fish genetics. ICLARM staff continued their technical advisory role in the collaborative tilapia genetic research project between the University College of Swansea, UK and the Freshwater Aquaculture Center of Central Luzon State University (FAC/CLSU), funded by the Overseas Development Administration (ODA),

UK. A Regional Tilapia Genetics Workshop in August was attended by Asian and African geneticists and representatives from the International Development Research Center (IDRC) of Canada, which supports an Aquaculture Genetics Network in Asia (AGNA). UNDP requested ICLARM to continue planning for increased international collaboration in finfish genetic improvement research, perhaps by means of a global network.

Integrated farming systems research

Aquaculture systems research draws upon the approaches used in farming systems research and pursues intersectoral research collaboration among agricultural, fisheries, forestry, recreation and waste management groups. There is much to learn from past mistakes, especially the widely held and persistent misconception of aquaculture as a special isolated sector, and naive and narrow views of integrated crop-fish and livestock-fish farming as simple additive systems. Building better systems requires an interdisciplinary and cross-sectoral mix of biological and social science research.

In order to design, model and test new aquaculture systems for low-income users, research is needed on the dynamics of aquaculture enterprises and of their interactions with other enterprises. Resource flows and trade-offs in terms of common 'currencies' (for example, land, water, nutrients, energy and cash itself) must be quantified so that the options for balancing and integrating aquaculture development can be evaluated within farms, communities and wider coastal and watershed areas.

The Program pursues such research mainly through outreach projects, presently in Bangladesh (p. 108) and Malaŵi (p. 93) and through an Integrated Rice-Fish Group (IRFG) (p. 101) which look at how aquaculture can fit into complete farming systems - a much broader approach than, for example, the narrow traditional view of rice-fish culture as meaning only small fish in flooded ricefields. The challenge is to generate results that will recruit new farmer entrants to integrated agriculture-aquaculture.

Outreach project teams have had considerable success in getting significant numbers of farmers (in the hundreds) to participate in trying integrated farming systems. Qualitative methods for agroecosystem maps and transects and bioresource flow models have been elaborated from these interactions with farmers. Such farmer participatory tools provide researchers with procedures that will enable large numbers of farmers to transform their existing farming systems. The Program's outreach project teams also provide results and experience to enable in-house work at ICLARM HQ on quantitative tools to capture, monitor and analyze farm system transformations. Some general methods to analyze systems performance and impact are already available. Linear and dynamic programming techniques have long been used for economic optimization. However, ICLARM has chosen to develop custom-built software interfaces (FARMBASE) between its farmer participatory tools and sophisticated analytical tools for bioeconomic and steady-state ecological modelling of integrated farming systems.

FARMBASE will provide a computerized database and analytical framework that links qualitative field methods to quantitative techniques and datasets. It will organize farm level data for ecological and bioeconomic

modelling and routine statistical analyses. It is being developed through collaboration with many groups. Work with farmers and generation of datasets is underway in Bangladesh, Malaŵi and the Philippines, in collaboration with the International Institute for Rural Reconstruction and Central Luzon State University. Next year, a new project team in Ghana (see Future Plans) will begin to interact with FARMBASE.

Programmers in ICLARM's Capture Fisheries Management Program are developing the database software and interfaces with statistical (SAS), economic (LP-88) and ecological software (ECOPATH II) (see p. 59). FARMBASE will also interface with FISHBASE (see p. 61), thus enabling users to access detailed information on the fish species used on farms. FARMBASE will be the main quantitative instrument for ICLARM's future participatory research with farmers who are new entrants to integrated aquaculture-agriculture farming systems.

Education and Training

Education and training remain an integral part of the Program's activities and are closely associated with research. The mechanisms used range from production of training materials to on-the-job training of individuals or small groups and more formalized courses for larger numbers.

For example, in the ICLARM-GTZ Malaŵi project:

- five graduate students, part-supervised by ICLARM staff, completed their master's theses in 1990, four at the University of Malaŵi and one at the Asian Institute of Technology, Bangkok, Thailand;
- a bioeconomic modelling workshop was organized to train thirteen participants in the use of appropriate software;
- seventeen research seminars were organized;
- research station 'open days' were held for fish farmers participating in the research;
- ICLARM has been invited to assist with future training in aquaculture systems research for the whole Southern African Development Coordination Conference (SADCC) subregion.

In Bangladesh, ten training courses were organized on farming systems research, aquaculture technology for small farms and data analysis for a total of 215 participants. In genetics, training was provided for two Vietnamese visiting scientists, for GIFT project personnel on data analysis and for other visitors by means of an Asian Regional Workshop.

Training books

Dr. Lightfoot and Ms. Bimbao, with assistance from Shelly Feldman, Cornell University, started work in Bangladesh on an "autotutorial" book "Household, Agroecosystems and Rural Resources Management". A draft has been prepared for a field pretest early next year. Work has also started on a training resource book for designing participatory on-farm experiments with a workshop held at Narendra Deva University of Agriculture and Technology (NDUAT) in eastern India. The book is a collaborative effort between ICLARM, the International Rice Research Institute (IRRI) and NDUAT.

Advisory Services and Other Activities

As in previous years, Program staff performed a wide range of services for external agencies including editorial services for primary scientific journals, reviewing of grant proposals (for example, for the International Foundation for Science) and responding to requests for information on sources of tilapia germplasm and more general enquiries, largely from developing countries. The most numerous enquiries came from Nigeria.

In addition, Dr. Pullin continued to assist the panel advising the UNDP Sepik River Fish Stock Enhancement Project in Papua New Guinea and has been asked to visit there to assess the current status of introduced common carp stocks. Dr. Pullin also acted as the ICLARM contact person for IUCN and worked closely with its Species Survival Commission and Fish Specialist Group, including a first meeting with IUCN officials in Copenhagen in August.

Dr. Lightfoot was a prominent member of the organizing committee of the First Asian Farming Systems Research and Extension Symposium held in Bangkok, Thailand, 19-22 November.

Program staff assisted the Philippine Department of Agriculture in discussions concerning the implementation of a large Fisheries Sector Program loan to the Philippines from the Asian Development Bank.

Program Plans

In mid-1991, two new projects will start in Ghana, both of two years duration with the Institute of Aquatic Biology (IAB), Accra, and funded by Germany as ICLARM-GTZ projects. One will take a broad look at the prospects for inland aquaculture development in Ghana, focusing in particular on the systems that might be appropriate for adoption by small-scale farmers. The results will be of importance not only for Ghana but as a pattern for application in other countries. The same applies to the other project which will involve IAB and the University of Hamburg and will work on methods, approaches and policies for the documentation and conservation of the freshwater fish genetic resources of Ghana, principally the tilapias.

The work of the Integrated Rice-Fish Group will also be extended in 1991 with a new project in Vietnam in collaboration with the University of Cantho.

The most important meeting of 1991 will be the Third International Symposium on Tilapia in Aquaculture (ISTA III), co-organized by the Centre de Recherches Océanographiques (CRO), Abidjan, Côte d'Ivoire, and ICLARM, planned for 11-16 November in Abidjan. Over 200 participants from 50 countries are expected and over 100 Abstracts have been submitted. The Organizing Committee has representatives from CTFT (Centre Technique Forestier Tropical), IDESSA (Institut des Savanes) and ORSTOM (Institut Français de Recherche Scientifique pour le Développement en Coopération) in addition to CRO and ICLARM.

ICLARM will sign a new Memorandum of Understanding with the International Institute for Rural Reconstruction (IIRR) and the two institutions will convene in late 1991 an Asian Regional Workshop on Proven Integrated Agriculture-Aquaculture Technologies at the IIRR station at Silang, Cavite, Philippines.

GTZ has indicated that the ICLARM-GTZ Malaŵi project will receive funding up to 1994. Research and training will be continued there and a new Research Scientist hired from August 1991.

At Manila HQ, DANIDA will provide the services of a new staff member (Farming Systems Researcher) from mid-1991.

On genetic research, the GIFT project will continue under UNDP funding. A workshop on the Genetic Resources of Asian Carps is planned for late 1991 or early 1992 in collaboration with the Asian Wetland Bureau, IDRC and the International Union for the Conservation of Nature (IUCN). The venue and dates have not yet been finalized. All the GIFT project scientific personnel will participate in the International Symposium on Genetics in Aquaculture, 29 April-3 May 1991, in Wuhan, China, and will present some of the project's important findings.

These future activities, together with continuation of the Network of Tropical Aquaculture Scientists (NTAS), linkages with francophone Africa, and the expanding activities of the Coastal Aquaculture Centre (see p. 116) will constitute an increased workload for Program staff, especially at this time when ICLARM is engaged on strategic planning work for its entry into the Consultative Group on International Agricultural Research (CGIAR). By 1992, ICLARM's transition into the CGIAR will be underway and this will bring changes to the Program, probably a move towards more core research and fewer new project starts until the staff can be expanded. However, the commitment of current donors to 'cornerstone' projects such as the GIFT project and farming systems activities in Africa (Malaŵi/Ghana) and Asia (Bangladesh/IRFG) will enable these to continue during ICLARM's entry into the CGIAR and will thereafter provide some of the elements needed for longer-term future research partnerships and networks.

Meetings Attended, Papers Presented

Seminar at the Central Institute for Freshwater Aquaculture, Bhubaneshwar, Orissa, India, 29 January. (B.A. Costa-Pierce, M.V. Gupta).
Paper presented:
Costa-Pierce, B.A. Capture and culture fisheries development in the Saguling Reservoir, Indonesia: lessons for Orissa.

Research Design Workshop, Narendra Deva University of Agriculture and Technology, Faizabad, India, 13-17 February. (C. Lightfoot).
Paper presented:
Lightfoot, C. Tools for farmer participation in on-farm experiments.

Meeting of the Aquaculture Society of Mauritius, Port Louis, Mauritius, 1 March. (B.A. Costa-Pierce).
Paper presented:
Costa-Pierce, B.A. ICLARM and south-south technology transfer: Asia and Africa.

Managing ASEAN's Coastal Resources for Sustainable Development, Manila and Baguio, Philippines, 4-7 March. (A.E. Eknath and R.S.V. Pullin).

Globe '90, Vancouver, British Columbia, Canada, 19-23 March. (J.L. Munro).

ICLARM-GTZ, Malaŵi Fisheries Department and University of Malaŵi International Conference on Aquaculture Research and Development in Rural Africa, Chancellor College, Zomba, Malaŵi, 2-6 April. (J.D.

Balarin, F.J.K.T. Chikafumbwa, S. Chimatiro, B.A. Costa-Pierce, D. Jamu, C. Jenya, W.K. Kadongola, E.K.W.H. Kaunda, C. Lightfoot, A.O. Maluwa, R.S.V. Pullin, A.A. van Dam).

Papers presented:

Balarin, J.D., B.A. Costa-Pierce and F.J.K.T. Chikafumbwa. Combinations of on-farm resources (napier grass, maize bran, and wood ash), urea and stirring for small-scale aquaculture.

Chikafumbwa, F.J.K.T., W. Kadongola, D.M. Jamu, J.D. Balarin and B.A. Costa-Pierce. Use of napier grass (*Pennisetum purpureum*) and maize bran (*madeya*) for small-scale aquaculture in Malaŵi.

Chiotha, S.S. and C. Jenya. The potential of fishponds in bilharzia (schistosomiasis) transmission.

Costa-Pierce, B.A. Some impacts of manual pond stirring on aquaculture ponds in Malaŵi.

Jamu, D.M. Ash as a liming agent in fishponds.

Kadongola, W.K. Effects of different feeding rates of maize bran (*madeya*) on *Oreochromis shiranus* and *Tilapia rendalli* juveniles in polyculture.

Kapeleta, M.V., B.A. Costa-Pierce and A.A. van Dam. Multivariate analysis of *Tilapia rendalli* growth as affected by water quality changes and inputs (napier grass, wood ash, maize bran) in aquaculture ponds in Malaŵi.

Kaunda, E.K.W.H. Relative performance of alternative fishpond harvesting techniques in Malaŵi.

Lightfoot, C. Participatory methods for integrating agriculture and aquaculture: examples of farmers' experiments in rice-fish integrated farming.

Maluwa, A.O. Fry production of *Oreochromis shiranus* in hapas.

Noble, R.P. and S. Chimatiro. The status of fish farming in Zomba District.

Noble, R.P. and S. Chimatiro. On-farm biotic resources for small-scale fish farming in Malaŵi.

van Dam, A.A. Why ANOVA is not very effective in analyzing pond experiments.

EIFAC/FAO Symposium on Production Enhancement in Still Water Pond Culture, Prague, Czechoslovakia, 15-18 May. (A.A. van Dam).

Paper presented:

van Dam, A.A. Modeling of aquaculture pond dynamics.

First Consultative Meeting of Fishery Scientists/Experts on the National Fisheries Research Program, Asian Institute of Tourism, Diliman, Quezon City, Philippines, 30-31 May. (R.S.V. Pullin).

ICLARM and the Rural African Farmer, University of Malaŵi, Zomba, Malaŵi, 1 June. (R.P. Noble).

World Aquaculture Society Meeting, Halifax, Nova Scotia, Canada, 10-14 June. (B.A. Costa-Pierce, C.R. dela Cruz).

Papers presented:

Costa-Pierce, B.A. Aquaculture development for resettlement in Indonesia: farmer participatory extension, training and institutional roles.

Costa-Pierce, B.A. Development of smallholder aquaculture in Malaŵi: the program of the International Center for Living Aquatic Resources Management (ICLARM).

dela Cruz, C.R., C. Lightfoot and R.C. Sevilleja. User perspectives on rice-fish systems in the Philippines.

Farming Systems Approaches to Aquaculture Development, Mzuzu, Malaŵi, 14 June. (R.P. Noble).

Integrated Agriculture Seminar at Goddard College, Plainfield, Vermont, USA, 29 June. (B.A. Costa-Pierce).

Paper presented:

Costa-Pierce, B.A. ICLARM's approach to rural development in Malaŵi, Africa.

4th World Congress on Genetics Applied to Livestock Production, Edinburgh, Scotland, 23-27 July. (A.E. Eknath).

Paper presented:

Eknath, A.E. Developing a national breeding program for tilapia.

First National Aquaculture Coordination Meeting, Lilongwe, Malaŵi, 24 July. (A.A. van Dam, R.P. Noble).

Asian Regional Workshop on Tilapia Genetics: Present Progress, Future Directions and Needs in Fish Genetics with Emphasis on Tilapias,

Muñoz, Nueva Ecija, Philippines, 29-31 August. (B.O. Acosta, M.P. Bimbao, A.E. Eknath, M.P. de Vera, R.S.V. Pullin, R.R. Velasco).

Papers presented:

Bimbao, M.P. and M. Ahmed. Market potential of tilapia in the Philippines: an assessment.

de Vera, M.P. Application of anaesthetics and tagging of tilapia stocks.

Eknath, A.E. Genetic improvement of farmed tilapias: evaluation of strains.

Eknath, A.E. Genetic improvement of farmed tilapias: project objectives, activities and plans.

Gjerde, B. and A.E. Eknath. National breeding programs.

Aquaculture International, Vancouver, British Columbia, Canada, 3-7 September. (M. Gervis).

Gender and Farming Systems Meeting, Joydebpur, Bangladesh, 11-14 September. (M. Ahmed, M.P. Bimbao, M.V. Gupta, C. Lightfoot).

Bellagio Conference on Third-World Aquaculture Development and the Environment, Bellagio, Como, Italy, 17-22 September. (J.L. Munro and R.S.V. Pullin).

Papers presented:

Munro, J.L. Aquaculture development and environmental issues in the tropical Pacific.

Pullin, R.S.V. An overview of environmental issues in third-world aquaculture development.

Second National Aquaculture Coordination Meeting, Lilongwe, Malaŵi, 2-3 October. (B.A. Costa-Pierce, A.A. van Dam).

78th Statutory Meeting of the International Council for the Exploration of the Sea (ICES), Copenhagen, Denmark, 4-9 October.

Papers presented:

van Dam, A.A., F. Chikafumbwa, D.M. Jamu and B.A. Costa-Pierce. Trophic interactions in a napier grass (*Pennisetum purpureum*)-fed aquaculture pond in Malaŵi.

Lightfoot, C., P.A. Roger, A.G. Cagauan and C.R. dela Cruz. Preliminary steady-state nitrogen models of a wetland ricefield ecosystem with and without fish.

10th Annual Asian Farming Systems Research and Extension Symposium on The Role of Farmers in FSRE and Sustainable Agriculture, Michigan State University, USA, 14-17 October. (C. Lightfoot).

Posters presented:

Bimbao, M.P. and R.S.V. Pullin. The NTAS: a network of researchers interested in integrated agriculture-aquaculture farming systems.

Lightfoot, C. and R.P. Noble. Pictorial modelling: a farmer participatory method for modelling bioresource flows in farming systems.

Paper presented:

Lightfoot, C. and D.R. Minnick. Farmer-first qualitative methods: farmers' diagrams for improving methods of experimental design in integrated farming systems.

Second Asian Reservoir Fisheries Workshop, Hangzhou, China, 15-19 October. (B.A. Costa-Pierce).

Paper presented:

Costa-Pierce, B.A. Multiple regression analysis of plankton and water quality relationships as affected by sewage inputs and cage aquaculture in a eutrophic tropical reservoir.

Asian Training on Research Diagnostic Tools for Farm and Household Analysis: Hands-on Training of Trainers, Los Baños, Laguna, Philippines, 11-17 November. (M.P. Bimbao, C. Lightfoot)

Paper presented:

Lightfoot, C. Participatory methods for ecologically sound agriculture. Training notes prepared for farm and household analysis. User's perspective with agricultural research and development.

Asian Farming Systems Research and Extension Symposium, Asian Institute of Technology, Bangkok, Thailand, 19-21 November. (C.R. dela Cruz, C. Lightfoot, M.V. Gupta, R.S.V. Pullin).

Poster presented:

Bimbao, M.P. and R.S.V. Pullin. The NTAS: a network of researchers interested in integrated aquaculture-agriculture farming systems.

Paper presented:

Lightfoot, C. and R.S.V. Pullin. Why Asia needs qualitative methods for integrating agriculture with aquaculture.

Publications and Consultancy Reports

Agüero, M. and M. Ahmed. 1990. Economic rationalization of fisheries exploitation through management: experiences from the open-water inland fisheries management in Bangladesh, p. 747-750. *In* R. Hirano and I. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Bimbao, M.P. and R.S.V. Pullin. 1990. The Network of Tropical Aquaculture Scientists: information exchange among tropical aquaculture scientists. Aquabyte 3(1): 4-6.

Bimbao, M.P., A.V. Cruz and I.R. Smith. 1990. An economic assessment of rice-fish culture in the Philippines, p. 241-244. *In* R. Hirano and K. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Chikafumbwa, F.J.K.T. 1990. Studies on napier grass (*Pennisetum purpureum*) as a pond input for the culture of *Tilapia rendalli* and *Oreochromis shiranus*. University of Malaŵi, Zomba, Malaŵi. 177 p. M.Sc. thesis.

Costa-Pierce, B.A. 1990. Water quality research or water quality checking: proposed guidelines. Aquabyte 3(3):2-4.

Costa-Pierce, B.A. and M.V. Gupta. 1990. Feasibility of resettlement aquaculture in Orissa State, India. Findings of a World Bank Consultancy Mission, 24 January-10 February 1990. 14 p.

Costa-Pierce, B.A. and H.Y. Hadikusumah. 1990. Research on cage aquaculture systems in the Saguiing Reservoir, West Java, Indonesia, p. 112-217. *In* B.A. Costa-Pierce and O. Soemarwoto (eds.) Reservoir fisheries and aquaculture development for resettlement in Indonesia. ICLARM Tech. Rep. 23, 378 p.

Costa-Pierce, B.A. and C.M. Roem. 1990. Waste production and efficiency of feed use in floating net cages in a eutrophic tropical reservoir, p. 257-271. *In* B.A. Costa-Pierce and O. Soemarwoto (eds.) Reservoir fisheries and aquaculture development for resettlement in Indonesia. ICLARM Tech. Rep. 23, 378 p.

Costa-Pierce, B.A. and O. Soemarwoto, Editors. 1990. Reservoir fisheries and aquaculture development for resettlement in Indonesia. ICLARM Tech. Rep. 23, 378 p. Perusahaan Umum Listrik Negara, Jakarta, Indonesia; Institute of Ecology, Padjadjaran University, Bandung, Indonesia; and ICLARM, Manila, Philippines.

Costa-Pierce, B.A. and O. Soemarwoto. 1990. Biotechnical feasibility studies on the importation of *Clupeichthys aesarnensis* Wongratana, 1983 from northeastern Thailand to the Saguling Reservoir, West Java, Indonesia, p. 329-363. *In* B.A. Costa-Pierce and O. Soemarwoto (eds.) Reservoir fisheries and aquaculture development for resettlement in Indonesia. ICLARM Tech. Rep. 23, 378 p.

Costa-Pierce, B.A., C. Lightfoot, K. Ruddle and R.S.V. Pullin, Editors. 1990. Aquaculture research and development in rural Africa: summary report of the ICLARM/GTZ-Malaŵi Department of Fisheries-University of Malaŵi Conference, Zomba, Malaŵi, 2-6 April 1990. ICLARM Conf. Proc. 27. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), GmbH, Eschborn, Federal Republic of Germany; and ICLARM, Manila, Philippines.

Costa-Pierce, B.A., B. Sudiarto, O. Soemarwoto and C.R. dela Cruz. 1990. Improved traditional hatchery technology for common carp (*Cyprinus*

carpio L.) in West Java, Indonesia, p. 217-220. *In* R. Hirano and K. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

dela Cruz, C.R. 1990. Fish culture trials in rice fields in North Sumatra, Indonesia, p. 141-144. *In* R. Hirano and K. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

dela Cruz, C.R. 1990. The pond refuge in rice-fish systems. Aquabyte 3(2): 6-7.

Edwards, P. and R.S.V. Pullin, Editors. 1990. Wastewater-fed aquaculture. Proceedings of the International Seminar on Wastewater Reclamation and Reuse for Aquaculture, Calcutta, India, 6-9 December 1988. Environmental Sanitation Information Center, Asian Institute of Technology, Bangkok, Thailand. 302 p.

Edwards, P., R.S.V. Pullin and J.A. Gartner. 1988. Recherche et formation pour l'expansion des systèmes d'exploitation tropicale intégrant l'agriculture, l'élevage et la pisciculture. ICLARM Stud. Rev. 16. French translation by Catherine Lhomme Binudin, 1990.

Eknath, A.E. 1990. A review of carp genetic research and possible approaches to genetic improvement of Asian carps, p. 473-476. *In* R. Hirano and K. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Eknath, A.E. and R.W. Doyle. 1990. Effective population size and rate of inbreeding in aquaculture of Indian major carps. Aquaculture 85: 293-305.

Eknath, A.E. and R.W. Doyle. 1990. Repeatability of relative size of individuals under communal stocking: implications for size-grading in aquaculture, p. 45-48. *In* R. Hirano and K. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Gupta, M.V. 1990. Role of aquaculture in the farming system of Bangladesh, p. 20-29. *In* M.V. Gupta (ed.) Trainer's training on aquaculture technologies to fisheries extension officers, 21-26 May 1990. Fisheries Research Institute, Mymensingh, Bangladesh.

Gupta, M.V. 1990. Rural women in aquaculture. Naga, ICLARM Q. 13(3): 8.

Gupta, M.V., Editor. 1990. Trainer's training on aquaculture technologies to fisheries extension officers, 21-26 May 1990. Fisheries Research Institute, Mymensingh, Bangladesh.

Jamu, D.M. 1990. Studies on ash as a liming agent in fishponds. University of Malaŵi, Zomba, Malaŵi. 193 p. M.Sc. thesis.

Kadongola, W.K. 1990. Maize (*Zea mays*) bran as a supplemental feed in the culture of *Tilapia rendalli* and *Oreochromis niloticus*. University of Malaŵi, Zomba, Malaŵi. 177 p. M.Sc. thesis.

Lightfoot, C. 1990. Agroecosystems mapping: a tool for sustainable agriculture workers, p. 176-173. *In* L.N. Capistrano, J. Durno and I. Moeliono (eds.) Resource book on sustainable agriculture for the uplands. International Institute of Rural Reconstruction, Silang, Cavite, Philippines.

Lightfoot, C. 1990. Integrated route to sustainable farming. International Agriculture Development 10(2): 9-11.

Lightfoot, C. 1990. Integration of aquaculture and agriculture: a route to sustainable farming systems. Naga, ICLARM Q. 13(1): 9-12. (Reprinted

in Eastern India Farming Systems Research and Extension Newsletter 4(3): 15-18; AFSRE, Association for Farming Systems Research-Extension Newsletter 1(1): 6-9; and ODI Agricultural Administration (Research and Extension) Network Newsletter No. 23(December 1990): 27-34.)

Lightfoot, C. 1990. Participatory methods for ecologically sound agriculture, p. 15-30. *In* R.E. Rhoades, V.N. Sandoval and C.P. Bagalanon (eds.) Asian training of trainors on farm household diagnostic skills. International Potato Center, Lima, Peru.

Lightfoot, C. and Nguyen Anh Tuan. 1990. Drawing pictures of integrated farms helps everyone: an example from Vietnam. Aquabyte 3(2): 5-6. (Reprinted in Information Centre for Low External Input and Sustainable Agriculture Newsletter 6(3): 18-19).

Lightfoot, C., C.R. dela Cruz and V.R. Carangal. 1990. International research collaboration in rice-fish research. Naga, ICLARM Q. 13(4): 10-11.

Lightfoot, C., P.A. Roger, A.G. Cagauan and C.R. dela Cruz. 1990. A fish crop may improve rice yields and ricefields. Naga, ICLARM Q. 13(4): 12-13.

Lightfoot, C., V.P. Singh, T. Paris, P. Mishra and A. Salman. 1990. Training resource book for farming systems diagnosis. International Rice Research Institute, Los Baños, Philippines; and ICLARM, Manila, Philippines.

Maluwa, A.O. 1990. Reproductive biology and fry production of *Oreochromis shiranus*. University of Malaŵi, Zomba, Malaŵi. 180 p. M.Sc. thesis.

Munro, J.L., Iskandar and B.A. Costa-Pierce. 1990. Fisheries of the Saguling Reservoir and a preliminary appraisal of management options, p. 285-328. *In* B.A. Costa-Pierce and O. Soemarwoto (eds.) Reservoir fisheries and aquaculture development for resettlement in Indonesia. ICLARM Tech. Rep. 23, 378 p.

Noble, R.P. and B. Rashidi. 1990. Aquaculture technology transfer to smallholder farmers in Malaŵi, Southern Africa. Naga, ICLARM Q. 13(4): 14-16.

Noble, R.P. and W.K. Kadongola. 1990. Smallholder farmers in Malaŵi adopt and improve technologies from collaborative research. Aquabyte 3(3): 7-8.

Pullin, R.S.V. 1990. Down-to-earth thoughts on conserving aquatic genetic diversity. Naga, ICLARM Q. 13(1): 5-8.

Soemarwoto, O., C. Roem, T. Herawati and B.A. Costa-Pierce. 1990. Water quality suitability of the Saguling and Cirata Reservoirs for floating net cage aquaculture, p. 18-111. *In* B.A. Costa-Pierce and O. Soemarwoto (eds.) Reservoir fisheries and aquaculture development for resettlement in Indonesia. ICLARM Tech. Rep. 23, 378 p.

Sudiarto, B., B. Zakaria and B.A. Costa-Pierce. 1990. Use of earthworm composts and introduction of new systems and techniques to improve production in hatcheries and nurseries for common carp (*Cyprinus carpio*), p. 272-284. *In* B.A. Costa-Pierce and O. Soemarwoto (eds.) Reservoir fisheries and aquaculture development for resettlement in Indonesia. ICLARM Tech. Rep. 23, 378 p.

van Dam, A.A. 1990. Is ANOVA powerful enough for analyzing replicated pond experiments? Aquabyte 3(3): 3-5.

van Dam, A.A. 1990. Multiple regression analysis of accumulated data from aquaculture experiments: a rice-fish culture example. Aquacult. Fish. Manage. 21(2): 1-15.

Zainal, S., B.A. Costa-Pierce, Iskandar, Rusydi and H. Hadikusumah. 1990. Aquaculture resettlement option in the Saguling Reservoir, Indonesia: its contribution to an environmentally-oriented hydropower project, p. 253-258. *In* R. Hirano and K. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. 991 p.

Some of the Aquaculture program staff with Kenneth Tod MacKay (Director General designate), Jay L. Maclean (Director, Information Program) and Rainer Froese (FISHBASE Project). *Seated from left:* Josephine B. Capili (Research Associate I, GIFT Project), Catherine Lhomme Binudin (Project Officer, Technical Cooperation with Francophone countries), Ravelina R. Velasco (Research Assistant), Belen O. Acosta (Program Assistant/Biologist), Marissa W. Manela (Secretary), Mary Ann P. Bimbao (Program Assistant/Economist) and Emma M. del Rosario (Secretary). *Standing from left:* Mahfuzzudin Ahmed (Technical Coordinator, Bangladesh Project), Barry A. Costa-Pierce (Project Director, Africa Aquaculture Project), Edwin de Guzman (Research Assistant, DBase Management and Programming), Anne A. van Dam (Associate Expert, Africa Aquaculture Project), Catalino R. dela Cruz (Project Leader, Rice-Fish Farming Project), Joe Nicolas (Junior Economist), Clive Lightfoot (Farming Systems Specialist), Jay L. Maclean, Roger S.V. Pullin (Director Aquaculture Program), Kenneth Tod MacKay, Rainer Froese, Modadugu V. Gupta (Aquaculture Specialist, Bangladesh Project) and Ambekar E. Eknath (Associate Scientist I, GIFT Project).

Aquaculture Program Project Summaries

Project Title : Network of Tropical Aquaculture Scientists (NTAS)

Duration : Continuous from July 1987

Key Personnel ICLARM : Ms. Mary Ann P. Bimbao (Network Secretary)
: Dr. Roger S.V. 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 a newsletter at regular intervals.

Results

The NTAS now links together 456 scientists who are actively involved in tropical aquaculture research. The regional distribution of NTAS members representing 81 countries is shown in Fig. 1. The Network continues to provide free services to members: publishing and distributing the newsletter, Aquabyte; and answering numerous requests for literature searches, reprints and reference materials needed for their aquaculture research. Increased interest of members was evident with more letters received and contributions submitted for Aquabyte. Three issues of Aquabyte were published this year. Fisheries and aquaculture research institutions receiving Aquabyte increased in number to 111 in 35 countries.

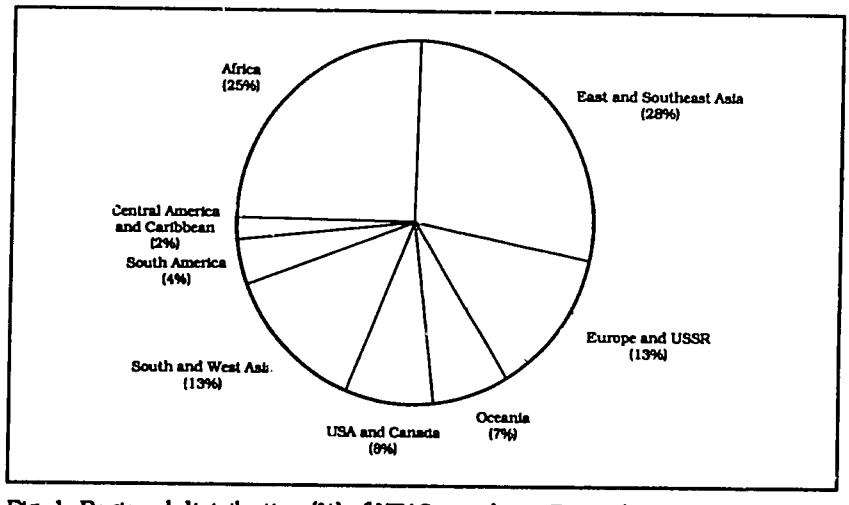


Fig. 1. Regional distribution (%) of NTAS members, December 1990.

A poster paper entitled, "The NTAS: a network of researchers interested in integrated aquaculture-agriculture farming systems", was presented at two international symposia sponsored by the Association of Farming Systems Research and Extension (AFSRE). One was presented by Dr. Clive Lightfoot at the 10th AFSRE Symposium on The Role of Farmers in FSRE and Sustainable Agriculture, East Lansing, Michigan, USA, 17-19 October; the other, by Dr. Catalino R. dela Cruz at the 1990 AFSRE Symposium on Sustainable Farming Systems in 21st Century Asia, Bangkok, Thailand, 19-22 November.

Project Title		: Genetic Improvement of Farmed Tilapias (GIFT)
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); the Asian Development Bank (ADB); and the United Nations Development Programme-Division for Global and Interregional Projects (UNDP/DGIP).
Duration		: 1988 to 1991
Key Personnel	NFFTRC/ BFAR	: Mr. Melchor Tayamen; Mr. Ruben Reyes; Mr. Marlon Reyes; Ms. Jodecel Danting; Ms. Edna Dionisio; Ms. Felicisima Longalong; Ms. Teresita Gonzales; 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 c. La Trinidad Fish Farm, Benguet – Mr. Jesus Astrero
	FAC/ CLSU	: Mr. Tereso A. Abella[1]; Mr. Antonio V. Circa; Mr. Hernando Bolivar; Ms. Remedios Bolivar
	UPMSI	: Dr. Julie M. Macaranas; Ms. Maria-Josefa R. Pante[2]; Ms. Carmen Ablan; Ms. Liza Agustin

[1]Currently studying for a Ph.D. at the University College of Swansea, Wales, UK.
[2]Joined GIFT project in October 1990 after completion of master's degree from the University of Houston at Clear Lake, USA.

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

ICLARM : Dr. Ambekar E. Eknath; Dr. Roger S.V. Pullin; Ms. Ravelina R. Velasco; Ms. Marietta P. de Vera; Ms. Josephine B. Capili[3]; Ms. Belen O. Acosta

Objectives

The project focuses on Nile tilapia (*Oreochromis niloticus*), a species with great immediate potential for aquaculture in Asia and elsewhere.

The primary objectives are to produce better breeds by selection for high growth rate and other economically important traits as and when appropriate and to provide such fish to national and regional testing programs and from thence to fish farmers. This will be accomplished with the following specific and sequential objectives:

- Documentation of tilapia genetic resources in Asia and Africa and establishment of a collection of promising strains from new importations from Africa and from existing Asian cultured stocks.
- Evaluation of new African germplasm along with existing cultured stocks in the Philippines in different culture systems and under various agroclimatic conditions.
- Selective breeding using promising strains and strain crosses (base population).
- Distribution of genetically-improved fish through national broodstock distribution channels and testing programs and finally to fish farmers.
- Dissemination of information and training of personnel from various national and regional institutions, through a series of training workshops and regional workshops.
- Formulation of plans and policy guidelines for effective genetic management of cultured stocks and establishment of national breeding programs.
- Defining methods and approaches to fish genetic improvement from this work with tilapia for application to other species.

Results

The year 1990 has been a momentous year for the GIFT project. The severe earthquake that affected Luzon on 16 July resulted in only minor damage to the project facilities and did not seriously interrupt the experiments in progress.

The major tasks of determining the magnitude of genotype x environment interaction in different farming systems, and of non-additive genetic effects when all possible crosses were made among eight test strains, were successfully accomplished. Low genotype x environment interaction and

[3]Joined GIFT project December 1990 after completion of master's degree from the University College of Swansea, Wales, UK.

low heterosis levels (less than 3%) suggest that a simple additive breeding program, commencing with a base population composed of best performing purebreds and crossbreds, is probably the best approach to genetic improvement in Nile tilapia (*Oreochromis niloticus*) in the Philippines.

The datasets generated were too large to be handled efficiently by the project's microcomputers installed in the collaborating institutions. Reallocation of some of the UNDP/DGIP budget enabled the project to upgrade the existing computers, purchase two additional computers for the explicit purpose of training project personnel, and recruit a research assistant to train project personnel in database management. The OS/2 version of the statistical package SAS has been installed.

Personnel

Following successful completion of their master's degrees, Ms. J.B. Capili (ICLARM) and Ms. M.J.R. Pante (UPMSI), joined the project. Ms. Capili will initiate baseline studies on current broodstock management practices of small-scale fish farmers in preparation for on-farm testing of improved fish breeds. Ms. Pante will help in the UPMSI component of the project.

Mr. T. Abella (FAC/CLSU) registered as a Ph. D. candidate at the University College of Swansea, Wales, UK. He was replaced by Ms. R. Bolivar as the designated research leader at FAC/CLSU.

Genetic Characterization of Strains

At UPMSI, genetic characterization of strains continued, including for the first time work on the Lake Turkana (Kenya) germplasm, shipped to the Philippines in August 1989, using isozyme and morphometric markers.

Isozyme analysis: Progeny from the eight test strains, four African (Egypt, Ghana, Kenya and Sénégal) and four Philippine strains (locally known as 'Israel', 'Singapore', 'Taiwan' and 'Thailand') were analyzed at 30 loci. All strains shared alleles at 14 monomorphic and 16 variable loci. Among African strains, characteristic allele frequency differences were observed at Aat-1, Adh, G3pdh-2, Mdh-1 and Sod loci. A dendrogram (Fig. 1) constructed from Nei's Genetic Distance (D) values revealed: (1) a clustering of the Philippine strains with Egypt and Ghana; (2) a distinct separation of the Sénégal strain; and (3) a larger separation of both groups from the Kenya strain confirming its recognition by Dr. E. Trewavas as a different subspecies. Observed heterozygosity values ranged from .027 to .076.

Morphometric analysis. A truss network of 21 landmark points (Fig. 2) on the body outline was set up using a digitizing tablet linked to a microcomputer. A computer program 'Computer Aided Monoscopic Analysis' (CAMA) was developed to calculate the coordinates for these landmark points. Principal Component Analysis (PCA) was performed using SAS. The first two components accounted for 91.6% of the variation. The first principal component (PC1), a measure of overall size, accounted for 88% of the variation. All 21 characters load positively on PC1. The second component (PC2) explained 3.5% of the variation. Regression was performed on the 21

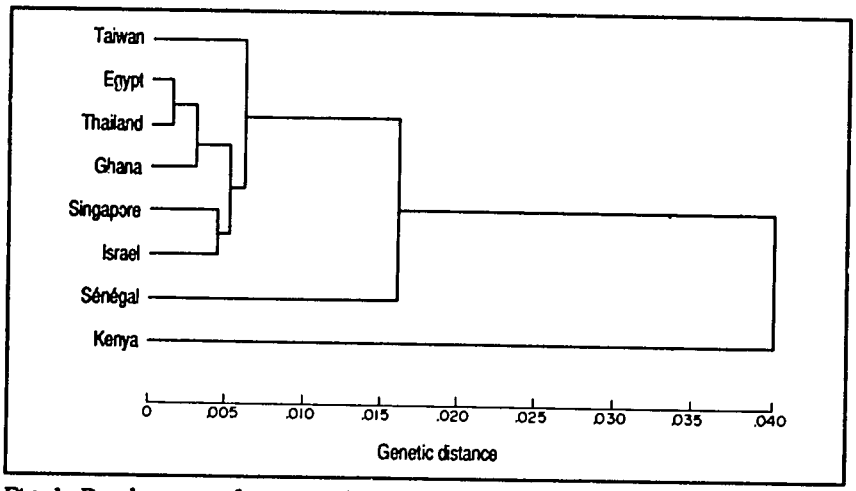


Fig. 1. Dendrogram of strains of Nile tilapia (*Oreochromis niloticus*) constructed from Nei's Genetic Distance values shows three separable groups - a cluster of 'Philippine' strains with Egypt and Ghana strains; Sénégal strain; and the Kenya strain.

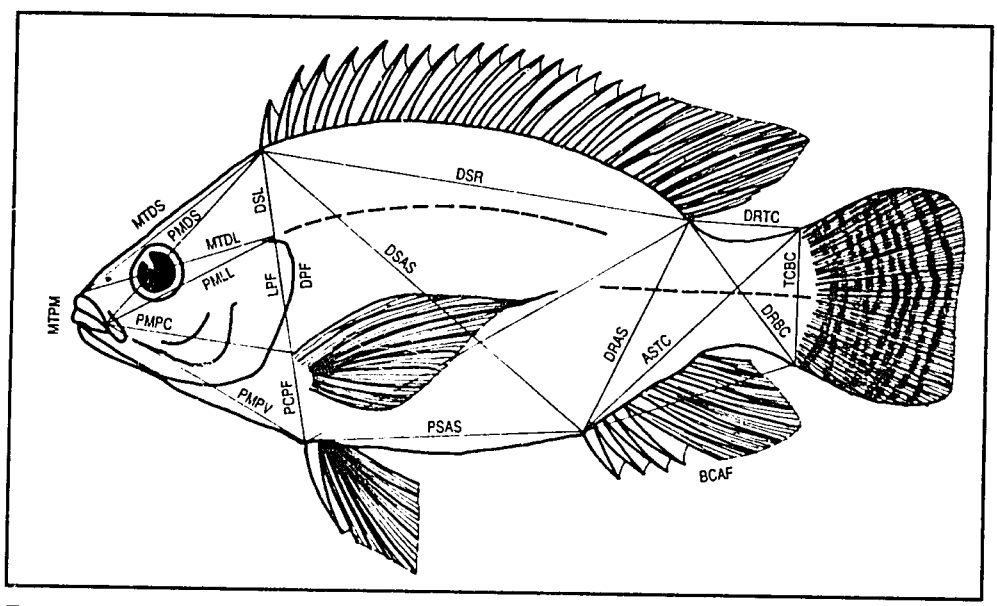


Fig. 2. Truss network of 21 landmark points on the body outline measured during morphometric characterization of the eight test strains of Nile tilapia (*Oreochromis niloticus*).

characters to derive residuals. The plot of PC1 against residuals separated out the Kenya strain, which has a relatively shorter and more streamlined midbody region than the rest of the strains. Overall, however, the results indicate very little morphological differences among the eight strains.

mt-DNA. For the past eighteen months, the project has concentrated on standardizing procedures for extracting mt-DNA. A technique which makes use of phenol to extract protein from isolated mitochondria and ethanol to precipitate the mt-DNA was found most suitable: mt-DNA precipitates were obtained from fresh gonad and liver samples. Muscle tissues gave low yields. Frozen tissue samples were unsuitable. Freeze dried mt-DNA was rehydrated with triple distilled water before restriction

enzyme analysis. However, no fragments were obtained from digestions using BamHI, XhoI, EcoRI and HindIII. Further work using an array of restriction enzymes is in progress.

Genotype x Environment Interaction

Identification and development of the most promising strains that have predictable and consistent performance for the target environments (different farming systems and different agroclimatic conditions) are among the primary objectives of fish breeding programs oriented to the needs of fish farmers. This involves determination of how different strains perform in different farm environments and the relative differences among the strains. The magnitude of Genotype x Environment (GE) interaction determines whether or not there is a need for developing specialized strains for different farming systems.

Estimation of the magnitude of GE can be a formidable task in Asian tropical aquaculture because of the diverse nature of farming systems and agroclimatic conditions under which each of the different strains must be tested. The GIFT project has focused on this during the past 20 months.

The first generation growth trials carried out from March to November 1989 involved 11,400 individually tagged fingerlings communally reared in 11 test environments for about 90 days. The large dataset has now been analyzed and indicates low GE interaction. The 1990 second generation complete diallele crossing trials (see below) included an automatic repeat of this GE interactions estimation in seven test environments. The results indicated:

- highly significant differences in growth performance among the eight test strains (Tables 1 and 2);
- with the apparent exception of the Ghana strain, the 'wild' African strains, after only two generations in captivity, performed as well as or better than the established 'domesticated' strains presently used by Philippine fish farmers;
- very low GE interaction across all test environments (Table 3); and
- little change in the relative ranking of the strains across environments (Fig. 3).

These results suggest that the growth performance of the tested strains is relatively consistent across all the test environments and that development of specialized strains for each of the farming systems is not necessary. Moreover, the total gene action realizable through 'additive' genetic variation in the strain that will be eventually released for culture will be there to be expressed to whatever degree the farm environments allow (Fig. 3).

Second Generation Experiments (January to October 1990)

The second generation experiments were undertaken to estimate the magnitude of nonadditive (heterotic) genetic effects when the eight strains were crossed among themselves, and to determine thereby whether a breeding program for farmed Nile tilapia in the Philippines should be based on a simple purebreeding strategy from a base population or on a crossbreeding

Table 1. Least mean squares of body weight at harvest of seven African and 'Philippine' strains of Nile tilapia (*Oreochromis niloticus*) cultured in different test environments: Generation I.

Strain	Agroclimatic regions			Farming systems							
				Ponds	Cages			Waste-fed			Rice-fish
	1	2	3		1	2	3	1	2	3	
African											
Egypt	147.0	68.0	38.6	90.0	9.4	20.0	85.7	31.5	45.0	38.2	19.9
Ghana	93.0	42.2	35.3	50.4	9.1	20.7	56.6	25.4	23.7	25.4	16.8
Kenya		.	.	.	.	.	.	.	.	.	.
Sénégal	117.7	50.2	36.8	71.9	10.5	21.8	74.6	25.8	28.1	32.2	20.7
'Philippine'											
Israel	115.8	54.1	35.7	73.4	8.7	16.6	72.9	28.4	27.8	33.0	16.5
Singapore	108.9	57.2	33.1	79.3	9.4	17.4	74.9	30.3	31.9	34.7	17.9
Taiwan	120.4	56.1	36.6	71.6	8.1	16.2	70.6	23.1	29.8	32.0	16.9
Thailand	131.0	57.5	35.5	75.9	9.4	24.4	72.1	25.0	31.7	32.0	17.0
Mean	120.9	54.7	36.4	74.8	9.4	20.1	72.8	27.8	31.5	32.6	18.1

Agroclimatic region 3 (Column 3, - La Trinidad Fish Farm) is a low temperature environment; Cages 1, 2, 3 represent different stocking densities and whether or not supplementary feed is given; cage 1: no supplementary feeding; cage 3: with supplementary feeding; waste-fed: means ponds loaded with different on-farm crop residues.

Table 2. Least mean squares of body weight at harvest of eight African and 'Philippine' strains of Nile tilapia (*Oreochromis niloticus*) cultured in different test environments: Generation II.

Strain	Agroclimatic regions			Farming systems				
				Cages	Ponds**		Waste-fed	
	1	2	3*		1	2	1	2
African								
Egypt	35.0	25.3		18.1	70.4	48.4	78.6	53.0
Ghana	29.4	22.8		13.8	58.4	38.7	62.2	40.4
Kenya	43.0	29.3		22.3	69.0	50.1	75.2	56.2
Sénégal	34.0	26.2		18.2	66.3	43.2	72.8	50.0
'Philippine'								
Israel	30.3	24.8		16.0	64.0	39.5	70.2	45.2
Singapore	27.7	26.1		13.5	65.3	44.2	72.9	52.5
Taiwan	30.8	26.9		14.7	65.9	41.7	70.2	45.5
Thailand	35.0	29.2		20.3	69.7	48.0	77.3	48.0

*Survival in this environment (La Trinidad Fish Farm - low temperature environment) was very low and was deleted for further analysis.
**Ponds: 1 - stocking density 2/m²
2 - stocking density 5/m²

During the project's first training workshop held in October-November 1989, the simplified strain crossing, with relatively sophisticated mathematical analysis, suggested in the project's original plan was reconsidered. In order to obtain a balanced composition of all strains and their crosses, it was decided to expand the mating design. A full diallele crossing scheme (8 strains x 8 strains = 64 crosses, including the 8 pure strains) was proposed.

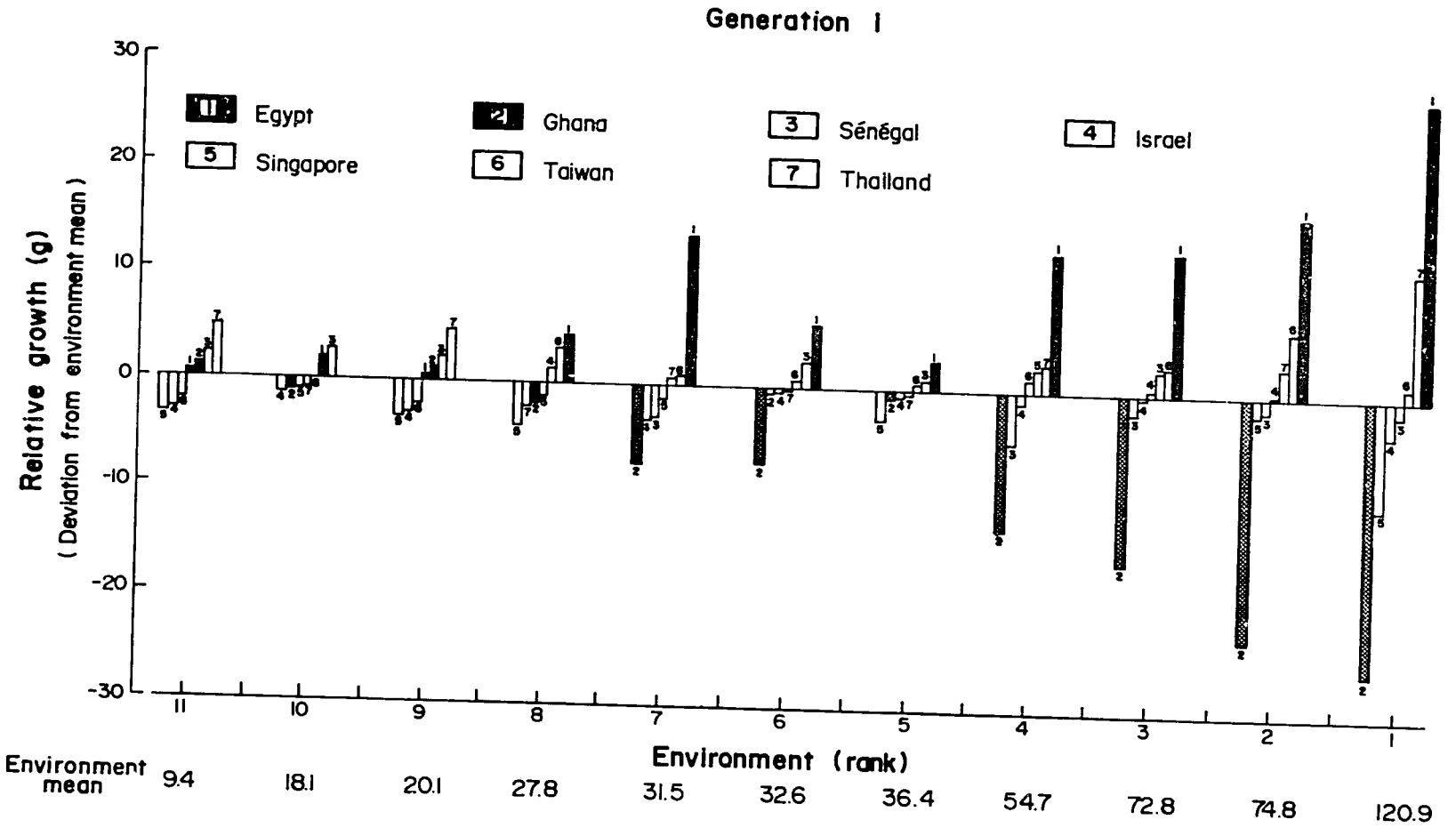


Fig. 3. Least mean squares of body weights at harvest of seven strains of Nile tilapia (*Oreochromis niloticus*) in different environments. The mean body weights of each strain have been plotted as deviations from the respective environment means. Environments have been arranged in an ascending order of the mean weights attained. This figure reveals: (1) consistency of growth performance of individual strains across test environments with very little change in relative ranking; and (2) potential for growth and the magnitude of possible differential growth performance among strains across a range of environments. The test environments were as follows: 1, 3 and 9, fish cage; 2 rice-fish culture; 4, 5 and 6, waste-fed ponds; 7, 8, 10, 11, ponds in various agroclimatic zones.

Table 3. Mean sum of squares (MS) generated by generalized linear model (GLM) procedure.

	Generation I			Generation II		
Source	df	MS[a]	Per cent[b]	df	MS[a]	Per cent[b]
Environments	10	2,924.9	73.3	6	227.5	19.3
Strains	6	63.4	1.6	8	18.5	1.6
Sex	1	864.6	21.6	1	844.3	71.7
Batch	-	-	-	3	17.3	1.5
Environment x strains	59	12.1	0.3	48	3.9	0.3
Environment x sex	10	123.9	3.1	6	62.4	5.3
Environment x batch	-	-	-	18	3.1	0.3
Batch (environment)	15	3.4	0.1	-	-	-
Error	4,866	0.8		2,058	0.95	
Model	101	328.3		90	97.50	
R^2		0.89			0.82	

[a]Type III MS for independent variables; all significant at $P<0.001$.
[b]Based on total MS for independent variables.

The practical implications, particularly the laborious and difficult organizational requirements, were discussed. It was finally agreed that from a scientific point of view, a full diallele crossing scheme would provide the most complete records that could be obtained from a single generation of strain crossing.

The fish harvested from all test environments, following the termination of the first generation GE studies, were used for the second generation trials. Mating (and crossing) were encouraged by stocking two females of each strain in 1-m^3 hapas with a single male. A total of six hapas (cages made of mosquito netting) per cross were installed per round of mating. The breeders were replaced six times to maximize the production of fry. A total of 390 hapas was installed initially. Additional hapas were installed later on for crosses that first yielded very small numbers of fry. In all, 500 hapas were installed in a 4,500-m^2 pond. Collection of fry was done in batches to control size and age effects. Rearing of fry was carried out in fine mesh nursery hapas. They were subsequently transformed to B-net hapas and the stocking density was progressively reduced.

Tagging of fish started in May and was completed in late June. Some 26,000 fish were tagged with modified fingerling tags and distributed to different test environments. Regular sampling was carried out every 21 days.

Preliminary analysis of the data was done during the Second Training Workshop (August 1990). Final analysis was completed in November, after harvesting of fish from all test environments. The results indicated low nonadditive genetic effects (hybrid vigor) (less than 3%) for both survival and growth (Table 4).

This significant result argues against a crossbreeding program. It suggests rather a simple selective breeding strategy, using a mixed base population ('synthetic' strain). This approach would also carry on a substantial

Table 4. Estimated mean heterosis (%) levels (non-additive genetic effects) for all possible crosses among eight strains of Nile tilapia (*Oreochromis niloticus*) cultured in eight different test environments.

(a) Growth: Average heterosis effect 2.80%

	1	2	3	4	5	6	7	8
1. Egypt		3.029	5.840	13.367	14.396+	-1.381	7.682	5.517
2. Ghana		x	-4.170	4.187	3.677	-0.403	4.658	4.044
3. Kenya			x	-4.235	4.322	-3.645	-0.282	1.267
4. Sénégal				x	8.325	-3.855	-0.414	2.053
5. Israel					x	0.615	9.437	3.925
6. Singapore						x	-0.401	1.320
7. Taiwan							x	-1.273
8. Thailand								x

(b) Survival: Average heterosis effect 2.9%

	1	2	3	4	5	6	7	8
1. Egypt		0.593	-0.557	0.552	-5.850	1.701	3.059	0.737
2. Ghana		x	17.419	17.271	-12.896	11.209	7.572	2.559
3. Kenya			x	4.781	0.395	2.049	5.394	4.183
4. Sénégal				x	0.980	6.910	-1.646	5.534
5. Israel					x	9.879	1.020	0.980
6. Singapore						x	6.144	-3.049
7. Taiwan							x	-5.761
8. Thailand								x

amount of the moderate nonadditive effects seen in the second generation. Based on their additive genetic performance, the 25 best performing purebred and crossbred genotypes were then chosen to build the base population and initiate the selective breeding program.

Two generations of selective breeding are now planned: to estimate genetic parameters of growth and reproduction traits and the magnitude of genetic gain.

Training

Training of project personnel from the Philippine collaborating institutions has always been a major component of the project. Training in 1990 was focused on providing intuitive understanding of the basic concepts of GE interaction, nonadditive genetic effects, 'synthetic populations', selection methods and systematic breeding strategies.

Two scientists from the Research Institute for Aquaculture No. 1, Dinh Bang-TienSon, Ha-Bac, Vietnam, (Messrs. Nguyen Huy Dien and Nguyen Cong Thang) completed two months (October-November 1990) training on tilapia genetics with the project, sponsored by FAO.

Several graduate students, working towards their M.Sc. (Aquaculture) degree at the College of Inland Fisheries, CLSU, are presently involved in the project. Mr. Delfin Papa successfully defended his M.Sc. thesis, "Caudal fin bars as an indicator of growth performance in seven African and Philippine strains of Nile Tilapia", in March 1990. Mr. Ruben Reyes (BFAR/NFFTRC) completed experiments for his thesis entitled "Comparative

analysis of Genotype x Environment interaction of different strains of Nile Tilapia under relatively 'stressful' and 'unstressful' environments". Ms. Marietta P. de Vera (ICLARM) successfully defended her thesis proposal, "Repeatability of relative growth rates of individuals under communal stocking". Ms. Liza Agustin (UPMSI) completed the experiments for her thesis entitled "RNA/DNA ratio as an indicator of growth performance".

The Second Training Workshop on Quantitative Genetics was held at FAC/CLSU from 22 August to 27 August 1990. Twenty participants from the collaborating institutions and other universities joined the workshop. The focus was on analysis and interpretation of data generated during the project's first and second generation experiments, strategies for building the base population, and planning of the selective breeding experiments.

Asian Regional Workshop on Tilapia Genetics

ICLARM convened the first Asian Regional Workshop on Tilapia Genetics on 29-31 August 1990 at CLSU. The theme was "Present progress, future directions and needs in fish genetic research".

This workshop brought together scientists from various groups working on tropical fish genetics. With support from ADB and UNDP/DGIP, a total of 60 participants came from 12 Asian and four African countries and representatives from several national, regional and international institutions and agencies (see box). They reviewed progress and discussed future directions and needs in fish genetics research. Recommendations were formulated by the participants grouped by region: South Asia and China, Southeast Asia/Pacific and Africa.

An associated discussion on networking was held at FAC/CLSU on 1 September. The conclusion was that there is a need to establish international collaborative linkages that can help the evolution of national fish breeding programs in those countries that have firm policies to improve their fish breeds and realistic prospects for succeeding. The provisional suggestion is to link the work in the Philippines (as it moves towards being an independent national program) to activities in China, Egypt and India and to begin a more thorough assessment of the needs and opportunities in Africa. In Asia, tilapia germplasm developed in the Philippines will be tested in a number of other countries with ADB and UNDP/DGIP endorsement and support.

The ADB has agreed to a six-month extension of the project until 30 September 1991. The UNDP/DGIP has agreed to extend the project with additional supplementary funding through 30 June 1992. UNDP/DGIP is also considering a proposal for a follow-on project of five years to begin in June 1992.

Countries and institutions/agencies represented at the Asian Regional Workshop on Tilapia Genetics, 29-31 August 1991, Muñoz, Nueva Ecija, Philippines.

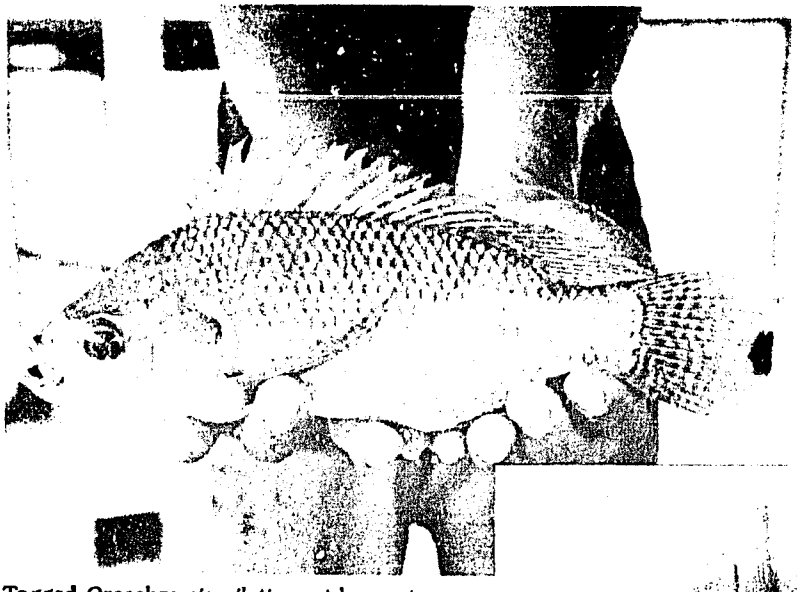
	Country	Agency/Institute
A.	*Asia and the Pacific*	
	Australia	Centre for Biological Population Management, Department of Biology, Queensland University of Technology, Brisbane
	Bangladesh	Fisheries Research Institute, Freshwater Station, Mymensingh
	China	Freshwater Fisheries Research Centre, Wuxi
	Fiji	Ministry of Primary Industries, Suva
	India	National Bureau of Fish Genetic Resources; Central Institute of Freshwater Aquaculture, Allahabad
	Indonesia	Research Institute for Freshwater Fisheries, Bogor; Provincial Fisheries Service, Yogyakarta
	Malaysia	Freshwater Fish Research Center, Malacca
	Pakistan	Fisheries Research and Training Institute, Directorate of Fisheries, Punjab
	Sri Lanka	Ministry of Fisheries and Aquatic Resources, Colombo
	Taiwan	Taiwan Fisheries Research Institute, Keelung
	Thailand	National Aquaculture Genetics Institute, Kasetsart University, Bangkok
	Vietnam	Faculty of Fisheries, Department of Hydrobiology, University of Cantho, Cantho
B.	*Africa*	
	Côte d'Ivoire	Centre de Recherches Océanographiques, Abidjan
	Egypt	Suez Canal University, Ismailia
	Ghana	Institute of Aquatic Biology, Accra
	Malaŵi	Fisheries Department, University of Malaŵi
C.	*Canada/Europe*	
	Canada	Dalhousie University, Halifax
	France	Ecole Nationale Superieure Agronomique, Toulouse
	Germany	University of Hamburg
	Norway	Institute of Aquaculture Research (AKVAFORSK), As
	UK	University of Stirling, University College of Swansea

D. *International*

Asian Development Bank (ADB), Manila, Philippines
Asian Institute of Technology (AIT), Bangkok, Thailand
ASEAN Aquaculture Development and Coordination Programme/European Economic Community (AADCP/EEC), Bangkok, Thailand
International Development Research Centre (IDRC), Singapore
International Center for Living Aquatic Resources Management (ICLARM), Manila, Philippines
Overseas Development Agency (ODA)/University College of Swansea, UK
Southeast Asian Fisheries Development Center (SEAFDEC), Iloilo, Philippines
United Nations Development Programme/Division for Global and Interregional Projects (UNDP/DGIP), New York

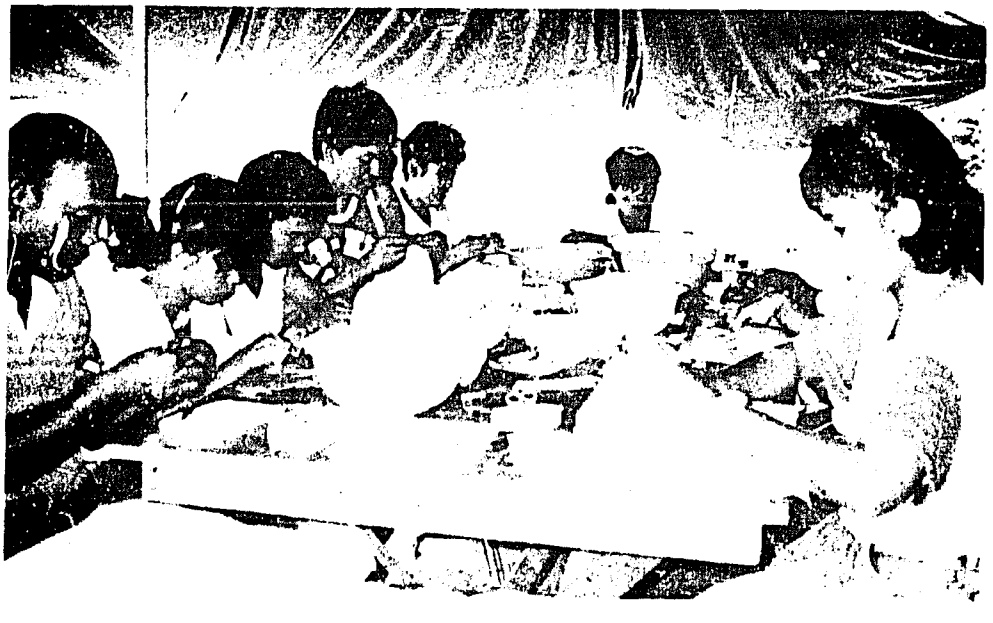
E. *National*

Central Luzon State University (CLSU), Muñoz, Nueva Ecija, Philippines
Bureau of Fisheries and Aquatic Resources, Department of Agriculture (BFAR/DA), Manila, Philippines
Philippine Council for Aquatic and Marine Research and Development (PCAMRD), Los Baños, Philippines
University of the Philippines/Marine Science Institute (UPMSI), Diliman, Quezon Quezon City, Philippines



Tagged *Oreochromis niloticus* at harvest.

Oreochromis niloticus as small as 3 g can be tagged.



The GIFT project team tagging different crosses of *Oreochromis niloticus* for stocking in various test environments.

Project Title		: Research for the Development of Tropical Aquaculture Technology Appropriate for Implementation in Rural Africa
Cooperating Institutions		: Malaŵi Fisheries Department (FD); Bunda College of Agriculture and Chancellor College of the University of Malaŵi (UM); National Research Council of Malaŵi (NRCM); Malaŵi/German Fisheries and Aquaculture Development Project (MAGFAD).
Duration		: Planning phase, November 1985-April 1986; Startup phase, May 1986-October 1986; Main project, November 1986-October 1991, extended to October 1994.
Key Personnel	FD	: Mr. Boniface Mkoko; Mr. Brian Rashidi; Mr. Justin Mutambo
	NRCM	: Mr. Orton Msiska; Mr. Winston Kadongola
	UM staff	: Dr. Zimani Kadzamira; Dr. Elenemo Khonga; Dr. Reg Noble; Dr. Leonard Kamwanja; Dr. Davis Ng'ong'ola; Mr. Jeremy Likongwe
	UM students	: Mr. Emmanuel Kaunda; Ms. Mayesero Kapalamula; Mr. Sloanes Chimatiro
	MAGFAD	: Dr. Gernot Otte; Dr. Thomas Gloerfelt-Tarp
	ICLARM	: Mr. John D. Balarin*; Dr. Barry A. Costa-Pierce; Mr. Anne A. van Dam; Ms. Chipo Jenya; Mr. Fredson Chikafumbwa; Mr. Daniel Jamu; Dr. Roger S.V. Pullin; Dr. Clive Lightfoot

Objectives:

- To develop aquaculture technologies appropriate to the prevailing agroecosystems, socioeconomic conditions and traditional knowledge systems of rural Africa.
- To train research and teaching personnel from Africa to strengthen their capabilities for supporting aquaculture research and development.
- To strengthen aquaculture research, training, education and information exchange between African and Asian institutions.
- To conduct collaborative research with African scientists in social

*Resigned May 1990.

and biological sciences for the furtherance of aquaculture as a means of rural development.

- To conduct research on-station in pond dynamics and associated fish yield characteristics using agricultural crop and natural plant residues widely available on smallholder farms in Malaŵi.
- To extend successful on-station results in integrated aquaculture-agriculture to smallholder farmers in Malaŵi using farming systems participatory approaches and to develop methods to monitor the introduced innovations.
- To provide African cooperating institutions with relevant information for the furtherance of rural aquaculture research and development.
- To publish and disseminate widely the results of all cooperative research and training activities.

Results

Highlights of 1990 were an ICLARM-GTZ-FD-UM landmark international conference on Aquaculture Research and Development in Rural Africa, held at Chancellor College (UM), Zomba in April and publication of the proceedings; successful demonstration of new technologies on-station; solid evidence that smallholder farmers are using widely results of applied research conducted at the FD's Domasi Experimental Fish Farm (DEFF); graduation of the first four master's students from the ICLARM/University of Malaŵi M.Sc. program and one from The Asian Institute of Technology (AIT) in Bangkok, Thailand; beginning of new pond and facilities construction and aquaculture farming systems programs at the Bunda College of Agriculture; and publication by ICLARM-GTZ of a book on the Context of Small-Scale Integrated Agriculture-Aquaculture Systems in Africa: A Case Study of Malaŵi.

On-Station Biological Research

Significant research progress was made towards the use of grasses and other plants as fishpond inputs; alternative liming methods and materials to improve pond water quality; use of a Lake Malaŵi native tilapia (*Oreochromis karongae*) as a promising new candidate for aquaculture; demonstration of alternative harvesting methods; tilapia population control methods for small-scale fish farming; and development of integrated vegetable-fish and rice-fish farming systems. In addition, the introduction of modern methods of aquaculture data analysis, completion and full operation of a modern analytical water quality laboratory have allowed staff to design, monitor and summarize aquaculture experiments more effectively. The transfer of Mr. Anne van Dam, an Associate Expert from the Netherlands to the project with his skills in data analysis, and modelling and expanded computer facilities and training in these areas, led to a large increase in the preparation of scientific contributions. By end 1990, DEFF research staff and collaborators published, had in press, submitted or in the final stages of preparation, two books and over 30 scientific contributions.

Most encouraging were research findings from the DEFF with regard to use of on-farm resources, harvesting ponds with reed fences and simple

pond management strategies that showed farmers could routinely harvest 2.5-3.0 t/ha/year of native species (*Oreochromis shiranus*, *Tilapia rendalli*). Table 1 summarizes input-output data using mainly on-farm resources. Recent work with new species, pond stirring, better management and harvesting systems have demonstrated that even higher yields of 5-6 t/ha/year are possible with available resources.

Table 1. Mean and ranges of net yields of fishponds, costs and incomes of fish farmers in Malaŵi using on-farm resources (from various sources).

Inputs	Input rates	Mean yields (kg/ha/year)	Range	Cost of input (US$)	Income (US$)
Napier grass (NG)	100 kg DM/ha/day	1,405	647-2,195	14.58	3[illegible].00
Maize bran (MB)	3% MBWD	1,726	406-2,368	2.65	41.[illegible]7
NG/MB	As above	3,013	2,726-3,299	17.23	82.70
Waste pumpkin leaves*	50 kg DM/ha/day	1,444	1,372-1,616	12.6	35.06
Maize stover compost/FWA**	3% MBWD; 2.5 t/ha	750	710-790	7.38	18.20
Smallholder farmers using MB	When available	NA	400-500	2.65	10.89
Smallholder farmers using MB	When available	951	241-3,336	2.65	23.01

Notes:
*Cost of waste pumpkin leaves based on labor input to harvest waste leaf.
**FWA = Fuelwood ash and agricultural limestone combination.
NA = Data not available
MBWD = Mean body weight per day
(1) Cost of fresh fish, 1991 retail prices @ US$ 1.21.
(2) Cost of maize bran @ US$ 0.04/kg dry matter @ 10% moisture.
(3) AL = Agricultural limestone @ US$ 0.04/kg.
(4) FWA (Fuelwood ash) = No cost: a waste resource from household cooking fires.
(5) Cost of maize compost based on labor input @ US$ 0.81/day to contruct compost heap; purchase of bamboos for pile aeration @ US$ 0.13/bamboo.
(6) Napier grass cost based on labor input to cut grass @ US$ 0.81/day.
(7) Costs of inputs are per kg per year per 200-m² pond (2 fish crops/year; 1-ha pond).
(8) Income is per 200-m² pond (2 fish crops/year; 1-ha pond).

On-Farm Participatory Research

Smallholder aquaculture is expanding rapidly in the Zomba District of Southern Malaŵi. By mid-1990, over 500 farmers were estimated actively engaged in fish culture in the district. ICLARM and its collaborators have contributed to this growth.

During 1990, open days at the DEFF were held for Farmers' Clubs from throughout the Zomba District to view the project's collaborative research, evaluate results and identify areas of common interest for further on-farm participatory research between smallholder farmers, ICLARM and FD staff. Organization of the ICLARM project around this approach is detailed in Fig. 1.

Exposing farmers to the "basket" of technologies being developed at Domasi has proven very successful. A recent survey showed that, of farmers who were invited to farmer awareness days at Domasi to see the recycling technologies, 86% of them were testing at least one of the technologies demonstrated. A surprising number (24%) who attended were implementing four of the technologies shown.

By first documenting and understanding, then working within traditional knowledge systems and existing on-farm resources at a research station and on smallholder farms in order to understand how social and technological aspects can be interwoven, the project has gained valuable new insights on how aquaculture can improve and make new or more efficient resource

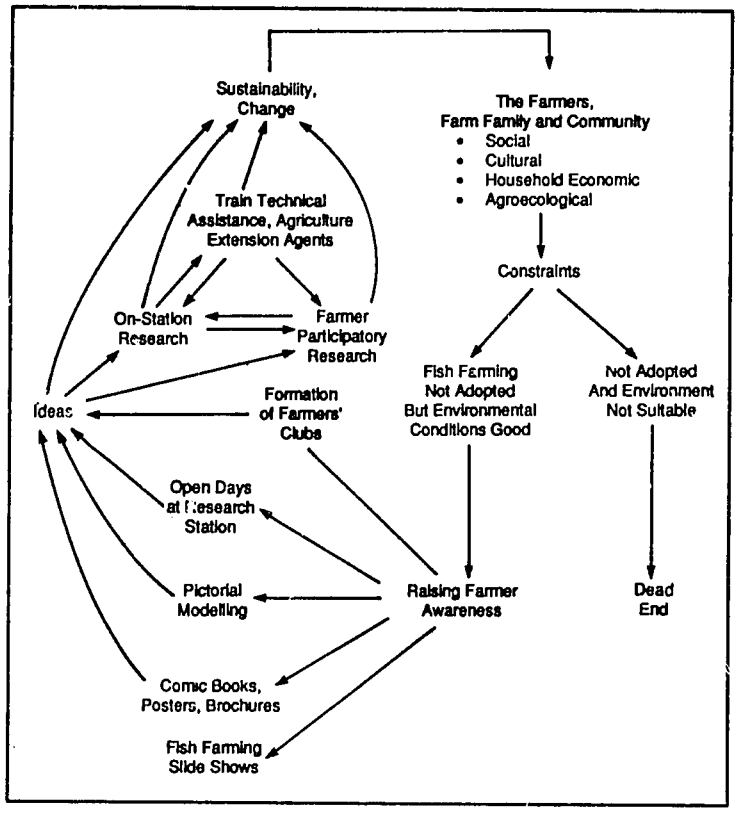


Fig. 1. Conceptual diagram of the interrelationships between farming systems research and extension, and the ICLARM and MAGFAD project activities leading to change and new sustainable farming systems: the approach being undertaken in Malaŵi by the ICLARM-GTZ and collaborating projects.

flows in the traditional maize-based farming system. As a result, ICLARM and its collaborators have achieved a dynamic flow of information between the DEFF, smallholder farmers and extension workers, with active involvement of farmers in the research agenda.

In 1990, ICLARM's successful methods were the subject of meetings with the Southern African Development Coordination Conference (SADCC) fisheries training directors, and the Chief Fisheries Officer of Malaŵi in Malaŵi and Manila, Philippines. Officials of USAID and professional staff of the Malaŵi Department of Agriculture have also expressed their interest in the project.

Bunda College of Agriculture

Mr. Anne van Dam relocated to Malaŵi from the Philippines in February and initiated collaborative projects with the Departments of Animal Science and Rural Development at the College.

In early September, construction of 21 research ponds was started at the Bunda Fish Farm and by December digging of seven ponds was completed. Completion of construction is expected by mid-1991 after which the ponds will be available for research projects and teaching/training activities.

A project entitled "Economics of small-scale integrated agriculture-aquaculture farming systems" was started in collaboration with Dr. Davis Ng'ong'ola, Head of the Rural Development Department in collaboration with extension staff of the Ministry of Agriculture, Lilongwe Agricultural Development Division (ADD). The project involves a survey of both fish farmers and other farmers in the vicinity of Bunda College. Detailed economic analyses of farming systems are being made and farmer problems analyzed using farming systems research methods. Obtaining more insight into the roles of fishponds in the economics of the whole farming system is the main objective of this project.

Preparations are being made for a series of aquaculture seminars at Bunda College. Speakers from various organizations/agencies will be invited. Biological research projects are in preparation.

Staffing

The major staff change in 1990 was the resignation of Mr. John Balarin as Project Director in May. Dr. Barry Costa-Pierce became Acting Director at that time, then was promoted to Project Director in November. In February, Messrs. Daniel Jamu, Fredson Chikafumbwa and Winston Kadongola were hired as ICLARM Research Associates, the last of them transferring later to the National Research Council of Malaŵi. At end 1990, the project had 11 professional staff and 47 technical and administrative staff at the DEFF and Bunda College.

Education and Training

Graduation of the first four Malaŵian M.Sc. students, namely, Messrs. Daniel Jamu, Fredson Chikafumbwa, Winston Kadongola and Alfred Maluwa, from the joint ICLARM-GTZ/University of Malaŵi M.Sc. in Biology (Aquaculture) took place in December. In addition, Mr. Aggrey Ambali finished his M.Sc. at the Asian Institute of Technology (Bangkok, Thailand). Mr. Orton Msiska, Principal Scientific Officer of the National Research Council of Malaŵi, registered for Ph.D. studies at the University of Malaŵi in 1990.

Drs. Costa-Pierce and Noble, functioning as Associate Professor and Lecturer, respectively, in the Department of Biology, University of Malaŵi, supervised four undergraduate research projects at the DEFF in water chemistry, aquaculture science and fish biology. Dr. Costa-Pierce and Mr. Kadongola organized training in aquaculture practices for MAGFAD and FD technical assistants at the DEFF.

During 1990, a Friday afternoon seminar series was initiated at the DEFF and the meetings attracted wide participation from all sectors of the

government and international fisheries community in Southern Malaŵi. In November, MAGFAD began to cosponsor the seminar series and provide transport so that all their technical assistants could attend.

After the international conference in April, ICLARM sponsored a bioeconomic modelling workshop at the Computer Center, University of Malaŵi, for 13 participants from all collaborating agencies. The workshop was led by Mr. Ron D. Zweig, President of EcoLogic, Inc., Falmouth, Massachusetts, USA. Participants worked with agroecological and aquaculture farming systems models using STELLA software. As a result of the workshop, modelling is an active research interest in the project, and scientific contributions from on-going work are expected in 1991.

In December, Fisheries Training Directors from SADCC nations visited Domasi. Plans were approved by SADCC to make Malaŵi the lead nation for all fisheries and aquaculture training in the 10-nation subregion. The University of Malaŵi/ICLARM's M.Sc. program, involvements in the B.Sc. program at Bunda and low-cost farmer extension methods featured prominently in meetings. In 1991-1992, the University of Malaŵi will implement a SADCC regional training program with the assistance of ICLARM.

Other Activities

ICLARM was involved in the planning and initiation of Malaŵi national aquaculture coordination meetings, two of which were held in 1990. Attending these meetings were senior staff from the Malaŵi Fisheries Department, EEC North and Central Regions Fish Farming Project, ODA Mulanje/Phalombe Fish Culture Project and MAGFAD. During the meetings and working groups formed, ICLARM contributed to a draft National Aquaculture Extension Plan for Malaŵi and initiated discussions on formulating a National Aquaculture Development Plan. Further coordination meetings are planned in 1991 in Mzuzu and Zomba.

Active collaboration with MAGFAD was strengthened in 1990. Joint activities started were: drafting aquaculture extension workbooks and brochures; an orientation slide show for new farmers; and collaborative on-farm research at MAGFAD sites in Chinseu and Namwera. MAGFAD and ICLARM have agreed to develop the MAGFAD station at Chinseu into a "way station" (farmer demonstration area) for technologies developed at Domasi by ICLARM and FD. In addition, MAGFAD and ICLARM have agreed to cosponsor 24 open days for farmers at Domasi and Chinseu in 1991.

Project Title		: Transfer of Asian Aquaculture Technologies to Africa
Cooperating Institutions		: Centre Technique Forestier Tropical (CTFT); Ecole Nationale Supérieure Agronomique de Toulouse (ENSAT)
Duration		: Continuous from 1988
Key Personnel	France	: Mr. Jean-Marie Travers, Multilateral Division, Ministry of Foreign Affairs; Jerome Lazard (CTFT); Dr. Jacques Moreau (ENSAT)
	ICLARM	Dr. Roger S.V. Pullin; Ms. Catherine Lhomme Binudin; Mr. John D. Balarin*; Dr. Barry A. Costa-Pierce; Ms. Mary Ann P. 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

Through this project, supported by the Ministry of Foreign Affairs of the French Government, a thorough study of African farming systems and their socioeconomic context is to be made, leading to ways in which Asian aquaculture technologies can be modified and applied in appropriate African contexts. Activities to date, however, have concentrated on the provision of relevant information for African researchers particularly in Francophone African countries. In connection with this, the hiring of Ms. Catherine Lhomme Binudin, a French national, has allowed ICLARM to launch a translation program starting with the translation into French of three of ICLARM's most important aquaculture publications for distribution to Francophone countries:

1. Tilapia Genetic Resources for Aquaculture, edited by R.S.V. Pullin. ICLARM Conference Proceedings 16. 1988 (French version published 1989).
2. Research and Education for the Development of Integrated Crop-Livestock-Fish Farming in the Tropics, by P. Edwards, R.S.V. Pullin and J.A. Gartner. ICLARM Studies and Reviews 16. 1988 (French version published 1990).

*Resigned May 1990.

3. A Hatchery Manual for the Common, Chinese and Indian Major Carps, by V.G. Jhingran and R.S.V. Pullin. ICLARM Studies and Reviews 11. 1988 (for publication in French in 1991).

In addition to these large translation tasks, the Africa page in "Aquabyte", the newsletter of the Network of Tropical Aquaculture Scientists (NTAS), has appeared in French and English since 1988. Three issues with articles in French have been published each year, and have contributed to the increase of French-speaking tropical scientists' membership to the NTAS network. From 15 such members in 1988, there are now 59.

Parallel to ongoing translation and information distribution work, ICLARM staff have established closer ties with aquaculture research and development groups in Francophone African countries and in France. Within this framework, the following activities were performed by ICLARM staff:

ISTA III

Following the signing in November 1988 of an agreement between ICLARM and the Ivorian Ministry of Scientific Research to hold the Third International Symposium on Tilapia in Aquaculture (ISTA III) in Côte d'Ivoire in November 1991, ICLARM staff travelled to Abidjan in March 1990 to meet with staff of the Centre de Recherches Océanographiques (CRO) and to continue the conference preparation. Contributions to conference costs have been pledged by the Fonds d'Aide et de Coopération (FAC) of the French Ministry of Cooperation and Development. ORSTOM (Institut Français de Recherche Scientifique pour le Développement en Coopération), CTFT and IDESSA (Institut des Savanes) form part of the ISTA III organizing committee with CRO and ICLARM. To date, over 200 persons have expressed interest to participate and over 100 abstracts have been received. ICLARM and CRO are convinced that ISTA III will contribute successfully to the development of aquaculture in developing countries. This Symposium will afford a major opportunity for African aquaculturists to discuss their work with Asian counterparts and forge new collaborative linkages. Its proceedings will be conducted and published in French and English.

Genetic and farming systems research

Meetings were held in Côte d'Ivoire among scientists from CRO, CTFT, ICLARM, IDESSA and ORSTOM to discuss possible fields of collaborative research work. In August 1990, a CRO scientist, Adou Cissé, was invited through the project to attend a Regional Workshop on Tilapia Genetics in the Philippines. He also visited farms and research institutions to learn about Asian aquaculture. Plans for collaborative research will be discussed at ISTA III.

Project Title		: Integrated Rice-Fish Group[1]
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); funded by the Asian Development Bank (ADB) and the International Development Research Centre (IDRC) of Canada
Duration		: February 1990 - ongoing
Key Personnel	FAC/ CLSU	: Prof. Ruben C. Sevilleja; Prof. Arsenia G. Cagauan; Dr. Rodolfo G. Arce
	IRRI	: Dr. Virgilio R. Carangal; Dr. Pierre A. Roger; Dr. James Litsinger
	ICLARM	: Dr. Catalino R. dela Cruz; Dr. Clive Lightfoot; Dr. Roger S.V. Pullin

Objectives

- To establish an Integrated Rice-Fish Group (IRFG) for Asian developing countries and to assist the national programs participating.
- To develop long-term support for rice-fish research through national government and donor commitments.
- To elucidate the feeding ecology and integrated pest management (IPM) aspects of culturing tilapia and other fish species in ricefields, including the effects of fish on rice growth.
- To develop bioeconomic models of rice-fish systems and to apply these in appropriate Asian countries.

Results

Activities of the Integrated Rice-Fish Group in participating countries

The Integrated Rice-Fish Group (IRFG) has been established with the strong support of IDRC. Its current and prospective membership is shown in Fig. 1. The current participating countries have diverse interests and conditions for rice-fish systems. The national programs will pursue their own research interests, provide training for their scientists and produce extension materials for their farmers. All national programs will benefit

[1]A follow-up project to the project entitled 'Rice-Fish Farming Systems Research' begun in August 1987 (see ICLARM Report 1989).

from the IRFG's services in training, regional workshops and meetings, and literature exchange. When requested, the international centers will provide guidance in national research prioritization, research assessment, policymaking and production of extension materials.

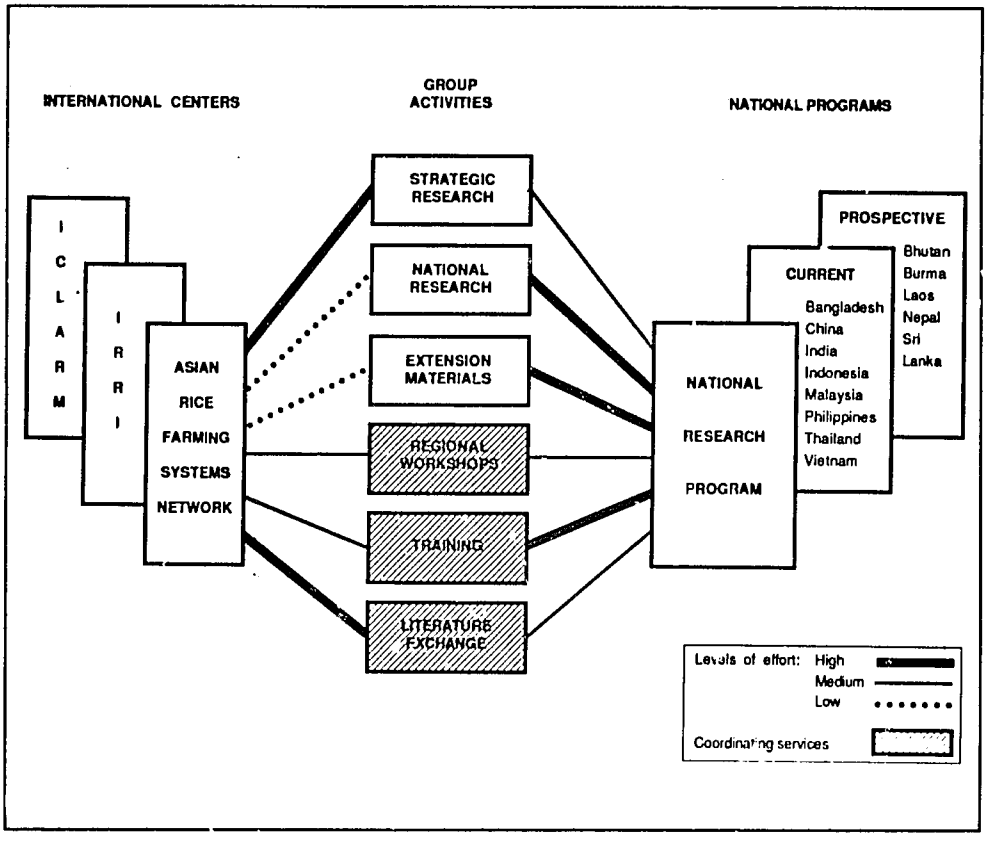


Fig. 1. Participants, activities and levels of effort of the Integrated Rice-Fish Group (IFRG).

In Bangladesh, on-farm rice-fish trials in irrigated environments are in progress at eight locations, led by the Fisheries Research Institute (FRI), Mymensingh, and ICLARM. The other institutions involved are the Farming Systems team of the Bangladesh Agricultural University (BAU), and the United States Agency for International Development (USAID) in Bangladesh.

Deepwater rice-fish farming is also new in Bangladesh. Through IRRI and ICLARM initiatives, on-farm rice-fish trials with fish pens and cages in deepwater rice environments were undertaken by the Bangladesh Rice Research Institute (BRRI) in Mirzapur in 1989.

In Central Luzon, Philippines, the Department of Agriculture has started on-farm rice-fish trials in collaboration with an ADB Technical Assistance project on Rice-Fish Farming Systems Research jointly implemented by ICLARM, FAC/CLSU and IRRI. Extension activities include information dissemination, establishment of demonstration farms and multilocation testing.

Deepwater rice-fish research was initiated in Thailand by IRRI and ICLARM in 1989, in collaboration with the DOA's Huntra Deepwater Rice Station and Ayutthaya Agricultural Campus.

In Vietnam, farmers are looking for ways to increase income from their ricelands. How aquaculture can be integrated into rice production systems to exploit synergistic effects is a pressing question. Research being conducted by the newly-established Farming Systems Research and Development Center at Cantho University was intensified this year by collaboration with ICLARM and IRRI, with funding from IDRC.

On-station research at FAC/CLSU and other activities

Rice-fish production experiments were completed during the rainy season to investigate: (1) the ecology of ricefields, stocked and unstocked with fish, treated and untreated with pesticides; and (2) the effects of providing missing plant rows in concurrent rice-fish systems. Activities on integrated pest management were started and work commenced on a spreadsheet economic model of rice-fish systems.

Ricefield ecology

A model (Fig. 2) was developed for nitrogen flows in wetland irrigated ricefields, with and without fish and in the presence and absence of pesticides. The experiment provided the necessary values for the model. Quantitative data expressed in kg N/ha of rice grain, rice straw, fish, phytoplankton, microbial biomass and soil N were collected. The further development of the model and analysis of the interrelationships among the components will be done using ECOPATH II software.

On-station and on-farm experiments are continuing to evaluate the effects of fish on increasing soil microbial biomass and rice grain N yield and in preventing N loss in floodwater. Furthermore, the effects of pesticides, fish or the interaction of the two, on nitrogen-fixing blue green algae and soil fauna (aquatic oligochaetes) are being determined.

Effects of missing rows on rice and fish production

During earlier experiments, leaving one row unplanted for every three rice rows, to give more space for fish and more light, resulted in decreased rice yields which were not fully compensated by fish yields, especially when small fingerlings were stocked at 5,000-7,500/ha. A new row arrangement was tried together with increased stocking densities using 5.3-8.0 g tilapia fingerlings. Treatment 1 employed the ordinary rice planting method (20 x 20 cm) stocked at 11,700 fish/ha; Treatments 2 and 3 both had one unplanted row for every six planted rows (20 x 16 cm) with stocking densities of 11,700/ha and 14,500/ha.

The results showed that neither fish nor rice yields were reduced by the new row arrangement. With the new row arrangement and increased stocking density, the highest mean fish yield obtained (fish stocked at 14,500/ha) was 44% higher than the maximum yield of 160 kg/ha at 7,500/ha stocking rate obtained in earlier trials.

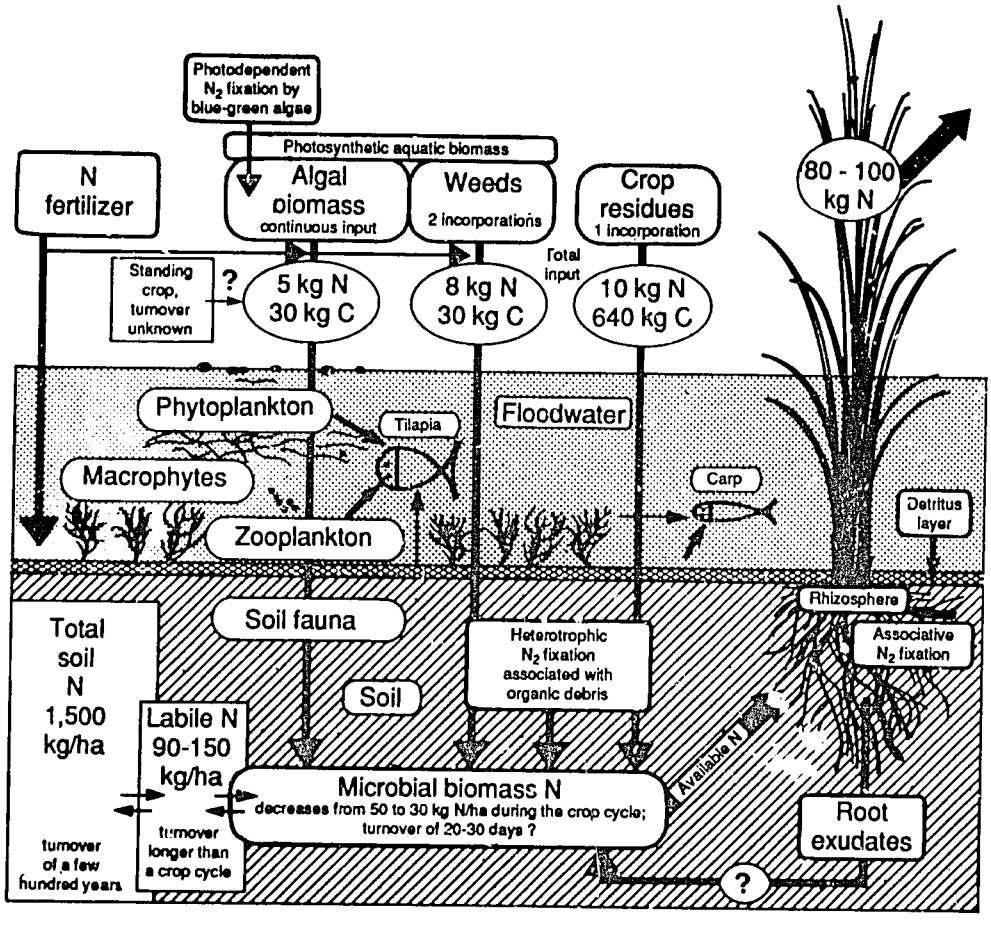


Fig. 2. Schematic representation of the rice-fish agroecosystem with a conceptual representation of the origin of the nitrogen absorbed by rice, the role of the microbial biomass in providing available nitrogen to rice and the pathways involved in the replenishment of the microbial biomass. All figures are per hectare per crop. (Source: Roger, P.A., R. Jimenez, S. Ardales and I. Watanabe. 1989. Nutrient input by the photosynthetic aquatic biomass in a ricefield and its contribution to the maintenance of soil microbial biomass. Poster presented at the 5th Symposium on Microbial Ecology, 27 August to 1 September 1989, Kyoto, Japan).

Development of a spreadsheet economic model of rice-fish systems

This activity will determine different financial indicators as measures of the viability of various rice-fish farming technologies, and develop an analytical framework for comparative assessment of different systems being practised in selected Asian countries. A major output of this activity is a spreadsheet software which will include input, analytical and graphic output sheets.

Prototype templates for the input sheets have been developed using standard software (Lotus 1-2-3). Input-output data from on-farm experiments conducted at Guimba, Nueva Ecija, Philippines, were used as basis in the development of the templates, which are currently being tested at on-farm site.

This activity is linked to the project on the "Financial Feasibility of Rice-Fish Farming Systems" under the Asian Fisheries Social Science Research Network (AFSSRN) (see p. 25), and with ICLARM's "FARMBASE" software development project (see p. 68).

Project Title		: Agricultural Research Project II (Supplement)
Cooperating Institutions		: Bangladesh Agricultural Research Council (BARC); Bangladesh Fisheries Research Institute (FRI); and United States Agency for International Development (USAID)
Duration		: May 1989 to April 1992
Key Personnel	BARC	: Dr. A.K.M. Nuruzzaman
	FRI	: Dr. Md. Aminul Islam
	ICLARM	: Dr. Modadugu V. Gupta, Dr. Clive Lightfoot, Dr. Roger S.V. Pullin, Ms. Mary Ann P. Bimbao

Objectives

The Government of Bangladesh (GOB) is implementing the Agricultural Research Project II (Supplement) with funding from USAID, for strengthening its National Agricultural Research System, aimed at increasing domestic food production, small farm incomes and rural employment. One of the components of the National Agricultural Research System to be developed through the project is aquaculture, a core discipline given priority by the GOB. ICLARM is providing technical assistance in 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 research programs.
- To recommend specific research ideas/technologies that could be incorporated in farming systems research programs.
- To provide technical guidance to farming systems research incorporating aquaculture.
- To assist the extension agencies in disseminating research results to farmers and fishermen.

Results

Farmer participatory research

Under ICLARM's guidance, farmer participatory research for optimizing production from fallow seasonal ponds and ditches through culture of tilapia (*Oreochromis niloticus*) has shown the viability of this operation. A sample survey of 309 farmers, involved in tilapia culture in small seasonal ponds and ditches (average size 170 m^2), indicated production of 1.1-1.9 t/ha in 5 to 10 months, when stocked with fingerlings of 5-8 g at a density of 20,000/ha. Rice bran was used as a supplementary feed. Against an average expenditure of Tk 156 (US$4.33) per pond (US$256/ha) on fingerlings,

feed and fertilizers, the average net return was estimated at Tk 751 (US$20.86) per pond (US$1,234/ha) (Fig. 1). Farmers consider this a good return in comparison to the near zero returns they were getting from small waterbodies in the past.

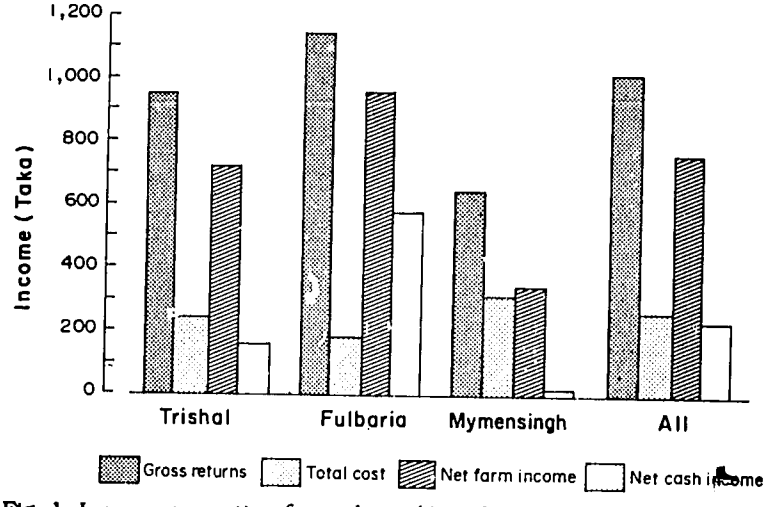


Fig. 1. Income generation from tilapia (*Oreochromis niloticus*) farming in seasonal ponds in Bangladesh (US$ 1 = Taka 36).

Studies on silver barb (*Puntius gonionotus*) as a potential species for culture in seasonal ponds and ditches have indicated that it is possible to get production of 1.2-1.6 t/ha of 110-120 g fish in six months, after stocking with 2.5-5.0 g fingerlings at 15,000/ha and feeding with rice bran but without any pond fertilization. Alternatively, fertilization of such ponds with chicken manure at weekly intervals has resulted in same growth and production of fish in only 3-4 months. This indicates the viability of aquaculture of this species, even in ditches which hold water for only 3-4 months. In perennial ponds, it would be possible to have three crops a year.

Integrated poultry-fish farming studies (500 broiler or layer chickens/ha of water area raised over fishponds) resulted in Indian and Chinese carp production of 4-5 t/ha/year, without the use of any fish feeds or additional pond fertilizers. Six batches of broilers amounting to 4 t/ha (live weight) were obtained. However, investment costs indicate that these operations are feasible only for relatively resource-rich farmers or farmers who have access to credit.

Farmers' Days were organized to show results of farmer participatory research. A larger number of rural women attended these demonstrations and their enthusiasm has resulted in several NGOs developing programs for involvement of women in homestead aquaculture.

Country-wide activities

The Bangladesh Agricultural Research Institute, Bangladesh Jute Research Institute and Sugarcane Research and Training Institute have been conducting farming systems research in different parts of the country located in different agroecological zones. In the past, fisheries was not given importance in farming systems research.

A two-day workshop organized at BARC indicated that the waterbodies in the project area are either unutilized or underutilized for aquaculture and identified the need for aquaculture practices that are compatible with other farming activities and utilizes on-farm inputs. Therefore, studies were initiated for optimizing fish production from seasonal ponds and ditches through culture of short cycle species (tilapia and silver barb) and through polyculture of carps and integrated poultry-fish farming in perennial ponds.

Dr. M.V. Gupta also provided guidance to FRI scientists in the implementation of eleven on-station aquaculture research programs (Table 1).

Table 1. List of on-station research programs in Bangladesh for which guidance was provided by ICLARM under the BARC/USAID-supported Agricultural Research Project II (Supplement).

1. Carp reproduction and hatchery systems
2. Development of nursery pond management practices
3. Breeding and culture of indigenous and introduced small-sized fish species
4. Breeding and culture of magur (*Clarias batrachus*)
5. Polyculture of carps for optimization of pond production
6. Polyculture of carp and shrimp
7. Culture of catfish *Pangasius pangasius*
8. Culture of fish in pens and cages
9. Pond culture of freshwater prawn (*Macrobrachium rosenbergii*)
10. Development of integrated livestock-fish farming practices
11. Integrated agriculture-aquaculture farming systems

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

Course	Date	No. of participants	Participants
Orientation course-aquaculture in FSR	15-16 May	6	FSR site coordinators
Aquaculture technologies	21-26 May	18	NGO extension officers
Fish pond management	30 May	40	Farmers
Nursery management of *Puntius gonionotus*	5-6 Jun	29	Nursery operators
Fish pond management	11 Jul	35	Farmers
Fisheries data analysis	22 Jul-9 Aug	20	FRI scientists
Tilapia culture	28 Jul	25	Farmers
Fisheries data analysis	18 Aug-3 Sep	20	FRI scientists
Farming systems research methodologies and aquaculture technologies	6-15 Oct	15	Farming systems research scientists
Orientation training on fish culture	21-23 Oct	7	Mennonite Central Committee* supervisory personnel

*One of the many nongovernmental organizations active in rural development in Bangladesh.

The project, in collaboration with BARC, FRI and USAID, organized a number of training programs (Table 2) for researchers, extension workers and farmers. Assistance was also provided to the Agricultural Expert Committee, appointed by the Government of Bangladesh, for drafting course curricula for fisheries graduate studies. A trainers' training manual on aquaculture technologies was produced.

Project Title		: Socioeconomic Impact of Fish Culture Extension on the Farming Systems of Bangladesh
Cooperating Institutions		: Bangladesh Agricultural Research Council (BARC); Department of Fisheries (DOF); Fisheries Research Institute (FRI); International Fund for Agricultural Development (IFAD); and Danish International Development Agency (DANIDA)
Duration		: June 1990-May 1993
Key Personnel	ICLARM	: Dr. Mahfuzuddin Ahmed, Dr. Clive Lightfoot, Ms. Mary Ann P. Bimbao, Dr. Modadugu V. Gupta, Dr. Max Aguero, Dr. Roger S.V. Pullin
	DOF	: Mr. A.K. Ataur Rahman
	BARC	: Dr. A.K.M. Nuruzzaman
	FRI	: Dr. Md. Aminul Islam

Objectives

The main objective of this project is to assess the socioeconomic impact of introducing fish culture techniques through extension programs on the rural households and community. Specific objectives are:

- To identify appropriate fish culture and extension practices from the point of view of cost-effectiveness and output efficiency within a whole farm system.
- To identify the most important factors affecting the fish culture system.
- To determine the degree to which an intensified extension program affects the rate of technology adoption by the farming community.
- To evaluate changes in production in the target region and determine impact on various social groups in terms of traditional welfare indicators (income, employment, nutrition, education and participation, etc.).
- To provide guidelines for future policies and strategies of aquaculture extension within the farming systems of Bangladesh.
- To provide training on fish culture techniques, extension and socioeconomic research.
- To develop a framework that will serve as a practical tool to assess the socioeconomic impact of fish culture practices within the farming system.

Results

The activities of the project started in June 1990 with the visit of ICLARM staff Drs. Pullin, Lightfoot and Ahmed and the subsequent

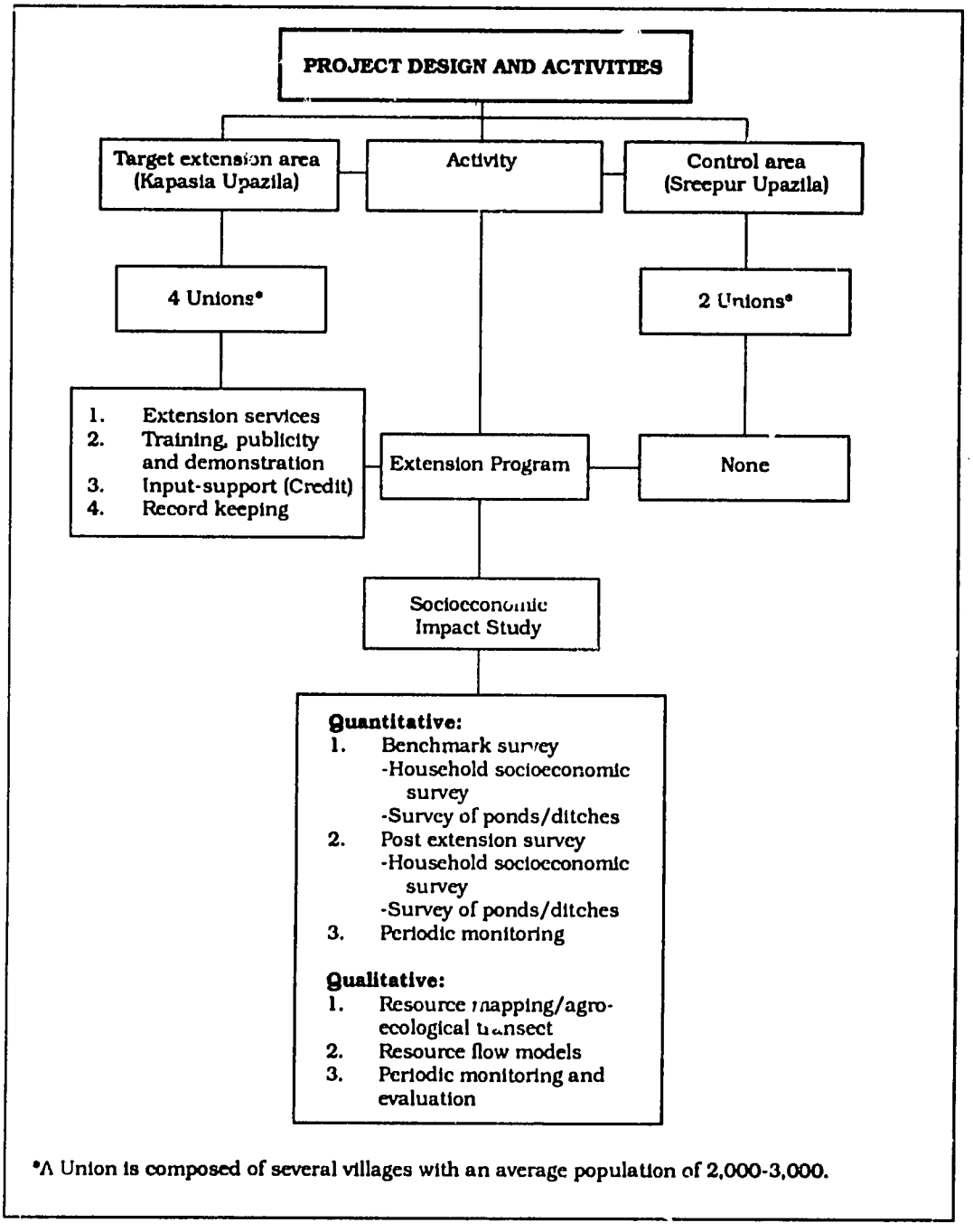


Fig. 1. Experimental design of the fish culture extension impact study.

outposting of Dr. Ahmed to Bangladesh as ICLARM Technical Coordinator. The project focuses on a few village target areas for an in-depth study of the impact of a fish culture extension program in two upazilas of Gazipur district: Kapasia and Sreepur, treated as the target extension area and the control area, respectively (Fig. 1).

INFORMATION PROGRAM

Progress of Work

Library

The ICLARM Library, renamed the Ian R. Smith Library and Documentation Center, was inaugurated in May 1990. The new name was based on a recommendation made by the ICLARM Board of Trustees during its 14th annual board meeting in 1989 to honor the late Dr. Smith.

As of December 1990, the library's holdings consisted of 10,015 volumes of books, monographs, theses and dissertations including conference papers and proceedings; 781 serial titles; 4,684 reprints; over 2,000 pamphlets and clippings; and 288 titles of nonbook materials such as microforms, videotapes, maps and filmstrips.

The library's computerized collection contains databases totalling 15,255 bibliographic references. Materials acquired from 1978 to 1986, however, are still maintained on a catalog card. A 1989 Book Catalog was produced inhouse and made available to other interested local and foreign fisheries libraries.

In 1989, there were 2,177 users representing a 15% decrease over last year because of two months' temporary suspension of library services during its renovation.

Use of the ASFA CD-ROM by external users has grown continuously since its introduction in late 1986. There were 631 users who made access to this database during 1990 representing a 14% increase over last year.

Quick access to the marine science libraries and information centers worldwide has been made possible through the use of SCIENCENET/OMNET electronic mail. The library staff monitors several electronic bulletin boards for other ICLARM staff as well. It is particularly helpful in providing interlibrary loan service to the researchers.

Publications

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 100,000.

Significant publications produced in 1990 include: *Reservoir Fisheries and Aquaculture Development for Resettlement in Indonesia; The Context of Small-Scale Agriculture-Aquaculture Systems in Africa: A Case Study of Malaŵi; The Accuracy of Some Length-Based Methods for Fish Population Studies;* four issues of *Naga, the ICLARM Quarterly;* three issues of *Fishbyte;*

and three issues of *Aquabyte*. In 1990, the Publications Unit has started to use the desktop publishing system to layout its publications.

Distribution of *Naga, the ICLARM Quarterly* (formerly the *ICLARM Newsletter*) from the first issue in July 1978 is more than 156,000 copies. Circulation at the end of 1990 was 3,011 of each issue.

ICLARM hosts the Asian Fisheries Society's Secretariat and handles its editorial and publishing functions. In 1990, the Center edited and produced for the Society three issues of the journal *Asian Fisheries Science*.

Book exhibits. In 1990, ICLARM's publications were exhibited during the Regional Conference on ASEAN's Scholarly Publishing, Universiti Kebangsaan Malaysia, Bangi, Malaysia, 27 to 29 August; the Beijing International Book Fair, 1 to 7 September; the Philippine Trade and Training Center Book Fair, Manila, 8 to 16 September; and the Fish Conservation Week at the Philippine Bureau of Fisheries and Aquatic Resources, Quezon City, 14 to 20 October.

Research

Two studies on the use of fisheries literature were completed. The results of the study by Jay L. Maclean and Joey Vega, comparing the citation behavior of scientists in two Philippine biological journals and an overseas journal were presented in the International Conference on Science Indicators for Developing Countries, Unesco, Paris, in October 1990. The findings of another study, by Managing Editor Letty Dizon, which analyzed citations to the same biological journals, were incorporated in a special problem submitted to the University of the Philippines Institute of Library Science for a master's degree.

Training

The library staff carried out the following training activities during the year:

Technical Advice in Database Management Using Unesco's CDS/ISIS System Software Package for the Information Officer of the Forum Fisheries Agency, Honiara, Solomon Islands, 24 January.

Technical Advice on the Establishment of a Computerized and Online Library System for De La Salle University Library Staff (2), Makati, Metro Manila, 14 February.

Meetings Attended, Papers Presented

Bay of Bengal Programme (BOBP) 14th Advisory Committee Meeting, Medan, Indonesia, 22-25 January. (J.L. Maclean)

Information Cooperation and Resource Sharing, Research Information Utilization Division of the Philippine Council for Aquatic and Marine Research and Development, Makati, Metro Manila, 14 March. (R.M. Temprosa)

Regional Conference on ASEAN's Scholarly Publishing, Universiti Kebangsaan Malaysia, Bangi, and Ming Court Hotel, Kuala Lumpur, Malaysia, 27 to 29 August. (L.B. Dizon)

Beijing International Book Fair, Beijing, China, 1 to 7 September. (L.B. Dizon)

Bellagio Conference on Third-World Aquaculture, Bellagio, Italy, 17-22 September. (J.L. Maclean)

Paper presented:

Maclean, J.L. Third-world aquaculture and harmful algal blooms.

Sixteenth Annual Conference of the International Association of Marine Science Libraries and Information Centers (IAMSLIC), Seattle, Washington, 1-5 October. (R.M. Temprosa, resource speaker)

Paper presented:

Temprosa, R.M. ICLARM's SFIS. Project ADD (Analysis and Document Delivery).

Network of Aquaculture Centres in Asia (NACA) Workshop on Fish Health Management in the Asia-Pacific Region, Pusan, Korea, 10-13 October. (J.L. Maclean)

Paper presented:

Maclean, J.L. Red tides and Asian seafarming.

International Conference on Science Indicators for Developing Countries, Unesco, Paris, France, 14-19 October. (J.L. Maclean)

Paper presented:

Maclean, J.L. and M.J.M. Vega. Citation behavior of Philippine biological scientists.

Asian Fisheries Society Council Meeting, Beijing, China, 21-22 October (J.L. Maclean)

Asian Fisheries Society Resource Allocation Workshop, Beijing, China, 23-24 October. (J.L. Maclean)

ICLARM Support Group meeting, Washington, DC, 28 October. (J.L. Maclean)

Consultative Group on International Agricultural Research (CGIAR) International Centers Week, Washington, DC, 29 October-2 November. (J.L. Maclean)

Meeting of the Council for Fisheries Research and Assistance Institutions (CIFRAI), Rosslyn, Virginia, 1-2 November. (J.L. Maclean)

53rd Annual Meeting of the American Society for Information Science (ASIS), Toronto, Canada, 4-8 November. (R.M. Temprosa)

Publications

Dizon, L.B. 1990. An analysis of citations to the *Fisheries Research Journal of the Philippines* and *Kalikasan, the Philippine Journal of Biology*. University of the Philippines Institute of Library Science, Diliman, Quezon City. 98 p. MLS special problem.

Maclean, J.L. and L.B. Dizon, Editors. 1990. ICLARM Report 1989. 167 p.

Maclean, J.L., R.M. Temprosa, N.I. Jhocson and A.F. Diaz. 1990. Measuring ICLARM's impact on research and researchers. Naga, ICLARM Q. 13(1): 13-14.

Pongase, A.D. 1990. Efficient aggregation of boxes in trophic ecosystem models. ICES C.M. 1990/L:66. 3 p.

Vega, M.J.M. 1990. Who's working on giant clam culture? Naga, ICLARM Q. 13(3): 9.

Vega, M.J.M. 1990. Who's working on tropical fish seed transport? Naga, ICLARM Q. 13(3): 10.

Project Title		: Selective Fisheries Information Service (SFIS) Phase II: Project ADD (Analysis and Document Delivery)
Cooperating Institution		: International Development Research Centre (IDRC), Canada
Duration		: 3 years beginning March 1988
Key Personnel	ICLARM	: Mrs. Rosalinda M. Temprosa Mr. Marcos Jose M. Vega Ms. Adelina P. Mendoza Ms. Matimtiman E. Cruz

Major Objective

To extend the capabilities of the existing ICLARM Information Program to users in tropical developing countries.

Specific Objectives

- To assist in an advisory capacity in strengthening the information capability of fisheries institutions in developing countries.
- To provide answers to specific questions to researchers working in subject areas in which ICLARM has special expertise - finfish and mollusc aquaculture, integrated farming, small-scale fisheries and resource management.
- To analyze 50 selected specific topics of the literature built up over the first three years of the SFIS.
- To provide key literature to enquirers.
- To produce bibliographies and minireviews on important topics are identified by trends in enquiries.

Results

Under the question-and-answer service component of the project, a total of 335 enquiries from 63 countries/territories were received from January to December 1990. Queries from the Philippines (55) were the most numerous, followed by Nigeria (33), then India (29). This differs from 1988 and 1989 results wherein Nigeria is the most numerous. An average of 28 enquiries is received each month. Fig. 1 shows the geographical distribution of enquiries received.

From the 335 enquiries, 17% were "user pays"; 62% were still answered free and 17% availed of the exchange procedure from which we received 21 reprints, 11 monographic/technical reports and 2 sets of photographs of research experiments. The remaining 4% whose requests were outside ICLARM's areas of expertise were referred to other services and appropriate information centers (Southeast Asian Fisheries Development Center

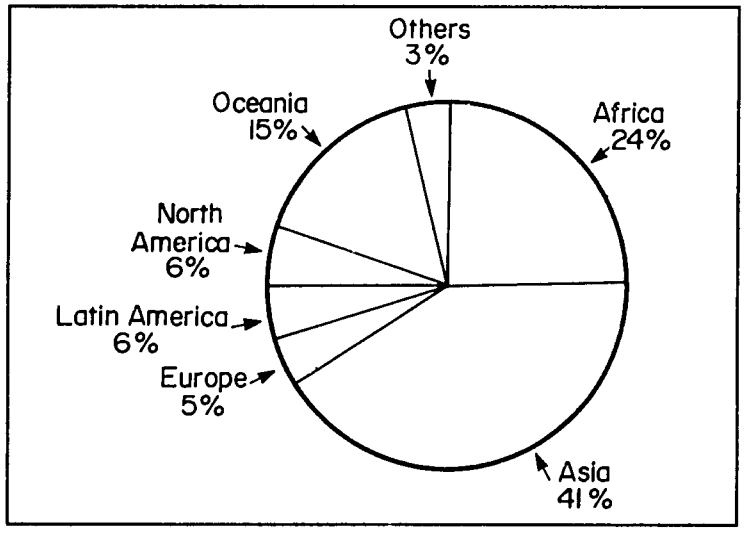


Fig. 1. Geographical spread of SFIS enquiries (January to December 1990, N = 335.

(SEAFDEC) Aquaculture Department, Network of Aquaculture Centres in Asia (NACA), Food and Agriculture Organization (FAO) in Bangkok, INFOFISH and the University of the Philippines (UP) Marine Science Institute). SFIS-ADD provided a total of 6,683 citations/abstracts (3,208 pages) from the Aquatic Sciences and Fisheries Abstracts (ASFA) and inhouse databases and photocopies of 779 key references (9,549 pages). Also, 253 copies of various ICLARM publications, including brochures and 56 volumes from the library collection duplicates were also distributed. Each information package sent was accompanied by a questionnaire card to assess the quality, quantity and effect of the information on the recipients, and to evaluate the usefulness of the user-pays policy. Many respondents commented on the promptness of the service and usefulness of the information.

Table 1 shows that fish biology (91) and culture systems (81) were the most requested topics. Crustaceans (59) and general fisheries (57) were the next largest groups. This pattern differs from the initial three-year phase of the project when tilapia, integrated farming and socioeconomic aspects, respectively, were the most requested subjects.

Table 1. SFIS enquiries by major subject (January to December 1990).

Topic	No.
Fish biology	91
Culture systems	81
Crustaceans	59
General fisheries	57
Molluscs	21
Ecology	18
Tilapia	17
Seaweeds	16
Fish/shellfish nutrition	14
Resource management	13
Integrated farming	12
Socioeconomics	8
Carps	6
Processing	4
Others	125

An analysis of occupation or position held by the enquirer was also made for those determinable. Fig. 2 shows that of the 292 known user types, in decreasing order of frequency of request, researchers made up 35%; administrators and academic/library personnel, 22%; students, 12%; and growers, 9%.

Assistance in information use and handling has been provided

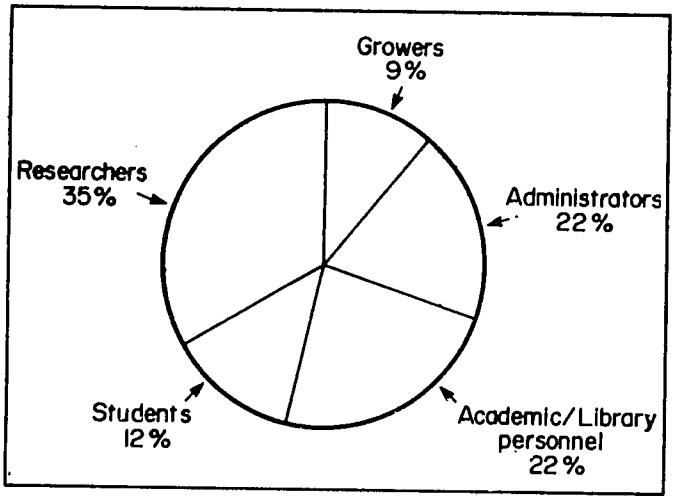


Fig. 2. Distribution of known user-types (January to December 1990, N = 292.

through participation in local and international conferences, workshops and meetings. Short-term training in fisheries librarianship, online searching and nontechnical library activities was also conducted for various groups and individuals, both local and foreign.

Cooperative information activities have also been strengthened with other specialized information centers like the Brackishwater Aquaculture Information System of the SEAFDEC Aquaculture Department, Seaweed Information Center of the Marine Science Institute of the University of the Philippines and the Indonesian Fisheries Information System.

Ten minireviews on various topics have been prepared, two of which have been published in the Naga. Prior to publication, each article is sent to two experts identified during the literature surveys.

SOUTH PACIFIC OFFICE

ICLARM's South Pacific Office (SPO) administers the Coastal Aquaculture Centre (CAC) and is responsible for the development and coordination of all other ICLARM activities in the South Pacific Region. One of the prime objectives for the CAC was to create a purpose-built giant clam hatchery in a representative Pacific equatorial environment at which giant clam farming systems could be tested for their practicality, productivity and economic viability.

The SPO and CAC operate under a formal collaborative Agreement with the Government of Solomon Islands (GSI).

Coastal Aquaculture Centre

Facilities

Giant clam culture

The Coastal Aquaculture Centre (CAC) is administered by ICLARM's South Pacific Office. The present work of the CAC remains focused on the development of farming systems for giant clams but the scope of work is now being expanded into other areas. The 5-ha site of the CAC is leased from the Government of Solomon Islands (GSI) for 50 years from 14 October 1986.

The facilities of the CAC include a hatchery/laboratory, houses for the Hatchery Manager and the Director, cottages for the Foreman and Deputy Foreman, a set of four small one-bedroom chalets and a processing facility. Additionally, there is a power house for a 12.5-kva diesel generator, a store and a workshop. A diving equipment store is located within the main hatchery/laboratory building. Two small freshwater pumps supply potable water from a spring which emerges on site.

The primary pumping facilities at the CAC are two stainless steel 100-mm pumps powered by diesel motors. Backup pumps consist of one 50-mm and one 100-mm diesel powered pumps. Seawater is drawn from the edge of the adjacent reef and is then passed through 80-mm PVC pressure pipes mounted 2-3 m above ground to a variety of circular fiberglass, vinyl and ferrocement tanks and raceways, used variously for broodstock holding and spawning, larval culture and settlement of spat.

The hatchery/laboratory building has a total area of 65 m^2 of general office space, plus a small (7.3 m^2) air-conditioned computer room and scientific laboratory (14.6 m^2). The wet laboratory on the ground floor of the laboratory/office building has seawater recirculation, two 1.6-m^3 fiberglass larval culture tanks and a small array of aquaria and wooden work benches.

A number of new tanks and raceways were constructed during 1990. A set of twelve small (1.0 m x 0.5 m) canvacon raceways with cement substrata has been constructed. These are arranged in four groups of three raceways and are raised on timber frames for ease of working. They will permit a greater range of experiments on conditions affecting growth and survival in the nurseries.

Five "canvacon" circular tanks with galvanized sheet steel walls were completed. These have been constructed using double-width canvacon (3.63 m wide) to give a tank width of 2.5 m and depth of 0.5 m. The bases of the tanks have been lined with cement. Materials cost about US$32.

A D-ended, in-ground continuous raceway, dubbed the "hippodrome", was constructed. The walls are lined with chicken wire and cement. The parallel-sided raceways are 2.5 m long x 1.25 m wide joined by a 1.25 m semicircle at each end. There is a standpipe drain at each end of the central divider. Using a set of simple "monks", the outflow from the online tank/raceway complex is diverted through the hippodrome. Spat are thriving in the system and it thus represents an effective use of the waste water from the system.

Additionally, a new design of 10-m^2 circular tanks constructed from concrete blocks, with a modest amount of reinforcing rods has been perfected. These cost US$230 each for materials and can be built by semiskilled labor.

All of these tanks represent additional space for rearing spat through the 2-9 mm size range as this is currently the limiting factor in production of juveniles at the CAC.

An information pavilion features posters about giant clams, aquaculture and ICLARM and has an 820-l seawater aquarium with displays of various species of giant clams, colorful coral reef fish and invertebrates. An outdoor "touch tank" contains various reef curiosities.

A small processing building with a comprehensive array of processing equipment including refrigerators, freezers, cooker, microwave, mincers, slicers and a smoking and drying kiln was completed in 1990.

In October 1990, ICLARM completed an Agreement with the Provincial Government of Western Province, Solomon Islands, for the development of a field station at Nusa Tupe near Gizo, in the Western Solomon Islands. Nusa Tupe (which translates to "Coconut Crab Island") is the site of the Gizo airstrip and is about 1.5 km offshore from Gizo and has no permanent inhabitants. The field station site is on the southeast corner of the island fronting an exclusive marine leasehold of about 13 ha of shallow sheltered reef. The area has strong tidal flushing and very high water clarity. The station is presently managed by a Scientific Assistant, provided by UK Voluntary Service Overseas. The Western Province Fisheries Department has assigned a Fisheries Officer to the station on a full-time basis and provides office space in Gizo.

Facilities of the station were nearing completion at the end of 1990 and will consist of houses for the Manager and a caretaker/technical aide and a small workshop, store and "laboratory". Capital costs have been funded by the Skaggs Foundation grant (see box). The station will be ICLARM's primary venue for work on selective breeding and on nursery and growout systems and will also serve as a distribution point for giant clam seed in the Western Province.

New grants and support for ICLARM's Coastal Aquaculture Centre and Nusa Tupe Field Station, Solomon Islands, during 1990.

Source	Support	Purpose/remarks
Australian International Development Assistance Bureau (AIDAB)	A$65,000/year	Giant clam predation research; in collaboration with James Cook University and the University of the South Pacific and four regional laboratories
Commonwealth Fund for Technical Cooperation (CFTC)	Full-time services of an Aquaculture Advisor for two years	Advisory services on giant clam nursery and growout systems region-wide
International Center for Ocean Development (ICOD), Canada	C$175,000 over two years	Giant clam production research; expanded facilities; coursed through the Forum Fisheries Agency (FFA)
Overseas Development Administration (ODA), United Kingdom	Full-time services of CAC hatchery staff and preparation of publications	Operation of the giant clam hatchery; publications including a review and bibliography on pearl oysters
United States Peace Corps Volunteers	Full-time services of a volunteer for two years	Maintaining giant clam ocean nurseries and managing CAC computer systems
United Kingdom Voluntary Service Overseas (VSO)	Full-time services of a volunteer for two years	Managing the Nusa Tupe Field Station and Western Province ocean nurseries

Recent Research

The main work of the CAC was carried out under the Giant Clam Mariculture Project (see p. 127). During 1989, larval rearing techniques for *Tridacna gigas* at the CAC had been greatly improved and very high survival rates through metamorphosis attained as a result of a combination of artificial feeds and good husbandry techniques. However, production of spat was relatively poor, principally as a result of heavy mortality of spat in the 3-10 mm size range. This was mostly attributable to heavy overgrowths of blue-green algae which smothered the clams. During 1990, a combination of various species of surgeon fish and saltwater acclimated tilapia, *Oreochromis mossambicus*, proved to be effective in controlling algal overgrowths in the nursery stages and the problem appeared to have been resolved by mid-year.

The CAC's *Tridacna gigas* broodstock were spawned seven times during the course of 1990. Additionally, one cohort of *Hippopus hippopus* was reared. Spat production in now in excess of 20,000, nine-mm spat per month. Inducers such as intragonadal injections of 2 mM serotonin, the addition of suspensions of frozen freshly spawned eggs (egg water) and/or macerated gonad to the spawning tanks, heat stress and changes in water level were routinely used but spontaneous spawnings also occurred. The

cost of the standard larval feeding regime (freeze-dried algae and Frippak microcapsules) is around US$50.00 per cohort; negligible in relation to other operating costs and the costs of the alternative use of axenic cultures of live algae. Departures from previously accepted larval rearing methods have included keeping pediveligers in vinyl-lined outdoor larval rearing tanks through metamorphosis until 3-4 weeks old and maintaining the feeding regime until large numbers of symbiotic zooxanthellae are visible in the juvenile clams.

The excess supply of juvenile clams permitted the CAC to start supplying fully quarantined larvae or juvenile clams to hatcheries in areas where *Tridacna gigas* and *Hippopus hippopus* have become extinct or nearly so. Preliminary experiments have shown adequate survival of 18-day old juveniles in sealed oxygen-filled bags over 3-6 days.

A new floating catamaran-style ocean nursery was designed and tested in relatively exposed waters at the CAC. The tests have confirmed that excellent growth and survival rates are attainable. By the end of the year, twenty such catamarans were in service at the CAC, two at Nusa Tupe and one in a village trial at Marau Sound, Guadalcanal.

The principal benefits of the floating ocean nurseries are that if, as appears likely, growth and survival rates of spat are improved over those retained in tanks, it will be possible to increase greatly the annual output of the land-based tank system by reducing the residence time in settlement tanks. A major secondary benefit will be that it is likely to be feasible to pass the spat to specialized village-based ocean nursery operators, adding value in the village.

The current production system is illustrated in Fig. 1. There are currently 19 cohorts of juvenile *T. gigas* and one of *Hippopus hippopus* in ocean nurseries situated at the CAC, Nusa Tupe and at 12 other locations around the Solomon Islands as part of the village-based trials. The oldest cohorts are in growout exclosures. Growth and survival rates for juvenile clams varied greatly between ocean nursery sites. To date, the best growth has been achieved in shallow sites (1 m) which are thoroughly flushed with oceanic seawater by tides and currents but are not exposed to significant wave action. Losses have been high in some habitats but by the end of the year about 70,000 juveniles were alive, of which 2,500 were in the village-based ocean nurseries. Significant improvements in survival rates are now being attained in the ocean nurseries and the expectation is that this trend will continue over the next few years. Experiments are in progress to attempt to assess the effects of density, handling, substrate and ocean nursery regime on growth and survival in juvenile clams.

Invertebrate predators of juvenile clams, particularly gastropods, have been studied in both the field and aquaria and it is expected that the results obtained will represent a significant advance in the knowledge of this aspect of giant clam farming (see p. 127).

A relational database, CLAMBASE, for tracking the history and disposition of cohorts of giant clams through the hatchery, nursery, ocean nursery, growout and harvest stages was completed and work started on inputting the enormous array of data gathered since 1987. The database permits the rapid evaluation of the precise history of any batch of clams, irrespective of the number of times they have been subdivided or recombined. Environmental factors, identities of predators and other pertinent information are monitored. Stocking densities, survival rates, mean sizes and age are automatically

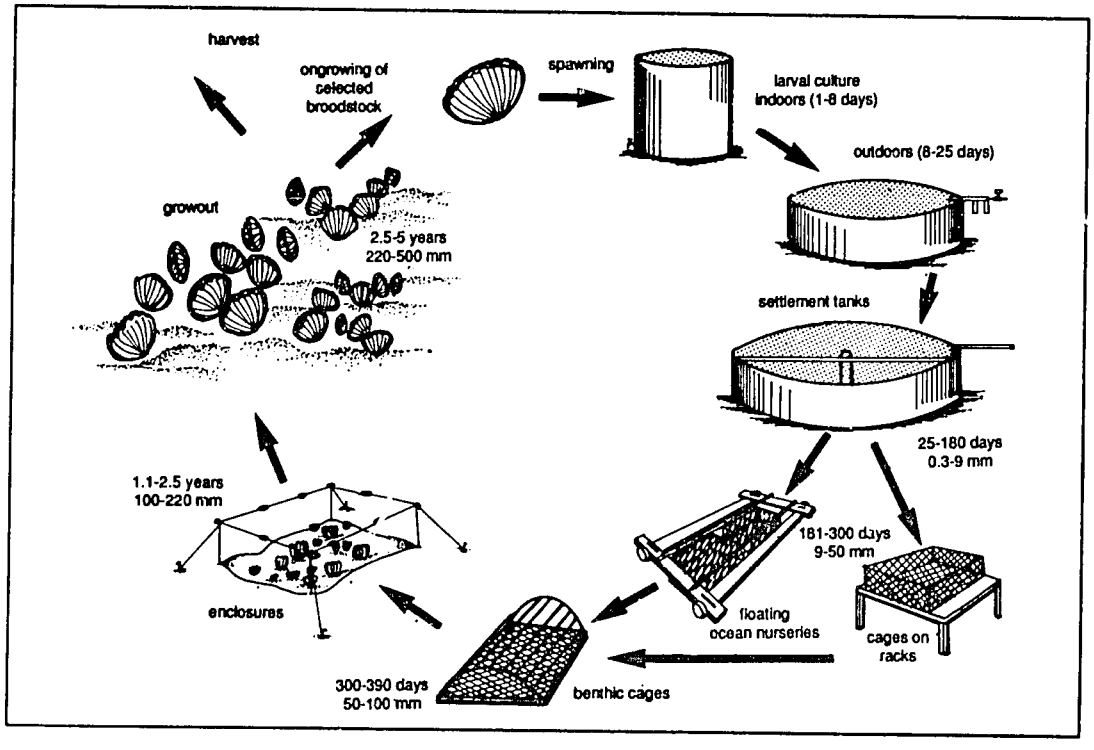


Fig. 1. The giant clam production system currently used by the Coastal Aquaculture Centre.

computed on a continuing basis. The database design is adaptable to almost any cultivated organism and we expect to be able to make it available for the use of other groups by the middle of 1991.

Work was continued in collaboration with the National Resources Institute (NRI) of the United Kingdom on the properties of *Tridacna gigas* muscle and mantle flesh, with a view to future product development. Work to date has shown that it is possible to produce dried "kaibashira" (dried white ligament) from *T. gigas*. However, additional work is required before the product is considered suitable for export markets. A relatively sophisticated but inexpensive smoking/drying kiln was constructed in Honiara for this work (see p. 132).

Heavy exploitation of giant clams for domestic consumption appears to be leading to a scarcity of *Tridacna gigas* broodstock in the eastern half of the Solomon Islands, reflected in a current market price of SI$85 (=US$33) for a 70-cm clam containing 8-10 kg of flesh. The CAC team is having to search further afield for broodstock.

Reef ranching systems

A project, funded by the South Pacific Regional Environmental Programme (SPREP) of the South Pcific Commission, designed to examine the movements of reef fishes within the CAC's exclusive marine leaseholding is being undertaken. Following delivery of the fish tags and construction of a fleet of ten Antillean Z-traps, several hundred fish have been tagged to date.

Pearl oyster cultivation

The CAC is considering research on mass cultivation of black-lip and gold-lip pearl oysters, *Pinctada margaritifera* and *P. maxima*. Initial funding was provided by the British ODA/BDDP to enable Mark Gervis to undertake a preparatory study starting in November (see p. 131).

There is much interest, on a worldwide scale in the cultivation of pearl oysters: for the culture of pearls, for their shells and for their flesh. Stocks have been exploited for centuries and unsurprisingly, many stocks have been drastically depleted. Three species of pearl oyster dominate the industry: *Pinctada fucata* from Asian and Japanese waters, *P. margaritifera* with a circumtropical distribution and *P. maxima* from the central Indo-Pacific region.

Techniques for the artificial culture of pearls have been brought to a high level of sophistication and are practised in a few countries where the expertise is available. However, the limited stocks of mature pearl oysters have remained a barrier to expansion of the pearl culture industry and wild stocks have become increasingly under pressure for their shells. Prices for shell were around US$6,000/t in 1990.

Reports have been published on the small-scale cultivation of the major species and some of these advances have been translated into successful mass cultivation methods by commercial concerns in Japan and Australia, but despite the high level of interest in the topic there has been no dissemination of the methodologies in the scientific literature.

The global shortage of adult pearl oysters for pearl culture and of pearl shells has been met by the development of spat collection techniques for *P. margaritifera* in some of the closed atolls of French Polynesia and in the Cook Islands. However, the Australian industry is still heavily dependent upon wild oysters (mostly *P. maxima*) for all aspects of production, as are the shell export industries of the Philippines, Indonesia, Papua New Guinea and of the islands of Oceania.

It is therefore apparent that the development of mass culture techniques for pearl oyster larvae and spat could be of very great importance in the South Pacific Region.

Linkages

The Coastal Aquaculture Network (CAN) (see p. 132) was formally created in 1988 to establish linkages with national and regional groups and individual scientists. It includes a Giant Clam Research Group with its own newsletter "Clamlines". Interested parties have been contacted in the Caribbean and the Pacific in connection with the creation of a "Reef Ranching Research Group". Links with the South Pacific Commission's Inshore Fisheries Research Project and with the Forum Fisheries Agency are maintained, particularly in matters connected with coral reef fisheries.

The CAC/CAN facilitates collaboration with national institutions wishing to reintroduce clam stocks; for example, *Tridacna gigas* to the Philippines where the species is virtually extinct and *Hippopus hippopus* to Western Samoa.

These initial attempts indicate that long-distance transport of larval and juvenile giant clams is feasible. Ecologically it is sounder than the

transfer of settled juveniles or adult clams because the chances of transfer of disease organisms is much smaller. For the recipient organization it is easier and cheaper to maintain very small juveniles in quarantine conditions than equivalent numbers of large postsettlement juveniles. Transport costs are also much lower.

ICLARM has entered into a formal Memorandum of Understanding with the Centre for Development Studies (CDS) of the University of Bergen to undertake collaborative studies. The initial focus is on "Economic, social and legal aspects of coastal aquaculture in the Indo-Pacific Region" and a proposal for support of the work has been drawn up by Drs. Edvard Hviding of CDS and John Munro of ICLARM. Dr. Hviding has previously worked in the Solomon Islands on traditional management of resources of the Marovo Lagoon and will return to the Solomons in late 1990 to investigate socioeconomic factors affecting the current village-based giant clam ocean nursery trials.

A Memorandum of Understanding has also been exchanged between ICLARM and the University of Ghent to facilitate collaborative research. The University of Ghent team, Dr. P. Sorgeloos and Mr. Peter Coutteau are involved in the development of a yeast-based microdiet for bivalves. A protocol for testing the diet against the CAC's standard 50:50 mix of Frippak Booster microcapsules and freeze-dried *Tetraselmis suecica* will be implemented in February 1991.

Dr. J. Benzie and Ms. S. Williams of the Australian Institute of Marine Science visited the CAC for several weeks in October to sample the CAC's *Tridacna gigas* broodstock and to collect samples of *T. maxima* for comparative electrophoretic studies.

Education and Training

The CAC provides supervision and course work for graduate students of the University of the South Pacific. Mr. Toata Molea is currently enrolled for the M.Sc. degree. He is jointly supervised by Drs. J.L. and P.E. Munro and by Dr. Alison Haynes of the University of the South Pacific. The Asian Fisheries Society confirmed a grant of US$9,200 in support of Mr. Molea's research project.

The Centre continues to attract considerable interest from local schools and groups of secondary students are regular visitors.

Program Plans

Further experimentation will take place on the use of various artificial diets for larval rearing. There will be continuing work on maximizing spat production in the land-based nursery system and sufficient additional tanks will be constructed to treble the output. Investigations will be made of the role of different strains of zooxanthellae in the growth and survival of juvenile *Tridacna gigas*.

Using the ICOD/FFA funding, additional concrete-block tanks plus two more "hippodromes" will be constructed in 1991 to give a total of 500 m^2 of tank space at the CAC. Two additional 4" pumps will be installed.

The ocean nursery system will be greatly expanded in size during 1991, particularly at Nusa Tupe, to accommodate the increased numbers of spat which are currently moving through the nursery system. Technical improvements in the design and durability of the floating ocean nurseries will be pursued in order to achieve greater cost effectiveness. Other lower cost options such as raised trestles will be tested in sheltered waters. Subject to availability of sufficient funds, the number of village nursery trials will be expanded to encompass 36 sites. Approximately half of the output of the hatchery will be sent to these sites and the remainder reared at Nusa Tupe.

Particular emphasis will be given to studying the life cycles and ecology of the major predators, particularly cymatiid and pyramidellid gastropods. Work on prey species and size selection by the major predators will be complemented by anatomical studies of the predators involved where appropriate. As more data are collected, comparisons will be possible between different ocean nursery designs, mesh sizes, substrates, maintenance regimes and geographic locations. Experiments will be carried out to find organisms suitable for the biological control of pyramidellid and larval cymatiid predators in particular.

Accumulated data on cohort histories will be analyzed and the costs of operation and construction of the giant clam hatchery at the Coastal Aquaculture Centre, in relation to production rates, will be subjected to economic analyses in order to evaluate the economic viability of various options.

Funds are being sought for a genetics project aimed at selective breeding from broodstock with favorable characteristics (particularly growth), the development of homozygous strains of giant clams by self-fertilization and the creation of triploid stocks.

Further funding is also being sought to expand work and processing, product development and marketing of giant clam products.

Work aimed at tagging a significant portion of the fish stocks on the CAC's reef and studying their relative ranges of movement will continue and funding will be sought to expand the work on the potentialities for coral reef fish ranching.

The Coastal Aquaculture Network (CAN) will be expanded and consideration will be given to the formation of additional research groups and the formation of linkages with other institutions concerned with tropical marine aquaculture.

Planning for future work on pearl oysters will be finalized and some preliminary work will be undertaken on spat collection and availability of broodstock.

Meetings Attended, Papers Presented

Globe '90, Vancouver, British Columbia, Canada, 19-23 March. (J.L. Munro).

South Pacific Forum Fisheries Committee. Fourth Annual Technical Subcommittee Meeting, Nauru, 23-27 April. (T. Molea).

Aquaculture International, Vancouver, British Columbia, Canada, 3-7 September. (M. Gervis).

Bellagio Conference on Third-World Aquaculture Development and the Environment, Bellagio, Como, Italy, 17-22 September. (J.L. Munro).
Paper presented:
Munro, J.L. Aquaculture development and environmental issues in the tropical Pacific.

Publications and Consultancy Reports

Gervis, M.H. 1990. Is there an optimum tank design for the rearing of giant clams? Clamlines 8: 7-11.

Govan, H. 1990. Effects of stocking densities on giant clams in ocean nurseries. Clamlines 8: 1-6.

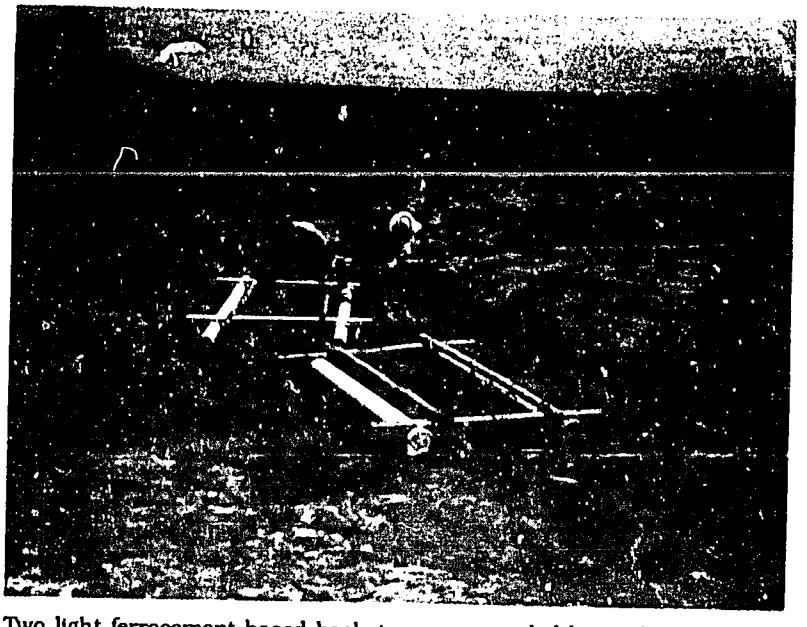
Munro, J.L., Iskandar and B.A. Costa-Pierce. 1990. Fisheries of the Saguling Reservoir and a preliminary appraisal of management options, p. 285-328. *In* B.A. Costa-Pierce and O. Soemarwoto (eds.) Reservoir fisheries and aquaculture development for resettlement in Indonesia. ICLARM Tech. Rep. 23, 378 p.

Potter, I., J.L. Munro and A. Wright. 1990. A review of research on baitfish biology in the Solomon Islands and the Maldive Islands (ACIAR Project 8543): a report to the Australian Centre for International Agricultural Research. 39 p.

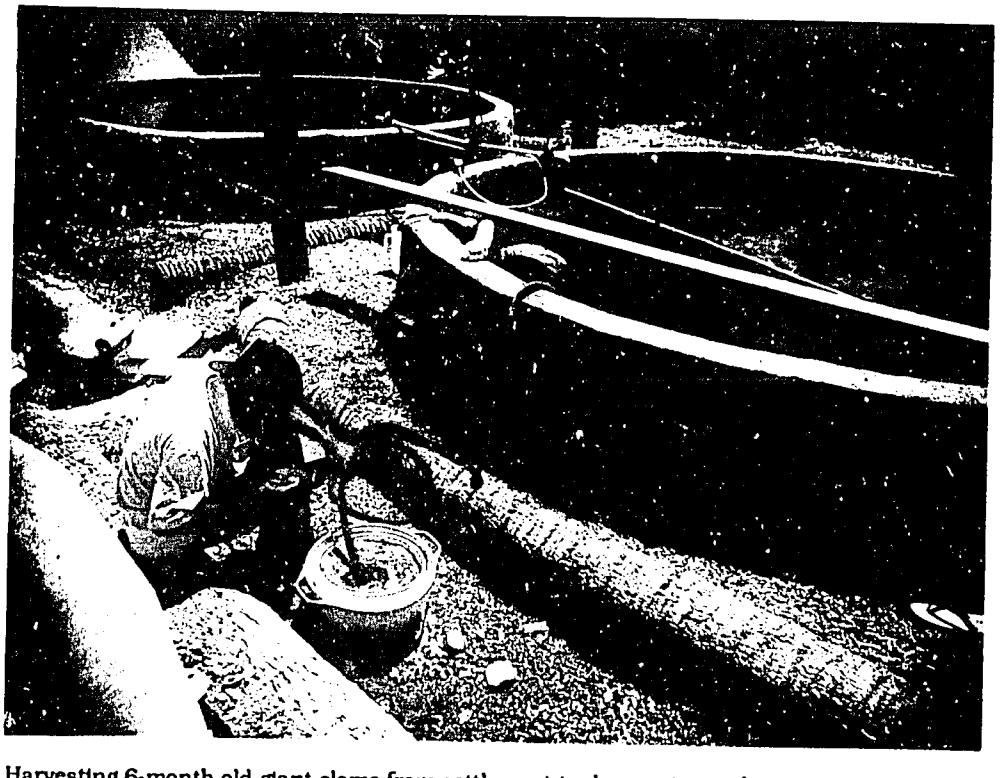
Usher, G.F. 1990. The Coastal Aquaculture Centre's larval rearing protocol for *Tridacna gigas*. Clamlines 9: 4-8.

Unloading giant clam, *Tridacna gigas*, broodstock at ICLARM's Coastal Aquaculture Centre, Solomon Islands.

Five-month old spat of *Tridacna gigas* ready for transfer to floating ocean nurseries.



Two light ferrocement based baskets are suspended beneath each of the catamaran-style floating ocean nurseries used for rearing giant clam spat from 9 mm to 50 mm, after which they are moved to protective cages on the sea bed.



Harvesting 6-month old giant clams from settlement tanks requires only a mask and snorkel, a paint scraper and siphon.

South Pacific Office Project Summaries

Project Title		: Giant Clam Mariculture Project
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. Graham F. Usher, Mr. Mark H. Gervis, Dr. Patricia E. Munro, Mr. Hugh Govan, Ms. Lucy Gilkes, Mr. Toata Molea, Mr. Thomas Shearer, Mr. Idris Lane.
	GSI	: Mr. Hugo Tafea, Mr. Sylvester Diake
	CDS	: Dr. Edvard Hviding
	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, survival and other desirable characteristics.
- To investigate economic, social and legal factors which affect giant clam culture in the South Pacific Region.

Results

The thrust of work at the Coastal Aquaculture Centre has consistently been directed towards investigating low-cost options for giant clam cultivation; to maximizing output per spawning, optimizing settlement densities, minimizing postmetamorphic mortality, speeding spat through the land-based nursery system and outputting to ocean nurseries at the smallest possible size.

Current indications are that it might now be possible to get *Tridacna gigas* into low-cost floating ocean nurseries at a size of only 9 mm or less without unacceptable losses.

During the first two years of operations of the Coastal Aquaculture Centre, a variety of larval rearing methods was used for *Tridacna gigas*, with erratic settlement success. However, given the year-round spawning at the CAC, it was always clear that a survival rate of even 1% from two-day old veligers to visible juveniles, would supply a predictable stream of spat. Since May 1989, a standard protocol for the rearing of larvae and early juveniles has been adopted, and survival obtained to harvest from settlement is now regularly above 1%. The emphasis has been on developing a protocol

that can be carried out by trained, semiskilled staff on a routine basis and the seven cohorts of *Tridacna gigas* and single cohort of *Hippopus hippopus* larvae spawned during 1990 were reared in this manner.

The protocol utilizes two fiberglass 1,500-l flat-bottomed tanks (diameter 1.13 m, height 1.5 m, side drain 20 cm above tank bottom) located in the semi-enclosed hatchery, four outdoor PVC-lined 2,350-l pools (diameter 2.48 m, depth 0.5 m, with central standpipe) and up to 100 m^2 of settlement tanks, depending upon the numbers of 21- to 28-day old juveniles obtained.

Larvae are fed a 50:50 mixture, by weight, of Frippak booster microcapsules and Celsys freeze-dried *Tetraselmis suecica* every second day starting on day 3. On day 8, most larvae have reached the pediveliger stage and they are moved to outdoor tanks. On day 9, symbiotic zooxanthellae are extracted from the mantles of broodstock and added to the rearing tanks at a density of 20-100 cells/ml. The last feed is given on day 13 by which time the symbiosis is well established and all spat are settled on the bottom of the tanks but are still highly mobile.

A feature of the protocol is that all tanks are sieved through an 80-µm screen every second day from day 2 to day 12 and the tanks refilled with filtered UV sterilized seawater. By the final water change on day 14 the larvae have metamorphosed into juveniles. These juveniles are then left in the PVC tanks for 1-2 weeks (depending on availability of settlement tanks) after which time they are sieved out a final time and quantitative samples taken for measurement and counting, before stocking into concrete settlement tanks. Water in these tanks is allowed to flow out of the top of the central standpipe for one week before a standpipe sleeve is fitted so that the outflow is taken from the bottom of the tank.

One of the most important aspects of the protocol is the holding of the larvae in the outdoor larval rearing tanks until they have undergone metamorphosis. This enables an accurate estimate to be made of survival through metamorphosis and stocking densities in the settlement tanks can then be adjusted to give maximum growth and survival. This is particularly important to avoid stunting due to overcrowding in the microscopic juvenile stages when density management by thinning is impossible.

Survival using the above protocol from day 2 veliger to juveniles stocked into the settlement tanks was between 3.3% and 6.2% during 1990. Survival from stocking to the first count at 57-119 days has ranged from 10.5% to 82.5%. However, in all cases where postsettlement survival was less than 20%, juveniles were stocked at much higher densities than 2/cm^2 due to lack of tank space. With the recommended stocking density a minimum survival rate of 50% is obtained. Therefore, taking a maximum number of 60 million day 2 veligers, it is expected that at least two million spat will be stocked into settlement tanks. Even taking a pessimistic estimate of 25% survival to two months old, approximately 500,000 macroscopic juveniles are obtained from each spawning.

During 1990, a new floating catamaran-style ocean nursery for giant clams was tested. The nurseries consist of two floats (1.94 m x 150 mm PVC pipe with end caps) linked by hardwood cross bearers, with two ferrocement-based baskets suspended between the floats at a depth of 45 cm (Fig. 1). Results of the trials, in which the growth and survival of batches of *T. gigas* in the floating ocean nurseries was compared with controls maintained in raceways, showed an increase from 10.3 mm to an average of 37.5 mm in

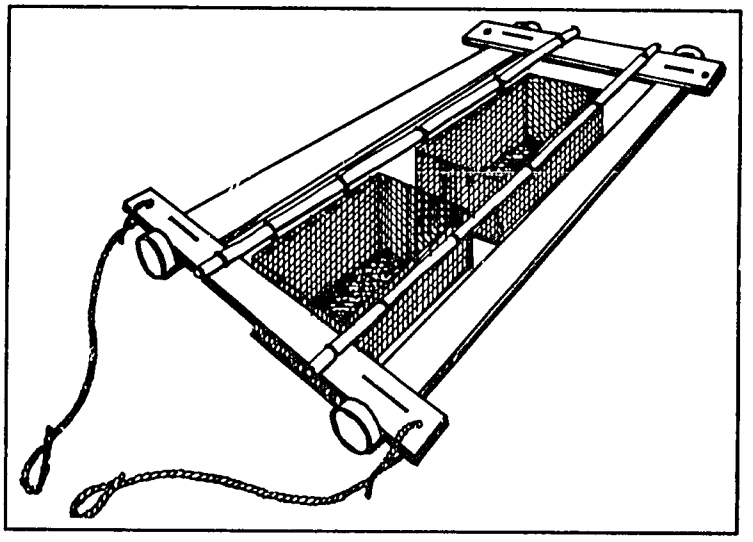


Fig. 1. Floating ocean nursery for giant clams.

150 days. In contrast, the controls increased to an average size of only 17.2 mm. Survival in the floating ocean nurseries averaged 79% while the controls in the raceways had 30% and 69% survival, respectively.

Most trials were done in the relatively exposed waters offshore from the CAC, but two floating ocean nurseries at Nusa Tupe were yielding excellent results by the end of the year.

Spat production at the CAC is expected to rise progressively to 60,000 per month as the new ICOD-funded settlement tanks come on line.

Algal overgrowth was the major constraint on production in 1989 and early 1990 but the use of surgeon fish, salt-acclimated *Oreochromis mossambicus* and various grazing invertebrates solved the problem. The surgeon fish, principally *Ctenochaetus striatus* and *Zebrasoma scopas*, seem to be particularly effective.

The CAC currently has 53 *Tridacna gigas*, and 10 *Hippopus hippopus* broodstock clams. There are 29 cohorts of juvenile *T. gigas* and one of *H. hippopus* in ocean nurseries situated at the CAC, at Nusa Tupe and at 12 other locations around the Solomon Islands as part of the village-based ocean nursery trials. The oldest cohorts will be moved to growout sites in the early part of next year. Growth and survival rates for juvenile clams varied greatly between ocean nursery sites. To date, the best growth has been achieved in shallow sites (1 m) which are thoroughly flushed with oceanic seawater by tides and currents but are not exposed to significant wave action. Losses have been high in some habitats but by the end of the year about 70,000 juveniles were alive, of which about 2,500 were in the village-based ocean nurseries.

Great enthusiasm has been shown by potential clam farmers throughout the Solomon Islands. The village-operated ocean nursery trials have, in general, achieved as good or better growth and survival rates than those achieved at the CAC and preliminary results appear to confirm the acceptability and suitability of the farming techniques for rural Solomon Islanders.

Project Title		: Reef Ranching Research Project
Cooperating Institution		: South Pacific Regional Environmental Programme, South Pacific Commission
Duration		: Indefinite
Key Personnel	ICLARM	: Dr. John L. Munro, Ms. Lucy Gilkes
	SPC	: 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 by artificial means.
- To investigate economic, social and legal factors which affect reef ranching or replenishment systems in the South Pacific Region.

Results

Work on the feasibility of coral reef fish ranching started in 1989. An inventory of species of potential interest was compiled and, following delivery of fish tags and construction of a fleet of ten Antillean Z-traps, several hundred fish were tagged within the CAC's exclusive reef leasehold. However, recovery rates were low indicating that either the numbers tagged were an insignificant fraction of the stocks, that substantial outmigration is occurring or that tag loss or tagging mortality has been severe.

An expanded fishing, tagging and observation program will be mounted in 1991. Additional funding is being sought to broaden the scope of the investigations.

Project Title		: Status of Cultivation of Pearl Oysters in the Indo-Pacific Region: A Review
Cooperating Institutions		: Various
Duration		: 14 months until December 1991
Key Personnel	ICLARM	: Mr. Mark H. Gervis, Dr. John L. Munro

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

Commencing in November 1990, Mr. M.H. Gervis visited most major establishments involved in pearl oyster cultivation in Australia and commenced a voluminous correspondence with other investigators on a worldwide basis. Mr. Neil Sims of Hawaii accepted an invitation to coauthor the review of the biology and cultivation of pearl oysters, which will include sections on the history and current status of pearl oyster cultivation and pearl culture.

Most of the bibliography, consisting of over 1,000 key references, had been compiled by the end of the year and a substantial part of the review had been completed. Arrangements have been made for the review and bibliography and, possibly, some translations to be published by ICLARM as joint ICLARM/ODA reports.

Project Title : Coastal Aquaculture Network

Cooperating Institutions : James Cook University of North Queensland, Townsville, Australia; Fisheries Research Branch, Department of Primary Industry, Brisbane, Queensland, Australia; Fisheries Division, Ministry of Agriculture and Fisheries, Suva, Fiji; Center for Oceanological Research and Development, Jakarta, Indonesia; Fisheries Division, Tarawa, Kiribati; University of Papua New Guinea, Port Moresby, Papua New Guinea; Silliman University, Dumaguete, Philippines; Marine Science Institute, University of the Philippines, Quezon City, Philippines; Fisheries Division, Honiara, Solomon Islands; Overseas Development Natural Resources Institute, Chatham, UK; University of Newcastle-upon-Tyne, UK; Fisheries Division, Apia, Western Samoa; and the Australian Institute of Marine Science, Townsville, Australia

Duration : Indefinite

Key Personnel ICLARM : Dr. John L. Munro, Ms. Cathreena M.T. Gervis

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 exchange of information and results by newsletters and meetings.
- To promote exchange visits between participating institutions.

Results

The Coastal Aquaculture Network (CAN) was formally created in 1988. Membership is now comprised of the 13 institutions participating in the "Giant Clam Research Group" plus over 100 individuals. Two issues of the newsletter "Clamlines" were published during the year. Interested parties have been contacted in connection with the creation of a "Reef Ranching Research Group" and the group will be formally launched early next year, including participants in the Caribbean and the Pacific.

Under the auspices of the CAN, over two million *Tridacna gigas* pediveligers were shipped to the Marine Science Institute, University of the Philippines, in support of their program to re-establish stocks of this species in the Philippines.

Each oxygenated plastic bag contained approximately 200,000 larvae in one liter of 1 µm filtered UV sterilized seawater, with 1 ppm chloramphenicol. Over 15% of the larvae were estimated to have survived and metamorphosed successfully and it was expected that 15,000 to 60,000 two-month old juveniles would be obtained from this batch. However, most succumbed in a heat wave in May when intake water temperatures rose to 34°C, and fewer than 2,000 were alive, but had attained a substantial size by the end of the year.

In December, over 200,000 three-week old *Hippopus hippopus* were shipped to the Fisheries Division, Western Samoa, in hermetically sealed oxygenated plastic bags, transported flat, thus allowing for greater surface area for gas exchange and eliminating leakage. This was a first step towards reintroducing this species to Western Samoa where it has become extinct. The transhipped spat or larvae were reared in filtered UV sterilized seawater and are to be maintained maintained in quarantine by the recipients for six months in accordance with established protocols.

Dr. Russell Parry of the Overseas Development Natural Resources Institute (ODNRI) in London worked at the CAC for two months from February to April investigating the properties of *Tridacna gigas* muscle and mantle flesh. A report has been prepared covering morphometrics and chemical composition of the mantle and adductor muscle, iced and frozen storage of mantle and adductor and accompanying textural changes, drip losses, effects of prolonged storage, effects of cooking and the preparation of dried adductor and mantle.

This work plus previous work on *T. derasa* adductor and mantle at ODNRI by T. Sanders in 1987 and subsequent work at the CAC confirms that it is possible to produce dried "kaibashira" (dried white ligament) from *T. gigas*. However, additional work is required before the product is considered suitable for export markets. A relatively sophisticated but inexpensive smoking/drying kiln was constructed in Honiara for this work.

ICLARM consultant Lynda Cowan visited Japan, Taiwan, Hong Kong and Singapore in May to investigate the range of shellfish products which are consumed, their prices, their preparation for consumption and the manner in which they are processed.

Project Title		: A Collaborative Investigation of Predation on Cultivated Giant Clams (Tridacnidae: Bivalvia)
Cooperating Institutions		: James Cook University of North Queensland, Australia; University of the South Pacific, Suva, Fiji; Silliman University, Dumaguete, Philippines; Marine Science Institute, University of the Philippines, Quezon City, Philippines
Duration		: Two years
Key Personnel	ICLARM	: Dr. John L. Munro and Mr. Hugh Govan
	JCU	: Dr. John 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 the identification of giant clam predators.

Results

This work is a collaborative research project funded by the Australian Special Purpose Grants to International Agricultural Research Centers.

Research programs are now underway in the five collaborating institutions in this study. Invitations to participate have also been extended to the Fisheries Divisions of Western Samoa and Fiji.

A draft of a review by Hugh Govan of current knowledge of giant clam predators was completed and circulated to the collaborating institutions. Work is continuing in order to identify the major predators of juvenile tridacnids at the different collaborating institutions.

Work has been carried out at JCU to determine the effect of parameters such as mesh size and substrate on predation. Predation in different locations and cage types is being compared at the CAC and data are being collected from all institutions to compare the distribution of predators through as wide a geographical and environmental range as possible.

The majority of predator- or pest-related mortalities appear to be caused by cymatiid and pyramidellid gastropods. All observations confirm that cymatiid snails are by far the most serious predators of giant clams in equatorial Pacific ocean-nurseries. Cymatiids may settle out of the plankton on or near clams in the larval stage or during metamorphosis. These larval cymatiid infestations can cause very high mortality and would appear extremely difficult to control. Work in progress at the CAC includes the experimental determination of growth and consumption rates, prey preference experiments and studies of the reproductive biology of the four species of *Cymatium* occurring at the CAC.

Pyramidellid snails are potentially important parasites that retard growth and increase mortality. They are, however, relatively easy to detect and control with adequate husbandry techniques. Pyramidellids are reported to be the most serious pests of clams found so far at the Orpheus Island Research Station (OIRS), operated by JCU on the Great Barrier Reef. Within the western Pacific two or three species appear to be implicated in infestations of giant clam nurseries. *Turbonilla* sp. is found at OIRS and in the Solomon Islands. *Tathrella iredalei* has been reported from Palau and an unknown species has been reported from Bolinao, Philippines. Reports of infestations can be expected from other institutions when higher densities of clams are reached in their nurseries.

A polyclad turbellarian has been found to kill clams at the CAC and appears to settle out of the plankton early in its life cycle into ocean nursery cages. It is too early to determine the risk posed by these animals but similar flatworms are reported to be a pest of cultured oysters in the Caribbean.

Other predators such as crabs, hermit crabs, fish and octopi appear to be relatively easy to control.

ADMINISTRATION AND FINANCE

Board of Trustees

The Center is administered by a Board of Trustees composed of fifteen members. Two of these members serve on an ex-officio basis, while the others, though affiliated or formerly affiliated with various international and national institutions, serve in their personal capacities. The ex-officio members of the ICLARM Board are the Center's Director General and the highest ranking Philippine government official with direct responsibility for fisheries (presently the Secretary of the Department of Agriculture).

The Board's primary responsibilities are:

a) to act as the policymaking body of the Center;
b) to lay down or approve the Center's programs;
c) to review the finances of the Center and approve an annual budget; and
d) to review the progress and management of the Center.

The ICLARM Board of Trustees also has several standing committees to assist the Board in carrying out its responsibilities. The Board members elect, from among themselves, members to these standing committees. In 1990, the Board had four standing committees - the Executive Committee, Finance and Management Committee, the Program Committee and the Nominating Committee.

A list of members of the 1990 ICLARM Board of Trustees and the activities and terms of reference of and membership on the 1990 Board Committees follows.

Board Membership

At the end of the 1989 annual meeting, which was held in December 1989, Dr. Martin Bilio, Ms. Hannah King and Dr. Keishi Amano having completed their first three-year term, were elected to serve for a second and final three-year term to expire at the end of the 1992 meeting. Meanwhile, retiring Board members, Dr. Gunawan Satari and Dr. Gunnar Saetersdal, were replaced by the following individuals who were elected, at the 1989 meeting, to a first term of three years:

1. Dr. Zimani David Kadzamira	Principal, Chancellor College, University of Malaŵi (1981 to present), and

2. Dr. E.A. Huisman — Head, Department of Fish Culture and Fisheries, P.O. Box 338, 6700 AH Wageningen, The Netherlands

At the 1990 Board Meeting, Dr. M.S. Swaminathan was elected to serve a second and final term to expire at the end of the 1993 annual meeting.

The full Board membership follows:

1. 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.
2. 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.
3. Mr. Senen Bacani: Philippine Department of Agriculture - Secretary (1990). Elected ICLARM Board Member in 1990.
4. Dr. Martin Bilio: Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Cooperation) - Head, Fisheries and Aquaculture (1982 to present). ICLARM Board Member since 1986.
5. Dr. Edgardo D. Gomez: University of the Philippines - Director, Marine Science Institute (1975 to present). ICLARM Board Member since 1989.
6. Dr. Alban F. Gurnett-Smith: Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia - Former Secretary (Research); International Rice Research Institute (IRRI) Board of Trustees - Former Member. ICLARM Board Member since 1982.
7. Dr. E.A. Huisman: Department of Fish Culture and Fisheries, The Netherlands - Head. Elected ICLARM Board Member in 1989.
8. Mr. Roy I. Jackson: International Pacific Salmon Fisheries Commission (1938-1955); International North Pacific Fisheries Commission (1955-1964); Food and Agriculture Organization (FAO) - Director, Fisheries Division (1964-1965), Assistant Director General (1966-1971), Deputy Director General (1972-1977). ICLARM Board Member since 1982.
9. Dr. Zimani David Kadzamira: Chancellor College, University of Malaŵi - Principal (1981 to present). Elected ICLARM Board Member in 1989.
10. Ms. Hannah R. King: Commonwealth Secretariat (London) - Fisheries Officer, Food Production and Rural Development Division. ICLARM Board Member since 1986.
11. 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.
12. Dr. David Adolph Philipp Muller: South Pacific Forum Fisheries Agency - Director (1981 to present). ICLARM Board Member since 1989.
13. Dr. Roger S.V. Pullin: ICLARM - Director, Aquaculture Program.
14. Mr. Basilio M. Rodriguez, Jr.: ICLARM - Director, Administration and Finance.

15. Dr. James A. Storer: Food and Agriculture Organization (FAO) - Director, Fishery Economics and Institutions Division of the Department of Fisheries (1969-1973); NOAA, US Department of Commerce (1973-1978); US Department of State - Director, Office of Fisheries Affairs, Bureau of Oceans and International Environmental and Scientific Affairs (1978-1986). ICLARM Board Member since 1983.
16. Dr. Monokumbu S. Swaminathan: India Ministry of Agriculture - Secretary (1979-1980); India Planning Commission - Member (1980-1982); International Rice Research Institute (IRRI) - Director General (1982-1988); International Union for the Conservation of Nature and Natural Resources (IUCN) - President (1984 to present). ICLARM Board Member since 1988.

1990 Meetings

In 1990, the Center's trustees held the following meetings:

- Program Committee Meeting
- 15th Annual Meeting of the ICLARM Board of Trustees - 20 to 21 May 1990
- Nominating Committee Meeting - 23 to 25 May 1990
- Finance and Management Committee Meeting - 22 May 1990
- Executive Committee Meeting - 27 and 29 October 1990

The various actions taken by the Board of Trustees during the above meetings are summarized below:

Programs

- Reviewed the progress and activities of the Center's research programs.
- Instructed the staff of ICLARM to begin the preparation of a Strategic Plan for ICLARM. Further instructed the staff to hire Dr. Curtis Farrar as a consultant for the Center's strategic planning effort.
- Encouraged the staff to seriously consider linkages with national programs as part of the proposed Strategic Plan.
- Expressed continuous support for the tilapia breeding program while endorsing a suggestion for the program to consider consumer acceptability in order to protect farmer yields.
- Recognized and stressed the importance of the global climatic change issue and for ICLARM to keep abreast of developments in this area.
- Reviewed the progress of the Study on International Fisheries Research (SIFR).

Finances

- Reviewed and accepted the 1989 external auditor's reports.
- Reviewed financial management progress in 1990.
- Reviewed the progress of the Center's fund raising activities and prepared strategies for the Center to meet the expected unrestricted funding shortfall in 1991.

Administration

- Reviewed and took action on the recommendations of the Acting Director General on personnel and management issues.
- Interviewed candidates brought forward by the DG Search Committee. Approved the appointment of Dr. Kenneth T. MacKay as ICLARM Director General.
- Reviewed the administrative implications involved in Strategic Planning and of affiliation with the CGIAR.
- Reviewed the security needs for the Center's personnel, document, material and data. Instructed staff to prepare security guidelines and procedures.
- Continued to review the status of ICLARM's request for land allocation from the Department of Agriculture to serve as the site of the proposed ICLARM Headquarters building.
- Followed up on the progress of ICLARM's efforts to obtain international organization status within the Philippines.

Board Matters

- Agreed that greater effort be made to increase the involvement of all trustees in Board activities and decisionmaking.
- Agreed to move the schedule of the Annual Meeting from November/December each year to the second quarter of each year.
- Elected the officers of the Board for 1990-1991 as well as the 1990-1991 Board Committee Membership.

Board Officers and Committees, 1990-1991

BOARD OFFICERS (1990 and 1990-91)

Mr. Roy I. Jackson	-	Chairperson
Mr. Senen Bacani	-	First Vice-Chairperson
Mr. Alban F. Gurnett-Smith	-	Second Vice-Chairperson
Dr. Roger S.V. Pullin	-	Treasurer
Mr. Basilio M. Rodriguez, Jr.	-	Secretary

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 (1990 and 1990-91):

Mr. Roy I. Jackson - Chairperson
Mr. Senen Bacani
Mr. Alban F. Gurnett-Smith
Dr. Martin Bilio
Dr. James A. Storer
Dr. M.S. Swaminathan
Mr. John L. Maclean

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 (1990 and 1990-91):

- Dr. James A Storer - Chairperson
- Mr. Roy I. Jackson
- Mr. Senen Bacani
- Mr. Alban F. Gurnett-Smith
- Dr. Martin Bilio
- Dr. M.S. Swaminathan
- Mr. John L. Maclean

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 of 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:

1990:

Dr. Martin Bilio - Chairperson
Dr. Keishi Amano
Ms. Hannah R. King
Dr. Peter Larkin
Dr. Edgardo Gomez
Mr. John L. Maclean

1990-91:

Dr. Martin Bilio - Chairperson
Dr. Agustin Ayala-Castañares
Dr. Peter Larkin
Dr. Edgardo Gomez
Mr. Philipp Muller
Mr. John L. Maclean

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:

1990:

Mr. Alban F. Gurnett-Smith - Chairperson
Ms. Hannah King
Mr. Philipp Muller
Dr. Agustin Ayala-Castañares
Mr. John L. Maclean

1990-91:

Dr. M.S. Swaminathan - Chairperson
Dr. Agustin Ayala-Castañares
Dr. Zimani Kadzamira
Dr. Keishi Amano
Ms. Hannah King
Mr. John L. Maclean

1990 SOURCES OF SUPPORT

1. Unrestricted Support

International Bank for Reconstruction and Development (IBRD)
United States Agency for International Development (USAID)
Australian International Development Assistance Bureau (AIDAB)
Danish International Development Agency (DANIDA)
Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ)

2. Restricted Support

Activity	Sources of 1990 Support
a. Giant Clam Project/Coastal Aquaculture Centre	Commission of the European Communities (CEC) Forum Fisheries Agency (FFA) Overseas Development Administration (ODA) South Pacific Commission Skaggs Foundation Australian International Development Assistance Bureau (AIDAB) United States Agency for International Development (USAID)
b. Asian Fisheries Social Science Research Network	International Development Research Centre (IDRC) of Canada
c. Management Options for Small-Scale Fisheries	Ford Foundation, New York
d. Selective Fisheries Information Service	International Development Research Centre (IDRC) of Canada
e. Network of Tropical Fisheries Scientists	Food and Agriculture Organization (FAO)/Danish International Development Agency (DANIDA) Norwegian Ministry of Development Cooperation (NORAD)

f. ASEAN/US Coastal Resources Management	United States Agency for International Development (USAID) Brunei Darussalam Government
g. Reservoir Management (Cirata and Saguling Dams, Indonesia)	International Bank for Reconstruction and Development (IBRD)
h. Appropriate Technology for Aquaculture in Africa	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
i. Germany-Israel Third-World Aquaculture Research Cooperation	Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ)
j. Rice-Fish Farming Systems	Asian Development Bank (ADB) International Development Research Centre (IDRC) of Canada
k. Publication - The Peruvian Anchoveta and its Upwelling Ecosystem: Three Decades of Change	Programa Cooperativo Peruano Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) through Programa Cooperativo Peruano
l. Management of Tropical Small-Scale and Open Water Fisheries in Bangladesh	Ford Foundation, Bangladesh
m. Interregional (Asia-Africa) Cooperation in Aquaculture	French Government
n. Tilapia Genetic Improvement	Asian Development Bank (ADB) United Nations Development Programme (UNDP)
o. Collaborative Research Support Program	University of Rhode Island (URI-USAID)
p. Artisanal Fisheries Resource Study, Uganda	Commission of the European Communities (CEC)
q. FISHBASE Project	Food and Agriculture Organization (FAO) Commission of the European Communities (CEC)
r. Software on Fish Stock Assessment	Food and Agriculture Organization (FAO)
s. Bangladesh Aquaculture Research	International Foundation for Agricultural Development (IFAD)/Danish International Development Agency (DANIDA)

t. Global Multispecies Trophic Modelling
u. Directory of Education and Training Opportunities
v. The Third International Symposium on Tilapia in Aquaculture

United States Agency for International Development (USAID)
Danish International Development Agency (DANIDA)
Food and Agriculture Organization (FAO)
French Government

STATEMENT OF REVENUES AND EXPENSES[1]
(US$)

		1990	1989
REVENUES			
Grants	$	3,940,613	3,375,903
Consultancy and service fees		51,464	122,405
Publications		24,698	26,367
Overhead income		195,165	163,016
Interest income		36,543	49,992
Insurance and other expense refunds		3,983	14,088
Gain on foreign exchange		54	46,713
Miscellaneous		15,892	8,102
	$	4,268,412	3,806,586
EXPENSES			
Aquaculture	$	1,821,766	1,406,345
Coastal Area Management		917,452	895,062
Capture Fisheries Management		598,169	555,561
Social Sciences[2]			95,586
Library and Information Services		191,447	214,839
Board of Trustees		113,670	117,032
Administration and Finance		395,581	232,797
General Operating Expenses		196,380	117,188
Capital Expenditures		40,558	93,278
	$	4,275,023	3,727,688
EXCESS (DEFICIENCY) OF REVENUE OVER EXPENSES	($	6,611)	78,898
FUND BALANCE AT BEGINNING OF YEAR		124,158	45,260
FUND BALANCE AT END OF YEAR	$	117,547	124,158

[1]As audited by Sycip, Gorres & Velayo and Co.
[2]Included under the Coastal Area Management Program.

ICLARM STAFF

Acting Director General
Jay L. Maclean, M.Sc.

Coastal Area Management Program

Chua Thia-Eng, Ph.D.	Director

ASEAN/US COASTAL RESOURCES MANAGEMENT PROJECT

Chua Thia-Eng, Ph.D.	Project Coordinator
Alan T. White, Ph.D.	Technical Advisor
Louise A. Fallon, Ph.D.	Resource Economist
Heng L. Thung, Ph.D.	Coastal Zone Planner
Rogelio O. Juliano, Ph.D.	Coastal Zone Planner (Brunei Darussalam)
Geronimo T. Silvestre, M.A.	Fisheries Resource Expert (Brunei Darussalam)
James N. Paw, M.Aq.	Project Specialist
Flordeliz Y. Guarin, M.S.	Project Specialist
Jeffrey S. Walters, M.S.	Research Fellow
Oliver G. Coroza, M.A.	Systems Analyst
Ma. Jessica Madeleine L. Dalusung, A.B.	Research Assistant
Len R. Garces, M.S.	Project Specialist
Socorro C. Guerrero, A.B.	Project Assistant (Half-time)
Marie Sol M. Sadorra, B.S.	Project Editor
Germilina B. Dizon, B.S.	Project Accountant
Rachel C. Josue, B.S.	Project Secretary
Rachel C. Atanacio	Project Artist
Maria Teresa G. Cruz, B.S.	Clerk/Typist
Noel Robles, B.S.	Computer Programmer
Marie Assunta A. Carigma	Assistant Editor (Part-time)
Romeo J. Santos, A.B.	Assistant Editor (Part-time)
Pamela P. del Rosario, A.B.	Assistant Editor (Part-time)
Cecille Y. Legaspi, A.B.	Assistant Editor (Part-time)
Francisco Torres, Jr., B.S.	Data Encoder
Edwin G. Rodriguez, B.S.	Clerk (Part-time)

ASIAN FISHERIES SOCIAL SCIENCE RESEARCH NETWORK

Louise A. Fallon, Ph.D.	Coordinator (Part-time)
Herminigildo M. Montalvo, M.S.	Research Associate
Ma. Angelina A. Agulto, A.B.	Project Assistant (Part-time)

Capture Fisheries Management Program

Daniel Pauly, Dr. habil. rer. nat.	Director
Annabelle Cruz-Trinidad, M.A.	Program Assistant
Felimon C. Gayanilo, Jr., B.S.	Research Associate
Mina L. Soriano, M.O.S.	Research Associate
Carmela C. Janagap, B.S.	Research Assistant II
Victor C. Sambilay, Jr., B.S.	Research Assistant I
Astrid Jarre, M.S.	Integrated Expert
Josefina Cañezo, B.S.	Program Secretary
Lorna Lou D. Arenas, B.S.	Program Secretary

GLOBAL COMPARISONS OF AQUATIC ECOSYSTEMS

Villy Christensen, Cand. scient.	Associate Scientist
Rosandra A. Gayosa, C.P.A.	Research Assistant I

FISHBASE

Rainer Froese, Dr. rer. nat.	Associate Scientist
Susan M. Luna, B.S.	Research Assistant I
Crispina B. Binohlan, M.S.	Research Assistant I
Dominic S. Tioseco, B.S.	Programmer
Roberto N. Cada	Artist

SOCIOECONOMIC VALUATION OF COASTAL RESOURCES OF SOUTHWESTERN LATIN AMERICA

Max Agüero, Ph.D.	Project Director
Exequiel Gonzáles, M.S.	Project Coordinator
Carlos Olivares, Computer Engineer	Project Analyst/ Programmer
Fanny Torres, B.S.	Project Assistant
Marisol Kuiseñor, Bilingual Secretary	Project Secretary
Angélica Arellano, Industrial Engineer	Research Fellow
Fabiola Bell, Civil Engineer	Research Fellow
Edgardo Araneda, Civil Engineer	Research Fellow
Ximena Flores, M.S.	Research Fellow
Harlan A. Lampe, Prof./ Resource Economist	Consultant
Mario Niklitschek, Ph.D.	Consultant

Peter Muck, Ph.D.	Consultant
Rosa Aguilera, M.S.	Consultant
Bernardo Zapata, Fisheries Engineer	Consultant
Marcela Cisternas, Tech. Engineer	Consultant
Ximena Malinarich	Research Assistant/Economics
Octavio Barrios	Research Assistant/Programming

Aquaculture Program

Roger S.V. Pullin, Ph.D.	Director
Catherine Lhomme Binudin, A.B.	Project Officer (Technical Cooperation with Francophone Countries)
Emma M. del Rosario, B.S.	Secretary
Marissa W. Manela	Secretary

GENETIC IMPROVEMENT OF TILAPIA

Ambekar E. Eknath, Ph.D.	Associate Scientist I
Belen O. Acosta, M.S.	Program Assistant/Biologist
Ravelina R. Velasco, M.S.	Research Assistant
Marietta P. de Vera, B.S.	Research Assistant

INTEGRATED FARMING SYSTEMS

Clive Lightfoot, Ph.D.	Farming Systems Specialist
Mary Ann P. Bimbao, M.S.	Program Assistant/Economist
Joven V. Custodio, Jr.	Encoder

AFRICA AQUACULTURE PROJECT

John D. Balarin, M.Sc.	Project Director*
Barry A. Costa-Pierce, Ph.D.	Project Director**
Anne A. van Dam, M.Sc.	Associate Expert (Bunda)
Fredson Chikafumbwa, M.Sc.	Research Assistant III
Daniel Jamu, M.Sc.	Research Assistant III
Winston Kadongola, M.Sc.	Research Assistant III
Mayesero Kapalamula, B.Sc.	M.Sc. Student
Sloans Chimatiro, B.Sc.	M.Sc. Student
Emmanuel Kaunda, B.Sc.	M.Sc. Student
Luke Malembo, B.Sc.	Research Assistant I (Bunda)
Chipo Jenya, B.Sc.	Assistant Librarian
Sylvester Chitenga	Accountant II
Lester Msoliza	Secretary II

*Resigned May 1990
**As of November 1990

Alice Luhanga	Secretary I
Patience Tsokonombwe	Library Clerk
Yusuf Fulaye	Office Aide
Boniface Kamuyambeni	Technical Assistant
Foster Makuwa	Technical Assistant
Sailes Msonthi	Technical Assistant
Robert Selemani	Technical Assistant
Allim Monjeza	Technical Assistant
Dickson Mkusanya	Technical Assistant
Roderick Mtayamo	Field Enumerator
Richard Gamulani	Field Enumerator
Phillip Kasomekera	Field Enumerator
Wilson Mkandawire	Field Enumerator
Bernard Mafuleka	Foreman
Stand Adani	Assistant Foreman
Wilson McLorry	Driver/Field Assistant
Patrick Kamoyo	Driver
Maulana Fletcher	Watchman
Lackson Pondiya	Watchman
James Meya	Watchman
Inaki Isaac	Watchman
Dickman Pinifolo	Watchman
Ekeleni Fourpence	Builder
William Mbunju	Builder
Mponda Lakisi	Builder
Gibson Likongaji	Carpenter
Peter Adack	Assistant Carpenter
Friday Machado	Cleaner
John Mussa	Cleaner
Nkomo Mirinje	Laborer
Adam Lajabu	Laborer
Richard Chimenya	Laborer
Bwana Chipire	Laborer
Jonathan Mkuwira	Laborer
Kwali Jackson	Laborer
Bosco Kalipalire	Laborer
Yahaya Friday	Laborer
Frackson Lifa	Laborer
Kesteni Chisawawa	Laborer
Jack Chakanika	Laborer
Paul Sitolo	Laborer
Atibu Chingwaru	Laborer
Fred Khanganya	Laborer
Jafari Samama	Gardener
Victor Nyundo	Gardener

RICE-FISH FARMING SYSTEMS RESEARCH

Catalino R. dela Cruz, Ph.D.	Senior Scientist and Project Leader

BANGLADESH AGRICULTURAL RESEARCH PROJECT

Modadugu V. Gupta, Ph.D.	Aquaculture Specialist

SOCIOECONOMIC IMPACT OF FISH CULTURE EXTENSION PROGRAM ON THE FARMING SYSTEMS OF BANGLADESH

Mahfuzzudin Ahmed, Ph.D.	Technical Coordinator
M. Abdur Rab, M.Phil.	Research Officer I
Md. Aynul Islam, M.Sc.	Research Officer II
Mujibur Rahman, M.Sc.	Research Officer II
Debashish Majumder, M.Sc.	Extension Officer
Abdus Sattar, M.Sc.	Extension Officer
Stephen Biswas, B.A.	Project Secretary
Kazi Ataul Kabir, B.Sc.	Field Investigator
Md. Shahidul Islam, B.Sc.Hons.	Field Investigator
Joyti Lal Barua, B.Sc.Hons.	Field Investigator
Kazi Giasuddin, M.S.S.	Field Investigator
Alamgir Munshi, H.S.C.	Field Assistant
Labeul Haque, H.S.C.	Field Assistant
Surujzaman, H.S.C.	Field Assistant
Abdul Wadud, H.S.C.	Field Assistant

Information Program

Jay L. Maclean, M.S.	Director
Leni-lou F. Estudillo, B.S.	Secretary

PUBLICATIONS

Leticia B. Dizon, M.L.S.	Managing Editor
Casilda I. Guevara, B.S.	Editorial Assistant
Priscilla T. Calalang, B.S.	Typesetter
Eloisa A. Espiritu, B.S.	Typesetter
Virgilio J. Castrillo	Typesetter
Ovidio F. Espiritu, Jr., B.S.	Senior Artist
Christopher M. Bunao, B.S.	Junior Artist
Albert B. Contemprate, B.S.	Artist
Ramon B. Estarez	Information Assistant

LIBRARY AND INFORMATION SERVICES

Rosalinda M. Temprosa, M.L.S.	Chief Librarian/Project Leader, Selective Fisheries Information Service (SFIS)
Norma I. Jhocson, M.A.T.L.S.	Librarian
Erlinda B. Gonzalez, B.S.	Associate Librarian

Marcos Jose M. Vega, B.S.	Research Assistant
Adelina P. Mendoza, B.S.	Library Assistant
Matimtiman E. Cruz, B.S.	Library Assistant
Reynaldo A. Damalerio	Library Aide

South Pacific Office
Coastal Aquaculture Centre

John L. Munro, Ph.D.	Senior Scientist and Director
John B. Hambrey, Ph.D.	Scientist
Patricia E. Munro, Ph.D.	Affiliate Scientist
Graham F. Usher, M.Sc.	Scientist
Mark H. Gervis, M.Sc.	Scientist
Hugh Govan, B.Sc.Hons.	Assistant Scientist
Lucy Gilkes, M.Sc.	Assistant Scientist
Toata Molea, B.Sc.	Scientific Assistant
Cathreena M.T. Gervis, B.Sc.	Scientific Assistant
Idris Lane, M.Sc.	Scientific Assistant
Thomas Shearer, B.Sc.	Scientific Assistant
Hugo Tafea, A.D.	Fisheries Officer of the Fisheries Division, Government of Solomon Islands
Rosemary Perry	Administrative Assistant/Secretary
Janet Coyne	Administrative Assistant/Secretary
Felistus Leung	Administrative Assistant I/Secretary II
Edgar Kaua	Senior Artisan I
John Suli	Foreman/Caretaker
Benson Kalea	Foreman/Caretaker
Maxwell Sau	Senior Technical Aide
Francis Alfred	Technical Aide
Joseph Harold	Technical Aide
Alfred Lau	Technical Aide
Andrew Pele	Technical Aide
Posi Young	Technical Aide
Henry Rota	Trainee Technical Aide
Basil Timo	Trainee Technical Aide
George Lionel	Semiskilled Laborer
Texlee Meve	Semiskilled Laborer
John Kareke	Laborer
Jack Kola	Laborer
Robinson Olerere	Laborer
Timothy Line	Laborer
Ngara Pila	Laborer
Julia Kakau	Cleaner
Ribeka Manisava	Cleaner
Agnes Kekecha	Gardener

Administration and Finance

Basilio M. Rodriguez, Jr., M.B.A.	Director
Remedios C. Apostol, C.P.A.	Chief Accountant
Paulino V. Manese, A.B.	Projects Administrator
Marieta D. Veneracion	Administrative Assistant
Arlene G. Balane, B.S.	Senior Accountant
Ma. Concepcion Q. Bernardo, B.S.	Senior Secretary
Alfredo F. Diaz, Jr., B.S.	Systems Specialist
Ma. Gemma A. Calderon, B.S.	Accountant II
Ofelia A. Celestino, C.P.A.	Accountant II
Irma C. Reyes, C.P.A.	Accountant II
Milagros Irene F. Robel, C.P.A.	Accountant I
Elsa T. Bibiano	Accounting Clerk
Ma. Concesa C. Gayanilo, B.S.	Clerk/Typist II
Belen R. Dagmil	Communications Clerk
Adielle Ma. Corazon G. Reyes, B.S.	Receptionist
Benjamin M. Bayron	Driver
Dominador V. Gomez	Driver/Mechanic
Florentino D. Paulino	Driver
Hermenegildo A. Magsino	Utility Aide
Emmanuel P. San Juan	Utility Aide