PN-ABP-572

ICLARM REPORT 1991

ICLARM

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

PN-ABP-572

ICLARM REPORT
1991

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 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

ICLARM REPORT 1991

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

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Cover: Mang Gil (*left*), one of the many farmers involved in on-farm trials of the Genetic Improvement of Farmed Tilapias (GIFT) project, and Dr. Ambekar Eknath, ICLARM's quantitative geneticist. See details on page 61. Photo by Rina Velasco.

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Details of Board membership and committees are on p. 115-119.

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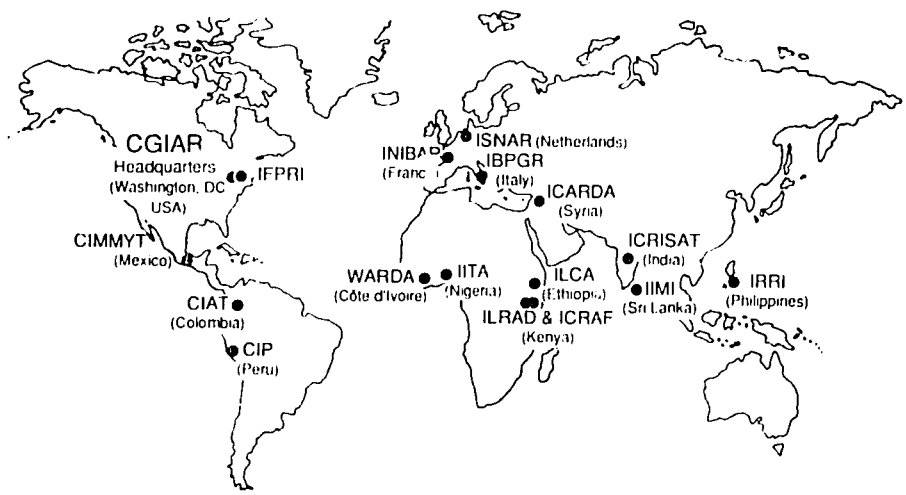
IN A YEAR OF STRATEGIC PLANNING

We noted in last year's report that ICLARM had been invited to join a prestigious group of international research centers with the same broad goal as this Center - to contribute to sustainable improvements in productivity of agriculture, forestry and fisheries in developing countries in ways that enhance nutrition and well-being, especially among low-income people.

The group is the Consultative Group on International Agricultural Research (CGIAR) which currently consists of 16 research centers (see Figure) and 40 public and private sector donors. The group was formed in recognition of the need for international strategic research of a long-term nature in agriculture.

Consultative Group on International Agricultural Research (CGIAR) Centers



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

The CGIAR research centers work to long-term Strategic Plans that are examined by the Group. From the strategies, the centers develop five-year or Medium-Term Plans which determine their activities over the period. A new focus within the CG system is a closer integration of the activities of the

various centers. The invitation for ICLARM to join the CGIAR bore with it the requirement to provide the Group with an acceptable Strategic Plan and, of course, a subsequent Mid-Term Plan of activities.

We began preparation of the Strategic Plan in earnest in December 1990. By May 1991, after five workshops involving at some stage all ICLARM professional staff and nearly 40 external scientists and advisers from around the world and numerous in-house meetings and consultations, a draft, Board-approved Strategic Plan was submitted to the Technical Advisory Committee (TAC) of the CGIAR in May 1991. TAC met the following month and asked for more elaboration of various aspects, particularly our expected interactions with national research systems. This entailed further meetings and consultations with over 100 additional persons by members of staff and preparation of an addendum to the earlier draft. TAC considered the addendum in October 1991 and was encouraged by the contents. They requested ICLARM to consolidate the Plan and refine some sections.

The process of refining the Plan; securing ICLARM Board approval; an external review by the CGIAR of the Center's fitness to become a CGIAR Center; and submission of the final Plan to TAC occupied much of the Center's staff time, including Christmas Day 1991, up to April 1992. The process also delayed, amongst other things, preparation of this Report, such that I can now state that TAC endorsed the Strategic Plan and ICLARM was admitted into the CGIAR system in May 1992.

The steps leading to our entry into the CGIAR were presented to point out the time-consuming nature of this exercise and the inevitable effects on our research progress and output during 1991.

It is much to the credit of staff that there is still so much research to report, despite the full year of Strategic Planning activities. I joined ICLARM as Director General on 1 April 1991, but attended some of the earlier planning workshops also. In this way I gained an early appreciation of the industrious nature of the Center.

My role is to channel this energy into new programs and projects that have emerged from the Strategic Planning process and which will begin to take effect towards the end of 1992 and as we develop our Mid-Term Plan for 1994-1998. The year 1993 will be a transitional year of expansion to meet our commitments to the Plan.

Thus, the near future of ICLARM will be an exciting period of growth, new directions and hopefully construction of a headquarters building and modest research facilities. It will therefore be a disruptive time as we adjust to new programs, the requirements of the CGIAR and perhaps a new site. Our experience during 1991 shows that the Center staff will cope well with the challenges associated with all these changes and we look forward to the future with a high degree of optimism.

KENNETH T. MACKAY
Director General
ICLARM

ICLARM AND ITS PROGRAMS, AN OVERVIEW

Background

ICLARM was incorporated in the Philippines in 1977. The Statement of Purpose in the frontispiece provides the broad mandate within which the Center operates. Within that mandate ICLARM's role has been to complement and support the activities of national and regional research systems in capture fisheries and aquaculture. Since 1986 this role has broadened to include aquatic aspects of coastal management.

ICLARM is an international, nonprofit, autonomous research center funded by governments and foundations around the world. In 1991, the total funding was US$4.5 million, of which only US$1.2 million was unrestricted core support. The Center is governed by a 15-member Board of Trustees, international experts acting in their private capacities. The Center staff are led by a Director General who answers to the Board. He is supported by the Program Directors and receives advice from a Program Committee composed of six Board members.

In November 1990, the Center was invited to prepare a long-term strategic plan of research as part of a process to join the Consultative Group on International Agricultural Research (CGIAR).

The process of strategic planning, which continued throughout 1991, will inevitably result in a new mission, goal and objectives within the present mandate, and based on the foundation of the Center's research achievements to date.

ICLARM operates from rented headquarters offices in Makati, Metro Manila, Philippines. It has modest coastal aquaculture facilities in the Solomon Islands and at present shares project facilities in aquaculture in the Philippines and Malawi.

Programs

The Center presently has three research programs - Aquaculture, Capture Fisheries Management, and Coastal Area Management - and an Information Program.

These programs have evolved during the present Five-Year Plan (1988-1992) of the Center. The focus in Aquaculture is on genetic improvement of cultured organisms and development of low-cost farming systems for small-scale producers. The major species of interest in freshwater are the tilapias and in marine waters, giant clams. In Capture Fisheries Management, attention is given to "management-oriented" research on aquatic resource assessment methodology and economic valuation of fisheries. The Coastal Area Management program focuses on the promotion and adoption of integrated coastal area management.

The geographic focus is on tropical and subtropical developing countries worldwide. As the accompanying Table shows, ICLARM conducted significant activities in sixteen countries during 1991 as well as maintaining a number of regional and global projects and networks.

Research and Related Activities, 1991

	Coastal Area Management	Capture Fisheries Management	Aquaculture
Bangladesh			●●❐
Brunei Darussalam	●		
Chile		●▲	
Côte d'Ivoire			❐
Ghana			●
India			▲
Indonesia	●○		
Malawi			●❐▲
Malaysia	●○		
Philippines	●○		●❐
Sierra Leone		●	
Singapore	●❐		
Solomon Islands		●○	●●○●
Sri Lanka	▲		
Thailand	●○		
Regional	●○	○	●●
Global	▲	●●●○	●○

Key: ● Project; ○ Network; ▲ Advisory Services; ❐ Workshop/conference/training organized by ICLARM.

These activities were carried out by a total of twenty-four internationally recruited staff of whom fifteen were based at headquarters in Manila, along with twenty-two Philippine professional staff.

The Information Program provides support to the research programs through library and publishing services. There is also an active information

service based in the library which provides a current awareness service through *Naga, the ICLARM Quarterly*, and answers research enquiries from around the world.

Looking Ahead

During 1992, the Center will have finalized its Strategic Plan and begun taking steps towards a transition period, during which a new program structure will be put in place to implement the strategy.

The new structure will reflect a systems approach. The new programs will be based on resource systems, chosen with regard to their importance as production systems, potential for increase, threats to their sustainability and contribution to improving welfare of the poor (equity issues).

The titles of the new programs reflect the resource systems on which ICLARM's future research will focus:

Inland Aquatic Systems
Coastal Resource Systems
Coral Reef Resource Systems

A fourth program, the National Research Support Program, will undertake activities that will contribute to strengthening national aquatic research systems, while Information will continue as a supporting service both to the Center's programs and to researchers worldwide.

The research work will be selected based on ICLARM's comparative advantage in the field, the needs of national institutions and the work of other research centers.

The Inland Aquatic Systems Program will include the present Aquaculture Program activities and extend the research to ways of removing social and environmental constraints to inland aquaculture development.

The other two existing research programs - Capture Fisheries Management and Coastal Area Management - will be combined into the Coastal Resource Systems Program, in which the focus will be on the resource users, and on developing integrated management strategies for use in formulating coastal area management policies and regimes.

The new Coral Reef Resource Systems initiative builds on the previous ICLARM experience in developing giant clam aquaculture and will be directed towards improving the income and welfare of communities in coral reef areas, and to improve the management and conservation of these resource systems.

The other new initiative, the National Research Support Program, seeks to strengthen national institutions through information, training, and support to research management and research policy.

COASTAL AREA MANAGEMENT PROGRAM

Background

The Coastal Area Management Program (CAMP), established in 1983, was built on the groundwork and experiences of the Association of Southeast Asian Nations/United States Coastal Resources Management Project (ASEAN/US CRMP) which had been implemented by ICLARM since 1986 under the Resource Assessment and Management Program (now Capture Fisheries Management Program). With the focus of the program on the promotion of the adoption of integrated coastal zone management in tropical developing countries worldwide, the goal is to provide sound socioeconomic justification for the conservation of critical habitats and the pursuit of long-term and sustainable productivity of coastal fisheries, forestry and other forms of environmentally compatible uses of coastal resources. Opportunities for appropriate public and private sector activities in the coastal area are promoted while nonsustainable forms of development are discouraged, through appropriate management strategies. Research, training and information dissemination are three essential elements in the program.

Progress of Work

ASEAN/US Cooperative Program on Marine Sciences: Coastal Resources Management Project

The activities of CRMP in 1991 centered on the completion of all remaining in-country tasks, primarily the revision and refinement of management plans of the six countries involved, holding a waste management conference, and refinement/editing of the project results for publication. Most of the in-country task activities were completed by the second quarter of 1991. The integrated coastal area management plans for the six countries have largely been completed.

The holding of the Conference on Waste Management in the Coastal Areas of the ASEAN Region in June 1991 in Singapore was a major activity. The major output of the conference was the adoption of the Singapore Resolution which aims to strengthen collaboration by: sharing information and technologies on waste disposal; educating the public, policymakers and producers of wastes on the benefits of waste management; and participation of NGOs and community organizations in the implementation of waste management strategies.

Training. The project has conducted training for 118 national staff. In June 1991, the project conducted a survey to determine the impact of ASEAN/US CRMP-initiated training programs on the trainees. The survey results showed that the training courses had addressed the growing need for CRM in the region.

Newsletter. The project has produced 14 issues of the *Tropical Coastal Area Management* (TCAM) Newsletter since its first issue in 1986. In 1992, TCAM, together with all ICLARM Program newsletters, will be integrated into *Naga, the ICLARM Quarterly.*

Publications. Since 1986, the project has published six technical reports; a poster and eight education series; nine conference proceedings; and a directory. Eight more publications are in the pipeline for 1992, including the six site-specific integrated management plans.

Impacts of CRMP. The CRMP has received recognition and support from both the national and regional levels for its CAM activities which are now being given due importance in national agenda. The impact in the region is evidenced by: policy changes; improvement of national capability; increased national commitment to CAM; fostering of regional cooperation and collaboration; improved knowledge in CAM.

Geographic Information System for Coastal Area Management and Planning

The Geographic Information System for Coastal Area Management and Planning Project (GISCAMP) is a two-year activity which began in September 1991 with the Philippine National Economic and Development Authority Region I Office as the participating institution. This is funded by the International Development Research Centre (IDRC) of Canada and the project site is the Lingayen Gulf area. The general objectives of GISCAMP are to upgrade regional capabilities in coastal area management and planning (CAMP) and to establish an information system for the storage and analysis of spatial and attribute data on the coastal areas for planning and management purposes through the use of geographic information systems (GIS). Preparations for data collection and encoding for the GIS databank are underway.

Asian Fisheries Social Science Research Network

The AFSSRN was coordinated by CAMP until May 1991, when the coordinator, Dr. Louise Fallon-Scura, left ICLARM. The Network was subsequently placed under the Office of the Director General.

The year was nevertheless a busy one for the Network, with the implementation of 10 new research projects; the search for a new coordinator; follow-up of outstanding projects from earlier phases of AFSSRN; production of a Network newsletter; and participation in IDRC's Global Fisheries Socioeconomic Survey. Two Network members left for Simon Fraser

University, Canada, under a collaborative agreement. There were also preparations for upcoming events in 1992 - a team leader's meeting; a seminar on coastal valuation; and participation in the Third Asian Fisheries Forum.

Linkages

The Program has developed linkages with various government agencies, research institutions and nongovernment organizations in the ASEAN region, in the US and Europe in areas of research, training and information dissemination. Apart from institutional linkages with 47 national institutions within ASEAN, the Program maintains close working relationship with regional and international organizations in promoting the concept of CAM and exchange of experience through workshops, seminars and conferences. The main linkages are facilitated through cooperation or collaboration directly with respective institutions or through projects including AIT, IUCN, WWF, UNESCO, FAO, UNDP, IOC, WESTPAC, GESAMP, UNEP, URI, Bay of Bengal Project, SAREC, ADB, World Bank and IDRC.

Advisory and Other Services

CAMP staff undertook a three-week mission for SAREC in March, to develop a research framework for management of Puttalam Lagoon, Sri Lanka. The mission was carried out by a team composed of Drs. Chua Thia-Eng, Director, CAMP, and Louise Fallon-Scura, Resource Economist and Mr. Gerry Silvestre, Fisheries Expert. Also, SAREC is exploring the possibility of the program's future involvement in a regional CAM program for East Africa.

Throughout 1991, the CAMP Director has been involved in a number of activities apart from those within ICLARM. Aside from serving as President of the Asian Fisheries Society, Dr. Chua is also Research Director of the International Development Research Centre-Asian Fisheries Society (IDRC-AFS) Small Grant Program. He is a Board Director of the International Coastal and Ocean Organization (ICO). He is a member of the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) of FAO. He serves as a Scientific Advisor of the International Foundation for Science (IFS) and Chairman of the Advisory Council for the World Fisheries Congress 1991. He is also a Member, Research Project Proposal Evaluation Panel of the Commission of the European Communities (CEC) and Member, Panel of Experts for Evaluation of Project Proposals under Global Environmental Facility (GEF). He is also a Member of the Project Advisory Committee, UNDP/FAO on Integrated Fisheries Management Project, and editor and regular correspondent for the journal *Ocean and Coastal Management*.

Program Plans

CAMP will continue to implement the scheduled activities of the ASEAN/US CRMP and GISCAMP. The CRMP will complete all activities by

the end of 1992. A workshop on CAM will be held in April 1992 to discuss experiences/lessons learned from the implementation of CRMP and evaluate the in-country management plans.

In addition, the program expects to start work on the following projects:

1. Resource and Ecological Assessment of San Miguel Bay, Philippines. This 17-month project, which will commence in April 1992, aims to provide: 1) an assessment of the status and exploitation/utilization of the fishery resources in San Miguel Bay, Philippines; 2) an evaluation of the status of the stresses/impacts of human activities on critical habitats; 3) an assessment of the socioeconomics of fisheries and the general socioeconomic development framework within which it operates; and 4) an elaboration of feasible management options, guidelines and strategies that maximize benefits from fisheries resources utilization/exploitation and minimize sectoral conflicts and/or incompatibilities.

2. Establishment of the Santiago Island Management Project, Bolinao, Philippines. This has been designed to serve as a pilot project for a consortium of donor agencies. It attempts to integrate five components: population, health and nutrition, education, alternative livelihood, and marine parks and protected area management. SAREC, in cooperation with SIDA, has expressed interest in the development of activities on education, alternative livelihood programs and marine park and protected area management. 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, an NGO.

3. The Coastal Area Management of Batangas Bay and Vicinity. Pilipinas Shell, in collaboration with other private companies and the Government of Batangas, Philippines, has established the Batangas Coastal Resources Development Foundation to promote integrated CRM in Batangas Bay and vicinity. ICLARM would be involved in the project.

Meetings Attended, Papers Presented

Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) Working Group 31 Meeting to finalize report on the environmental impacts of coastal aquaculture, Kiel, Federal Republic of Germany, 7-11 January. (T.E. Chua).

Sixth CRM Project Steering Committee Meeting, Manila, Philippines, 8-10 February. (ASEAN/US CRMP Staff).

Twenty-first Session of GESAMP, London, England, 18-22 February. (T.E. Chua)

National Workshop on Coastal Resources Management, Bandar Seri Begawan, Brunei Darussalam, 27 April-1 May. (T.E. Chua, G.T. Silvestre, S.C. Guerrero, M.L. Dalusung).

Papers presented:

Silvestre, G.T. and H.J. Matdanan. 1991. Brunei Darussalam capture fisheries: a review of resources, exploitation and management.

Fallon-Scura, L.A. and M.L. Dalusung. 1991. Socioeconomic contribution of coastal resources of Brunei Darussalam.

UNEP Consultation Meeting on Coastal Area Management, Athens, Greece, 13-18 May. (T.E. Chua).

Conference on Waste Management in the ASEAN Region: Roles of Governments, Banking Institutions, Donor Agencies, Private Sector and Communities, Singapore, 28-30 June. (T.E. Chua, S.C. Guerrero, L.R. Garces, R.C. Josue).

Coastal Zone Management Forum, Asian Institute of Technology, Bangkok, Thailand, 6-10 July. (T.E. Chua).

Batangas Foundation Meeting, Batangas City, Philippines, 19 August. (T.E. Chua, M.D. Pido).

A Forum on Hazardous Waste Management: Facing the Challenge, Quezon City, Philippines, 9 September. (L.R. Garces).

Experts Workshop on Community-Based Resource Management: Perspectives, Experiences and Policy Issues, Los Baños, Laguna, Philippines, 19-20 September. (H.M. Montalvo).

Consultative Meeting of the Indonesian CRMP in connection with Segara Anakan, Puncak, Indonesia, 6-9 October. (T.E. Chua and J.N. Paw).

Meeting with the Ministry of Environment, Singapore, 10 October. (T.E. Chua and J.N. Paw).

Asian Fisheries Society Council Meeting, Taipei, Taiwan, 21-22 October. (T.E. Chua).

Second Fisheries Education Workshop, Asian Fisheries Society, Taipei, Taiwan, 23-25 October. (T.E. Chua).

Review Committee, Small Grants Project, Asian Fisheries Society, Taipei, Taiwan, 26-27 October. (T.E. Chua).

Philippine Geothermal and Coal-Burning Technologies Conference, Quezon City, Philippines, 26-27 October. (L.R. Garces).

Research Project Proposal Evaluation Panel of the Commission of the European Communities (CEC), Brussels, Belgium, 2-8 November. (T.E. Chua).

Regional Seminar on Ecology and Conservation of Southeast Asian Marine and Freshwater Environments Including Wetlands, Kuala Lumpur, Malaysia, 4-6 November.

Paper presented (no participation from CAMP):

Chua, T.E. and L.R. Garces. Marine living resources management in Southeast Asia: lessons learned and integrated management approach.

Second WESTPAC Symposium (and meeting with SIDA and IOC/WESTPAC officials), Penang, Malaysia, 1-8 December. (G.T. Silvestre).

Publications

ASEAN/US CRMP. 1991. The coastal environmental profile of South Johore, Malaysia. ICLARM Tech. Rep. 34, 65 p.

Chia, L.S. and L.M. Chou, Editors. 1991. Urban coastal area management: the experience of Singapore. ICLARM Conf. Proc. 25, 128 p.

Chou, L.M, T.E. Chua, H. V. Khoo, P.E. Lim, J.N. Paw, G.T. Silvestre, M.J. Valencia, A.T. White and P.K. Wong, Editors. 1991. Towards an integrated management of tropical coastal resources. ICLARM Conf. Proc. 22, 455 p.

Chua, T.E., Editor. 1991. Coastal area management education in the ASEAN region. ICLARM Conf. Proc. 29, 92 p.

Chua, T.E. 1991. Reconciliation of coastal resource use conflicts in Southeast Asia, p. 157-178. *In* B.H.K. Othman, N.M. Mahadi, A.B. Jaafar and S.L. Tong (eds.) The marine environment: challenges and opportunities. Vol. 2. Ocean Studies and Management, ENSEARCH, Kuala Lumpur, Malaysia.

Chua, T.E. and L.A. Fallon-Scura, Editors. 1991. Managing ASEAN's coastal resources for sustainable development: roles of policymakers, scientists, donors, media and communities. ICLARM Conf. Proc. 30, 125 p.

The Conference on Waste Management in the Coastal Areas of the ASEAN Region. 1991. Singapore resolution on waste management in the coastal areas of the ASEAN region. ICLARM Conf. Proc. 32, 12 p.

Garces, L.R. 1991. Conference on waste management in the coastal areas of the ASEAN region. LAUT 4(3):5-6.

Paw, J.N. and T.E Chua. 1991. An assessment of the ecological and economic impact of mangrove conversion in Southeast Asia, p. 201-212. *In* L.M. Chou, T.E. Chua, H.W. Khoo, P.E. Lim, J.N. Paw, G.T. Silvestre, M.J. Valencia, A.T. White and P.K. Wong (eds.) Towards an integrated management of tropical coastal resources. ICLARM Conf. Proc. 22, 455 p.

Paw, J.N. and T.E. Chua. 1991. Climate changes and sea level rise: implications on coastal area utilization and management in Southeast Asia. Ocean Shoreline Manage. 15:205-232.

Paw, J.N. and T.E. Chua. 1991. Managing coastal resources in Cilacap, Indonesia and Lingayen Gulf, Philippines - an ASEAN initiative. Mar. Pollut. Bull. (EMECS'90) 23:779-783. (Poster).

Coastal Area Management Program Project Summaries

Project Title : ASEAN/US Coastal Resources Management Project

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

Cooperating Institutions

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

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

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

Philippines : Department of Science and Technology; Philippine Council for Aquatic and Marine Research and Development (coordinating

agency); University of the Philippines (UP)-Marine Science Institute, College of Social Work and Community Development; UP-Visayas College of Fisheries; Bureau of Fisheries and Aquatic Resources; and National Economic and Development Authority (NEDA)-Region I

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

Thailand : Office of the National Environment Board, Ministry of Science, Technology and 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, extended until December 1992

Key Personnel ICLARM : Dr. Chua Thia-Eng (Project Coordinator); Dr. Louise A. Fallon-Scura (Resource Economist); Dr. Heng L. Thung (Coastal Zone Planner); Mr. Geronimo T. Silvestre (Stock Assessment Expert); Mr. James N. Paw (Project Specialist); Mr. Michael D. Pido (Research Associate); Ms. Socorro C. Guerrero (Program Assistant); Mr. Oliver G. Coroza (Research Associate); Mr. Len R. Garces (Project Specialist); Ms. Madeleine L. Dalusung (Project Specialist - Economist); Ms. Zoraida N. Alojado (Systems Analyst)

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

Most of the PSC-approved in-country task activities were completed by the second quarter of 1991. The countries are now nearing completion of their CRM plans.

At the sixth Project Steering Committee meeting held in February 1991, it was decided to request USAID for a one-year extension until December 1992 without additional funding for the purpose of completing the publication of project documents. USAID approval was granted in September 1991.

Highlights of project activities during 1991 in the six countries are:

Brunei Darussalam. All field work and data collection have been successfully completed by the national team with the assistance of technical experts from the ASEAN countries and the corresponding reports submitted. The information from these reports have been incorporated into the CRM plan for Brunei Darussalam. It was deemed necessary that the plan receive the full support and endorsement of concerned government agencies and policymakers. Thus, a national workshop on CRM was held on 30 April-1 May 1991. The plan covers various issues affecting the coastal resources of Brunei Darussalam and its socioeconomic implications as well as recommendations on the national management of these resources. A companion monograph deals with various coastal resources, their present conditions, exploitation and other technical details.

Indonesia. Three pilot projects identified in the management plan were implemented in 1990 to lay down the groundwork for the full implementation of the plan after 1992. The projects are: the creation of a Segara Anakan Task Force (SATF) which involved most of the concerned local agencies; the delineation of zonation boundaries; and the training of Kampung Laut residents on integrated aquaculture. These were completed in June 1991 and led by the Directorate General of Fisheries (DGF) in close cooperation with the local government (the *Bupati* of Cilacap and BAPPEDAS). The *Bupati* of Cilacap supported the continued operation of SATF beyond June 1991 and conducted some of the activities recommended in the CRM plan.

The plan was accepted by the local planning group in Cilacap in July 1991. On 8-9 October 1991, a two-day national consultative meeting in Puncak, south of Jakarta, was held to present the management plan to the national and other relevant agencies and discuss how it could be adopted, supported or implemented by the national government. The final technical revision is completed and the plan is being readied for publication in 1992.

Malaysia. All research and CRM plan development activities have been completed, including the environmental profile of South Johore State. The

integrated CRM plan is currently being reviewed by internal and external consultants. While the plan awaits federal and state government approval, some of its recommendations have been incorporated in the Johore structural plan by the Town and Country Planning Department. The CRM plan is already being used by the private sector in their project proposals, and by the government in their environmental impact assessments and decisionmaking on the proposals of the private sectors. Besides the plan, activities in 1991 focused on heightening public and government awareness on the need for an integrated CRM plan on a national level through the presentation of project results at local and international seminars, trainings and workshops.

Philippines. A task force has been created to revise/finalize the management plan for Lingayen Gulf. One of the key recommendations is a zonation scheme for the Gulf's coastal zone, e.g., fisheries, aquaculture, tourism and industrial activities. Consultative meetings are being held regularly to ensure acceptability and relevance of the plan. The final version of the plan was completed by year-end and will be presented to the Regional Development Council of Region I for adoption early in February 1992.

Singapore. Data collection for the CAM plan of Singapore has been completed and the plan is currently being refined. The preliminary CAM plan was presented at a national workshop on 9-10 November 1989 and a proceedings volume was published this year. The two remaining tasks on the utilization of seaspace for netcage culture (Task 210-S) and the role of artificial reefs in living coastal resources enrichment (Task 510-S) were completed in March 1991.

Thailand. The technical review of the management plan by the planning team has been completed. The major activity in 1991 was a national workshop. It was held in June 1991 at Pattaya, Cholburi Province, to present the results of the project activities and solicit support and comments from government agencies on the CRM plan for adoption by the national government.

Training and Information Dissemination

Training. By 1990, the project had completed 8 short-term training courses, 5 medium-term academic training, and 10 on-the-job training courses, involving 118 national staff.

In June 1991, the project conducted a post-training survey to assess: 1) appropriateness of the training programs; 2) trainee satisfaction; 3) achievement of program objectives; and 4) effectiveness of training to the individual trainee's work and to the host country.

The results of the survey show that the training courses have addressed a growing need for CRM. A significant number of the trainees are now in jobs where they are able to use actively the techniques and skills learned. Nearly all the respondents acknowledged the relevance of the training courses since these have enabled them to participate more actively in research activities, improve operational procedures and services, influence or make policy, initiate new projects, manage projects and train others. Their use of

the skills and techniques learned is mainly hampered by lack of equipment, resources and supplies within their respective organizations. Many have since gained job promotions, salary increases or additional training. Although they may have merited these from proven past performance in their jobs, they acknowledge that the training has enhanced their professional capabilities and their potentials have been recognized.

Conference. Waste Management in the Coastal Areas of the ASEAN Region: Roles of Governments, Banking Institutions, Donor Agencies, Private Sector and Communities, 28-30 June 1991, Republic of Singapore.

This was one of CRMP's major activities in 1991. It was the offshoot of the successful Policy Conference on Managing ASEAN's Coastal Resources for Sustainable Development which was organized by CRMP in March 1990. The Waste Management Conference aimed to assess the severity of environmental threats of waste disposal to the region's coastal zone; demonstrate technologies in waste management; explore ways in which international banking institutions and donor agencies could assist in waste management; and solicit the commitment of ASEAN political leadership in the enforcement of waste management schemes. The conference adopted the Singapore Resolution on Waste Management in the Coastal Areas of the ASEAN Region which highlights environmental principles vital to the sustainable development of coastal areas. There were 62 participants which included, among others, top government officials from Southeast Asia and Canada. The conference was co-organized by the Ministry of the Environment, Singapore, and had financial support from the Asian Development Bank and the Canada-ASEAN Centre, Singapore.

Information. The project undertook a number of information dissemination activities to: 1) create a better understanding of the principles and philosophy of CAM as well as on the methodology in planning and implementation; 2) promote public awareness on the consequences of the nonsustainable activities in resource use; and 3) provide project personnel with knowledge pertaining to CAM. The activities were:

Newsletter. The *Tropical Coastal Area Management* (TCAM) Newsletter is currently distributed to more than 1,500 individuals and institutions; 50% of the recipients are from the six ASEAN countries and the rest, from 78 other countries. The only international newsletter that deals with CAM in the tropics, TCAM has received considerable appreciation worldwide.

The project produced two issues of the newsletter in 1991. The last issue in 1991 contains summaries of the CAM plans for the six project sites. TCAM ceased publication as a distinct newsletter at the end of 1991 and will be integrated into ICLARM's magazine, *Naga* (along with other ICLARM program newsletters), to ensure its continuation. A classification of articles featured is shown on p. 15.

		No. of articles	Percentage
Planning, management and policy		16	18
Research/analytical tools		15	17
Environmental studies		19	21
Degradation	4		
Enhancement	3		
Protection	4		
Profiling	8		
Coastal ecology		4	4
General	2		
Case studies	2		
Community-based approaches	1	1	
CRM project progress		21	23
Project updates	4		
News/highlights	14		
Regional workshops	3		
Information updates		14	16
Total		90	

Other Publications. In 1991, the project published one technical report; one booklet for the education series; and five conference proceedings.

Working Paper Series. In 1991, the project produced 13 working papers: the workplan and progress report of each of the six member-countries, and the Project Coordinator's report.

Project Title		: Geographic Information System for Coastal Area Management and Planning
Funding Institution		: International Development Research Centre (IDRC) of Canada
Cooperating Institution		: National Economic and Development Authority Region I Office (NRO), San Fernando, La Union, Philippines.
Duration		: September 1991-1993
Key Personnel	NRO	: Mr. Leonardo Quitos; Ms. Agnes Grace Cargamento; Mr. Josefino Guiang
	ICLARM	: Dr. Chua Thia-Eng, Mr. James N. Paw, Ms. Zoraida N. Alojado

Objectives

The general objectives of GISCAMP are to upgrade regional capabilities in coastal area management and planning (CAMP) and to establish an information system for the storage and analysis of spatial and attribute data on the coastal areas for planning and management purposes through the use of geographic information systems (GIS).

Results

The GISCAMP is a two-year activity with the National Economic and Development Authority Region I Office (NRO) as the participating institution. This is funded by IDRC of Canada and the project site is the Lingayen Gulf area, Philippines.

The project was approved in September 1991, during which a Memorandum of Grant Conditions was signed between IDRC and ICLARM. Also signed was a Memorandum of Understanding between NRO and ICLARM. Purchase of equipment and software has already been made. A three-month training for NRO staff is scheduled in February 1992. Preparations for data collection and encoding for the GIS databank are underway.

Project Title	:	Asian Fisheries Social Science Research Network
Funding Institution	:	International Development Research Centre (IDRC) of Canada
Cooperating Institutions	:	INDONESIA - Faculty of Economics, Universitas Diponegoro (UNDIP); 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 - Faculty of Economics and Administration, Universiti Malaya (UM); Natural Resource Economics Department, Universiti Pertanian Malaysia (UPM); PHILIPPINES - Bureau of Fisheries and Aquatic Resources (BFAR); Freshwater Aquaculture Center, Central Luzon State University (CLSU); Economics Section, Research Division, Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC-AQD); Department of Agricultural Economics, College of Economics and Management, University of the Philippines at Los Baños (UPLB); Faculty of Arts and Sciences, University of the Philippines in the Visayas (UPV); THAILAND - Fisheries Economics Research Subdivision, Department of Fisheries (DOF); Department of Agricultural and Resource Economics, Faculty of Economics and Business Administration, Kasetsart University (KU); Coastal Resources Institute, Prince of Songkla University (PSU)
Duration	:	Phase I, 1983-1985; Phase II, 1985-1988; Phase III, 1989-1992
Key Personnel ICLARM	:	Dr. Louise A. Fallon-Scura; Mr. Herminigildo M. Montalvo; Ms. Ma. Angelina A. Agulto

The AFSSRN, currently composed of 14 universities and research institutions in Indonesia, Malaysia, the Philippines and Thailand, is coordinated by ICLARM. Now in its third phase, the Network is being funded by the International Development Research Centre (IDRC) of Canada.

Objectives

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

Results

The major activities undertaken by the Network during the period centered on:

1. implementation of ten research projects which were approved for funding the previous year;
2. worldwide search for a new Network Coordinator;
3. preparation and organization of the team leaders' meeting in January 1992, Seminar on Economic Valuation in April 1992 and participation in the Third Asian Fisheries Forum in October 1992;
4. implementation of the Simon Fraser University (SFU)-AFSSRN Collaborative Agreement with the admission of two Network members at the university for graduate studies;
5. publication of the Network newsletter, *AFSSRNews*;
6. follow-up of outstanding pre-Phase III projects;
7. participation in IDRC's Global Fisheries Socioeconomics Survey Project; and
8. technical assistance provided to researchers by ICLARM staff.

The implementation strategy focused on strengthening the institutional base of the AFSSRN. The above activities were geared towards sustaining, on the long term, progress achieved during the previous periods of Phase III.

Research

Under Phase III, the Network received a total of 17 proposals from member institutions. Of the 17, ten passed both external and technical reviews. Six of the proposals are in the area of aquaculture, four in capture fisheries, and one covers both. The research projects, all beginning in 1991, are as follows:

- *Programming Models of Integrated Agriculture-Aquaculture Farms (Universiti Pertanian Malaysia)*
  Objective:
  To explore economically viable alternatives in aquaculture-related enterprises that are feasible for small-scale farmers (operating less than 2 ha of land).

- *The Management of A Prawn Fishery: A Simulation-Optimization Approach (Universiti Pertanian Malaysia)*
  Objective:
  To develop a regional bioeconomic model related to a specific fishery resource base which can serve as a basis for reviewing and evaluating alternative management programs for a specific region and can assess the current rate of exploitation given the biological resource base and the present level of investment in the fishery.

- *Labor Force Participation and Economic Contribution of Women in the Postharvest Small-Scale Fisheries Sector, Kelantan, Peninsular Malaysia (Universiti Malaya)*
  Objective:
  To examine the nature and magnitude of female labor force participation in postharvest activities within the small-scale fisheries sector.

- *Economic Assessment of the Prawn* (P. monodon) *Hatchery Industry in Western Visayas (SEAFDEC Aquaculture Department)*
  Objective:
  To analyze the capital investments, production efficiency and effects of externalities, i.e., market forces, environment and diseases, in the profitability levels of the hatchery operators.

- *Socioeconomic Study on the Oyster and Mussel Industry in Western Visayas (SEAFDEC Aquaculture Department)*
  Objectives:
  To assess the status of oyster and mussel farming in Western Visayas; to study the characteristics and social conditions of oyster and mussel farm operators; to assess the farming methods and technology practised in oyster and mussel culture; to analyze the detailed input-output data of operations and their production performance indicators of efficiency in terms of resource utilization and rate of returns; and to determine the development potential, identify problems and constraints, and formulate appropriate management policies that would sustain the development and viability of the oyster and mussel industry.

- *Management of Mangrove Areas in Calauag Bay, Quezon Province (University of the Philippines in Los Baños)*
  Objectives:
  To understand the dynamics of converting mangrove areas to fishponds; to estimate the revenues and costs associated with brackishwater fishpond production; and to estimate resource rent of mangrove areas.

- *Financial Feasibility of Rice-Fish Farming System (Central Luzon State University)*
  Objective:
  To determine financial indicators as measures of the viability of various rice farming technologies including the development of an

analytical framework for within-country and across-country assessment of different rice-fish systems.

- *Economics and Management of Gillnet and Seine Fishing in Guimaras Strait and Adjacent Waters (University of the Philippines in the Visayas)*
  Objectives:
  To examine the relative economic efficiency of resource use among the different gillnets; to examine their production and profitability; to determine the interaction among the different inputs in gillnet and seine fishing; and to suggest management schemes affecting the gillnet and seine fishers and households.

- *Small-Scale Fisheries and Shrimp Farming in Nakorn Bay: Options for Coastal Resources Management (Kasetsart University, Prince of Songkla University and Department of Fisheries, Thailand)*
  Objectives:
  To provide recommendations on options for coastal resource management between small-scale fishing and shrimp cultivation in Pak Phanang with the objective of upgrading the living conditions of the coastal community on a sustainable basis and by investigating income earnings, social factors, infrastructure and processing in the two area.

- *Enforcement and Compliance with Regulation in the Malaysian Fishery (Universiti Pertanian Malaysia)*
  Objectives:
  To define and delineate the extent and patterns of noncompliance of trawler fishers with zoning and regulation; and to define and delineate the extent and pattern of noncompliance with regulation on gear type and boat licensing by both small-scale fishers (fishers operating within 8 km of the coast) and trawler fishers.

Training and Workshops

Simon Fraser University/AFSSRN Collaborative Agreement. The SFU/AFSSRN Collaborative Agreement has been implemented two years after it went into effect. Two Network members passed the admission requirements of SFU and are pursuing graduate studies, commencing Fall Term 1991.

Workshops. A one-day workshop of Philippine team leaders for the development of a country paper was held on 27 September 1991 in Iloilo City. A paper will be prepared reviewing the status and use of earlier fisheries socioeconomic research in the Philippines and identifying research gaps.

Publications

1. *AFSSRNews*, Network Newsletter. The Network came out with two issues of the *AFSSRNews*. The first issue was piggybacked with the *Tropical Coastal Area Management* Newsletter when the Network was still under the Coastal Area Management Program.

2. Research Reports. Efforts were made to collate all research reports since the start of the Network in 1983. The Network has generated 33 reports since Phase I. These will be reviewed internally and externally and the best ones will be published.

Coordination

Dr. Fallon-Scura resigned as Coordinator in May 1991. To ensure that the impact of the absence of a coordinator was minimized, the Network, which was then under the Coastal Area Management Program, was placed under the Office of the Director General. Until December 1991, Mr. Herminigildo M. Montalvo, AFSSRN Research Associate, acted in an interim capacity liaising with IDRC and member institutions. Network activities went on as scheduled, except for the holding of a training course and the team leaders' meeting which were held in abeyance pending the hiring of a new Coordinator.

In mid-September 1991, Dr. Robert S. Pomeroy of Clemson University, South Carolina, USA, was selected as the new Coordinator. He will assume the post on 1 January 1992.

From June to December, the AFSSRN Research Associate made seven monitoring trips to followup progress of research projects and to meet team members.

Efforts were also made to followup incomplete or outstanding pre-Phase III projects in order to update Network and IDRC records.

On 1 August 1991, the Research Associate and team leaders from UPM, UM and KU met in Kuala Lumpur, Malaysia to discuss the Network's participation at the Third Asian Fisheries Forum in October 1992.

Global Survey in Fisheries Economics Project (1990-ongoing)

In late 1990, the Fisheries Program of IDRC initiated a project to survey the current state of knowledge on fisheries socioeconomics in developing countries. The primary aim of this project is to assist IDRC in incorporating socioeconomic factors into its fisheries projects as well as to provide a useful base of information globally.

Dr. Louise Fallon-Scura, then Coordinator, was approached by Dr. Anthony T. Charles, the Project Coordinator, to assist in the preparation of this report. This would involve writing a chapter on "Socioeconomic Studies of Asia/Pacific Fisheries" and compiling/writing an annotated bibliography. After Dr. Fallon-Scura's departure, the work has been continued by Mr. Montalvo. The project has been extended for several more months.

Work Plan for 1992

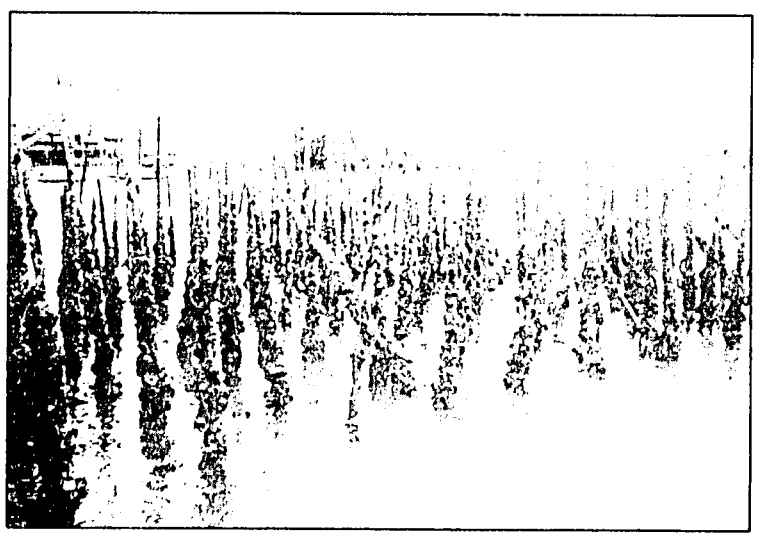
The last year of the Network's Phase III (1992) will largely be spent in completing ongoing research projects and any other additional projects which will be approved; implementation of the AFSSRN-SFU Collaborative Agreement on the Graduate Studies and Visiting Scholars Programs; holding of team leaders' meetings, national workshops, and training courses; participation in the Third Asian Fisheries Forum in October 1992; reviewing completed research project reports for secondary dissemination

as journal articles, ICLARM publications, conference proceedings, etc.; and publication of these reports, the membership directory and the Network newsletter.

A mid-term review of the Network will be undertaken in May 1992 to assess its overall accomplishments and progress in Phase III.

The Network is also planning to go into a fourth phase. A proposal for a Phase IV will be developed and submitted to various donor agencies.

AFSSRN Research Associate Hermie Montalvo (*left*), AFSSRN-CLSU Team Leader Ruben Sevilleja (*center*) and a rice-fish farmer-cooperator inspect a demonstration farm in Muñoz, Nueva Ecija.



Mussels clinging on bamboo stakes in a river in Capiz, Philippines.

CAPTURE FISHERIES MANAGEMENT PROGRAM

Background

Throughout the tropics, coastal fisheries are under threat. The resource base upon which they depend is much reduced in terms of biomass and biodiversity, with valuable, large species rare on many fishing grounds and the harvests often dominated by low value and seasonally variable small fish. The coastal fisheries suffer from excessive numbers of new entrants: not only new family members in fishing households, but often the landless to whom fishing has become an occupation of last resort.

Given the finite nature of the resource, these new entrants reduce the harvests of existing fishers - a repeat of the "tragedy of the commons". Fishing communities, faced with reduced harvests have increasingly tolerated destructive fishing "gears" such as explosives and poisons, seriously depleting the resources; a process now called "Malthusian overfishing".

At the regional and national levels, export-oriented policies and subsidies encourage urban-based, industrial fisheries also exploiting coastal fisheries resources, in direct competition with small-scale fisheries. Also encouraged are development schemes, notably the aquaculture of shrimps in coastal wetlands which further reduces the habitats from which young fish are recruited into coastal fisheries.

Inland, deforestation, mining and urbanization generate millions of tonnes of silt, tailings and wastewaters that are flushed through estuaries and coastal lagoons, further reducing the extent and quality of critical fisheries habitats.

Not all facets of this bleak picture occur along all developing-country coastlines - indeed, some countries still have vibrant coastal fisheries. Yet, throughout the tropics and especially in Asia, most fishers belong to the "poorest of the poor", and the fisheries trends and intersectoral conflicts alluded to above all apply, gravely threatening the sustainability of what are still major productive systems.

However, given appropriate knowledge on the resources and the fisheries, clear policies and enforcement, these trends can be arrested and fisheries rehabilitated.

The CFMP contributes to required knowledge via the development of new methods and software for the assessment of tropical multispecies fisheries resources and the economic valuation of fisheries; and via the dissemination of these products through publications, training courses, supervision of theses and a large information network.

Moreover, for clear policies to emerge, a closer integration of the biological components of fisheries research with socioeconomic consideration is necessary. This integration is illustrated below through several of the

projects that were active in 1991 and will be strengthened in the coming years.

Progress of Work

The FISHBASE project, which is developing an encyclopedia-like biological database on fish, evolved into a major activity with two full-time scientists, four research assistants, two artists and a programmer at headquarters, and three fishery biologists in separate in-country modules. Since December 1990 the total number of species covered as well as the number of species with in-depth information have been doubled.

During 1991, the project received, for incorporation into FISHBASE, a large database on oxygen consumption in fish, and a first set of 1,000 records on fish occurrences from the Dr. Fridtjof Nansen project. The complete records covering 15 years of worldwide sampling by the research vessel *Fridtjof Nansen* will eventually be contained in FISHBASE.

A milestone was reached in 1991 with regard to population parameters. FISHBASE now contains these data for over 700 species, making it the largest such compilation. Changes in catches from changes in size of first capture or changing effort can be estimated for all these species without costly duplication of fish growth studies.

The project continues to draw attention from developing countries and also from advanced scientific institutions with offers of contributions to the database or assistance in validating entries.

The first version of FISHBASE will be ready for distribution to collaborators in September 1992.

A Fisheries Data Acquisition System (FIDAS) for storing and analysis of fisheries data was created in the context of a joint project with the Institute of Marine Biology and Oceanography, Freetown, Sierra Leone, and it is anticipated that FIDAS will serve as a model for other countries in West Africa.

The DANIDA financed project on "Global comparisons of aquatic ecosystems" continued its rapid development in this its second year of operation.

Two new versions of the ECOPATH II Software System, developed as part of the project, were released, along with a much enhanced manual. ECOPATH II, a system for parametrization and balancing of ecosystem models, has become very widespread; more than 200 copies were released, and at the end of the year close to 50 ecosystem models, from areas throughout the world, though with a concentration in tropical areas, were either published or in draft.

The project spent much of its resources on strengthening cooperation with scientists in national laboratories, notably in the form of research support toward the development of ecosystem models. At headquarters, efforts were also made at creating a framework for modelling of farming systems.

A test version of a new type of dynamic model for fisheries management, a form of length-based multispecies virtual population analysis, was developed. This allows design of management strategies based on analysis

of fishing patterns and which simultaneously accounts for predatory interactions between fish populations.

The development of the joint FAO-ICLARM software in stock assessment (FISAT: FAO-ICLARM Stock Assessment Tools) had its first major test when our partner institutions agreed to use the beta-release for the FAO/DANIDA Fish Stock Assessment Project's course in Suva, Fiji (11 Nov. - 6 Dec. 1991). This resulted in the realization of the need to modify several subprograms and the first release of the software is now expected to be ready by early 1993 - six months later than anticipated.

A mathematical model for socioeconomic valuation of coastal resources was developed in the context of the ECLAC/ICLARM Collaborative Project on Socioeconomic Valuation of Coastal Resources of S.W. Latin America. The model integrates biological, technological, economic and environmental components of the coastal ecosystem. Costs and returns generated by the various activities taking place during the exploitation process of each coastal resource are evaluated by means of a Net Benefit Function, determining at the same time the economic value of each resource. Externalities, environmental cross-sectorial impacts and nonmarket values for the loss of important ecosystem functions of coastal resources are also considered in the valuation process.

A software package to solve large mathematical programming models (1,000 activities or larger "tableaus") using minimum memory (640 K of RAM) requirements for IBM PC compatible personal computers was developed within an interactive user-friendly environment. It will serve as the basis for future work in linking Mathematical Programming Models with Geographical Information Systems (GIS), thus providing ways to solve large problems of natural resources valuation/allocation.

A submodel for valuing mangrove areas was developed and applied using existing data for Ecuador. The conceptual framework developed for the coastal resources valuation model and the software package developed for its solution was used for this purpose. This submodel will become an integral part of the larger valuation model in its application to tropical coastal areas.

An important project on Improved Management of Openwater Fisheries in Bangladesh entered its second phase; this activity executed jointly with the two agencies of the Government of Bangladesh aims to supersede old, exploitative modes of production and to ensure productivity and sustainability of publicly owned inland openwater fisheries under a new management policy.

Education and Training

Dr. Lourdes Palomares successfully graduated from the Ecole Nationale Supérieure Agronomique (ENSAT), Toulouse, France with a thesis supervised by Prof. J. Moreau of ENSAT and Dr. D. Pauly and entitled "La consommation de la nourriture chez les populations de poissons: étude comparative, mise au point d'un modèle prédictif et application aux réseaux trophiques". She then returned to ICLARM to work on the FISHBASE Project.

Dr. Daniel Pauly taught a course on "Software Packages for Fish Stock Assessment" at the Alfred Wegener Institute for Polar and Marine Research.

During this period, he also took the final exam and led the thesis defense of two of his doctorate students, Ms. Silvia Opitz, with a thesis titled "Quantitative models of trophic interactions in Caribbean coral reefs (Institut für Meereskunde, University of Kiel), and Mr. Jaime Mendo, with a thesis titled "Stock identification of Peruvian anchoveta (*Engraulis ringens*): morphometric, tagging/recapture, electrophoretic and ecological studies" (Fachbereich für Biologie, University of Bremen), a thesis which emerged out of joint ICLARM/GTZ activities in Peru throughout the 1980s.

Other postgraduate students supervised or assisted were from the University of the Philippines (by D. Pauly and V. Christensen), Université de Clairmont-Ferrand (France) (by D. Pauly) and University of Hamburg (Germany) (by V. Christensen). Dr. Max Agüero supervised a thesis at the Universidad Catolica de Chile.

Four fish stock assessment scientists were trained in the use of ELEFAN/FISAT at ICLARM HQ in late 1991.

Advisory Services

Dr. Pauly presented a formal lecture at the University of Perpignan, Perpignan, France, on 20 June, entitled "*Modelisation trophiques des ecosystems aquatique*"; this led to an agreement between the Centre de Biologie et d'Ecologie Tropicale et Méditerranéene of the University of Perpignan, and the Program to cooperate in various areas, and specifically for Dr. Galzin and Dr. Pauly to jointly supervise the doctorate thesis of Mr. Ernesto Arias-Gonzalez, a Mexican student who will use the ECOPATH II software for modelling coral reef systems in French Polynesia.

Dr. Rainer Froese visited the Expert Center for Taxonomic Identification in Amsterdam on 28-29 January to share his experience on the development of identification systems.

Mr. Felimon Gayanilo, Jr. joined the CRMP/Fish Stock Assessment Component Team in Brunei to present to staff of the Fisheries Department the low-level GIS developed by the CFMP and called B:RUN. Mr. Gayanilo was later invited as lecturer at the FAO/DANIDA Fish Stock Assessment Project's Course in Suva, Fiji from 11 November to 6 December 1991.

Dr. Agüero spent several days at Puerto Montt, Chile, at the School of Fisheries and Economics of the Universidad Austral, to assist in planning a Training Program in Fisheries and Coastal Area Management/ Environmental Economics and in preparing a research agenda for the forthcoming decade. He also participated in a short mission to Egypt for the World Bank in May on the feasibility of conducting an economic valuation of a waste-fed aquaculture project in Suez.

Program Plans

The underlying element of all plans for 1992 is the need to adjust to the structure and activities that are emerging in the course of the Center's ongoing strategic planning work. It is anticipated that this will require the Program to be phased out by the end of 1992, and hence many of its projects to be either terminated or restructured.

Regardless of these events, we will be releasing in the second half of 1992 the first version of FISHBASE and publishing the first book on the ECOPATH II approach and software. Both of these will help toward (re)establishing strong links with colleagues and institutions with whom the Program had long cooperated, as well as to interest new partners in collaborative research.

Meetings Attended, Papers Presented

Mini-symposium on Science and Management of Large Marine Ecosystems, American Association for the Advancement of Science, Washington DC, 18 February. (D. Pauly).

Paper presented:

Pauly, D. and V. Christensen. Stratified models of large marine ecosystems: a general approach, and an application to the South China Sea.

Coastal Resources Management Project Workshop, Bandar Seri Begawan, Brunei Darussalam, 29 April - 1 May. (F.C. Gayanilo, Jr.)

Software presented:

Gayanilo, F.C., Jr., G. Silvestre and D. Pauly. B:RUN: a geographic information system for managing demersal fisheries of Brunei Darussalam.

Meeting at the Academy of Scientific Research and Technology, Cairo, Egypt, 28 May. (M. Agüero).

Lecture:

Agüero, M. The economics of waste-fed aquaculture.

The Philippine Environment: Financing Environmental Conservation and Rehabilitation Projects/Programs, conference organized by the Philippine Futuristics Society, Hyatt Regency Hotel, Manila, 30-31 May. (D. Pauly).

Paper presented:

Pauly, D. and A. Cruz-Trinidad. Sound ecology is good economics: four vignettes from Philippine fisheries.

Group of Experts Meeting and International Workshop on Wetland Valuation, Centro Agronomico de Investigacion y Enseñanza, Turrialba, Costa Rica, 31 May-4 June. (M. Agüero).

Lecture:

Agüero, M. Economic valuation of mangrove ecosystems.

Seminar on Canadian Geomatic Applications for Environmental and Resource Management in the Philippines, Manila, Philippines, 28 June. (F.C. Gayanilo, Jr., E. de Guzman, N. Robles).

International Workshop on Techniques for Biological Assessment in Fisheries Management, Forschungszentrum Jülich, Germany, 17-24 July. (V. Christensen and D. Pauly).

Paper presented:

Christensen, C. and D. Pauly. A framework for length-based multispecies VPA.

Software presented:

B:RUN, FISAT, MAXIMS, ECOPATH II

FAO/DANIDA Workshop on Fisheries Stock Assessment and Management, Suva, Fiji, 11 November - 6 December. (F.C. Gayanilo, Jr., lecturer)

The Third International Symposium on Tilapia in Aquaculture, Abidjan, Côte d'Ivoire, 11-16 November. (M. Ahmed, R. Froese, M.L.D. Palomares, D. Pauly).

Papers presented:

Pauly, D., J. Moreau and F.C. Gayanilo, Jr. A new method for comparing the growth performance of fishes, applied to wild and farmed tilapias.

Palomares, M.L. and D. Pauly. Models for estimating the food consumption of tilapias.
M. Ahmed. Economics of tilapia aquaculture in small waterbodies in Bangladesh.
Villwock, W., R. Froese, U. Sienknecht and L. Agustin. Presentation of the tilapia strain registry (poster).

International Council for the Exploration of the Sea (ICES) Statutory Meeting, La Rochelle, France, 26 September - 1 October. (R. Froese).
Papers presented:
Froese, R. Progress report on FISHBASE: the global biological database of living aquatic resources.
Froese, R. The use of shape for classifying fish into ecological groups.
Reichow, D., C. Largiader, C. Klingenberg, C. Clemmensen, R. Froese and B. Ueberschär. The use of multivariate morphometrics to determine the nutritional condition of marine fish larvae.
Welsch, W., K.-G. Barthel, R. Froese, B. Hermann, J. Lenz, S. Mees, D. Schnack and U. Waller. A high-speed video recording system for *in-situ* studies on small-scale distribution of zooplankton and ichthyoplankton; preliminary results on the distribution of plankton in the Bornholm Basin (Central Baltic).

Computer-Aided Software Engineering (CASE) Convention, 1991, Manila, Philippines, 25-26 September. (F.C. Gayanilo, Jr., E. de Guzman, D. Tioseco, G. Coronado and N. Robles).

ICOD Ocean Forum: Seeking Sustainable Development of the Oceans, Halifax, Canada, 20-21 November. (D. Pauly, panelist).

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Capture Fisheries Management Program
Project Summaries

Project Title	:	Tropical Fish Stock Assessment Project
Funding Institution	:	Unrestricted Core
Cooperating Institutions	:	Predominantly in-house studies, with informal linkages with various research institutions
Duration	:	Continuous from July 1979
Key Personnel ICLARM	:	Dr. Daniel Pauly; Mr. Felimon Gayanilo, Jr.; Mr. Geronimo Silvestre; Dr. Rainer Froese; Mr. Villy Christensen; Dr. Maria Lourdes Palomares (from October 1991); Dr. Joe Padilla (from October 1991)

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

Since its inception, this project has led to the development of several new approaches, techniques and computer program routines for stock assessment, now widely used by fisheries researchers in developing countries and increasingly in developed countries as well.

Several new approaches were developed and/or published in 1991. It is expected that these will also find wide applications:

(i) A vast series of food consumption estimates of wild fish populations was assembled and used to: a) derive a general model for estimation of food consumption in wild fish populations; and b) demonstrate that marine and freshwater fishes have the same food consumption if account is taken of their size, shape, food type and of the temperature of their habitat. These two results will be particularly useful to support multispecies modelling activities by fisheries scientists worldwide.

(ii) An empirical equation was derived, based on numerous analytical studies on wild and cultured tilapias and other freshwater fish populations, for estimation of food consumption in tilapia (Fig. 1).

(iii) Work was continued on the use of fish shapes to distinguish ecological groups, and thus to provide a sound basis for future work on the relationship between fish shape and fish growth.

(iv) An approach was identified for interfacing, in a user-friendly manner, a multispecies, multigear implementation of the Thompson and Bell

yield-per-recruit model with linear programming and goal analysis, such as to make these powerful tools accessible to users, especially in tropical developing countries, without access to computers with specialized program "libraries".

(v) An approach was developed to improve the analysis of the ELEFAN I response surface to improve estimation of growth parameters from seemingly unsuitable length-frequency data.

Several of the project results were incorporated into products of other Program projects, notably the ICLARM Software Project.

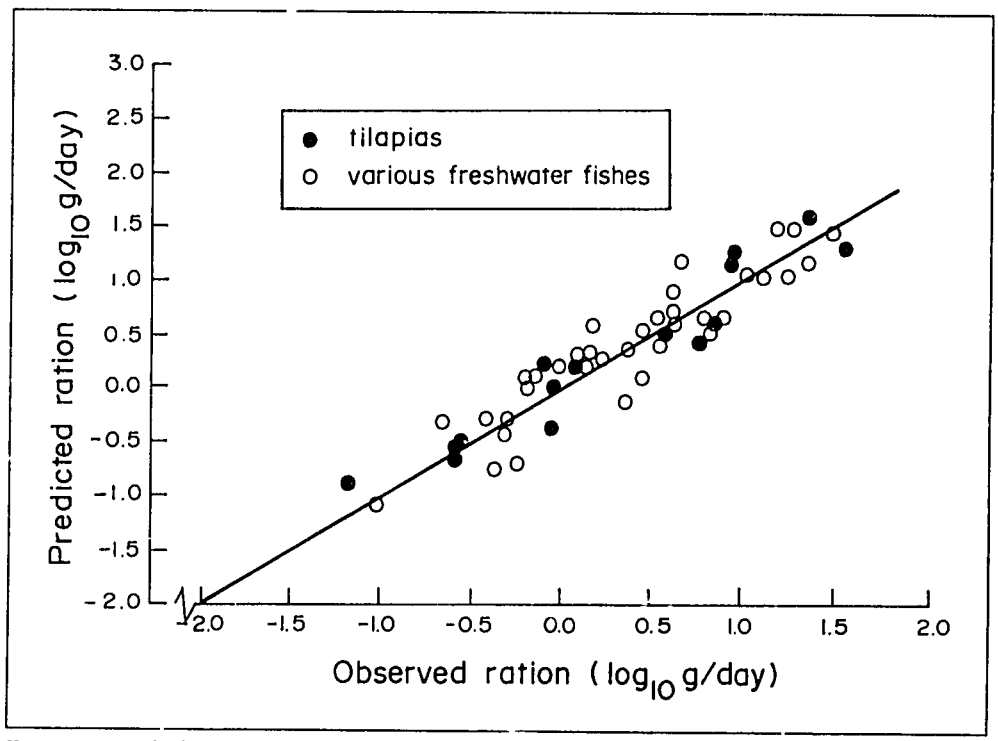

Fig. 1. Example from a comparative study of the food consumption of fishes (from Palomares, M.L.D. and D. Pauly. Models for estimating the food consumption of tilapias. Paper presented at the Third International Symposium on Tilapia in Aquaculture, Abidjan, Côte d'Ivoire, 11-16 November 1991). The line represents a 1:1 ratio. Such relationships can be used for pond dynamics models and for determining feeding regimes.

Project Title		: Network of Tropical Fisheries Scientists
Funding Institutions		: Unrestricted Core; Food and Agriculture Organization (FAO); Danish International Development Agency (DANIDA)
Cooperating Institution		: FAO/DANIDA Training Course in Tropical Fish Stock Assessment
Duration		: Continuous from April 1982
Key Personnel	ICLARM	: Dr. Daniel Pauly, Fishbyte Editor; Ms. Abbie Cruz-Trinidad, Network Secretary

Objectives

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

Results

Total membership of the NTFS by the end of 1991 was 1,100 individuals; all received the two large issues of Fishbyte produced in 1991. As in previous years, FAO-DANIDA Regional and National Courses in Tropical Fish Stock Assessment have been the primary source of funding and of new NTFS members, this year especially from Fiji, Iran and India.

In line with the streamlining of ICLARM's operations, the December 1991 issue was the last issue of Fishbyte as an independent newsletter. From January 1992 on, NTFS contributions will be published in the Fishbyte section of *Naga, the ICLARM Quarterly*, to which all NTFS members will receive a free subscription, as well as a complete index to the nine volumes of Fishbyte.

In 1991, four network members - three from the Philippines and one from Hong Kong - were trained at ICLARM HQ in computer-based methods for fish stock assessment.

Project Title	: Socioeconomic Valuation of Coastal Resources of Southwestern Latin America
Funding Institution	: Unrestricted Core
Cooperating Institution	: United Nations Economic Commission for Latin America and the Caribbean (ECLAC)
Duration	: June 1990 to November 1991 (with extension to June 1992)
Key Personnel	: Dr. Max Agüero; Mr. Edgardo Araneda; Ms. Angelica Arellano; Ms. Fabiola Bell; Ms. Ximena Flores; Mr. Exequiel Gonzalez; Mr. Carlos Olivares; Ms. Marisol Ruiseñor

Objectives

- To identify the major processes, relationships and factors determining the dynamics of coastal resource uses.
- To identify existing data/information related to coastal resources 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.

Results

The project is directed by Dr. Max Agüero, who has been based at ECLAC since June 1990, 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.

The adoption of a coastal ecosystems approach in modelling the value components of coastal resources has proven to be useful in identifying the relevant components, linkages, currency flows and interactions among and between resources and the ecosystem. Mathematical programming techniques have shown versatility and great efficiency in handling the large data processing requirements of this kind of exercise. Statistical analysis has been used to estimate key parameters, expressing fundamental relationships in the coastal ecosystem.

For modelling purposes, the coastal area has been decomposed into four interrelated group of resources: "Fisheries", "Forestry", "Tourism" and "Ecosystem". Sustainable yield functions for renewable resources (fisheries, forestry, environment, etc.) have been used as constraining factors to identify levels of resource use consistent with sustainability and to account for scarcity value of resources (shadow price vector). Resources not traded in the market (ecological functions, externalities, etc.) are determined outside the model and introduced as parameters. Nonrenewable resources

(land area, factor endowments, etc.) are also introduced as constraining factors of the various production functions.

The model has been applied on a preliminary basis to Concepcion Bay, Chile. A total of 700 activities (equations) have been used to model the various sectors, resources, activities, production functions, constraints and costs/return flows. The model was also applied to study the impact of mangrove conversion for shrimp farming in Ecuador (Fig. 2). More testing and validation will be carried out in 1992.

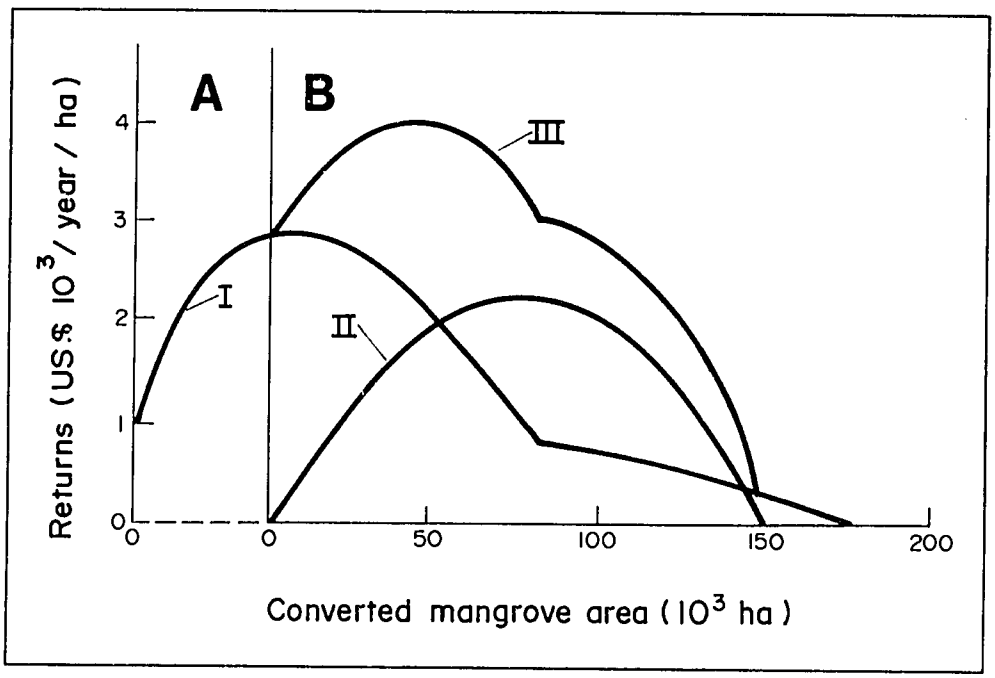

Fig. 2. Schematic representation of economic returns from alternative mangrove use/exploitation strategies. Plane A corresponds to a strategy with "no-conversion", while plane B corresponds to a strategy with varying levels of conversion. Curve I depicts the rent derived from the use of mangroves in their natural state; Curve II depicts net benefits derived from alternative uses of mangroves (shrimp mariculture) at various levels of conversion; and Curve III depicts social net benefits and results from the summation of I and II at various levels of conversion.

Project Title : The ICLARM Software Project

Funding Institutions : Unrestricted Core; Food and Agriculture Organization (FAO)

Cooperating Institutions : Predominantly in-house activity, with informal linkages with various individuals and research institutions

Duration : Continuous from 1986

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

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 of interest to ICLARM.

Results

The thrust of software development since 1990 is in two major areas:
(i) the development of a joint FAO-ICLARM software for length-based stock assessment; and
(ii) the development of a low level geographic information system (LL-GIS) for analysis and display of fisheries data.

Other software development supporting and paralleling our various efforts in tropical stock assessment included a small program called AUXIM for the comparison of growth parameters of fish populations; and a set of routines for displaying and/or analyzing data in FISHBASE of which some may eventually be distributed separately.

Item (i) is part of the development of a joint FAO-ICLARM software for length-based fish stock assessment called FISAT (FAO/ICLARM Stock Assessment Tools, Fig. 3). FISAT includes improved versions of the routines previously incorporated in the

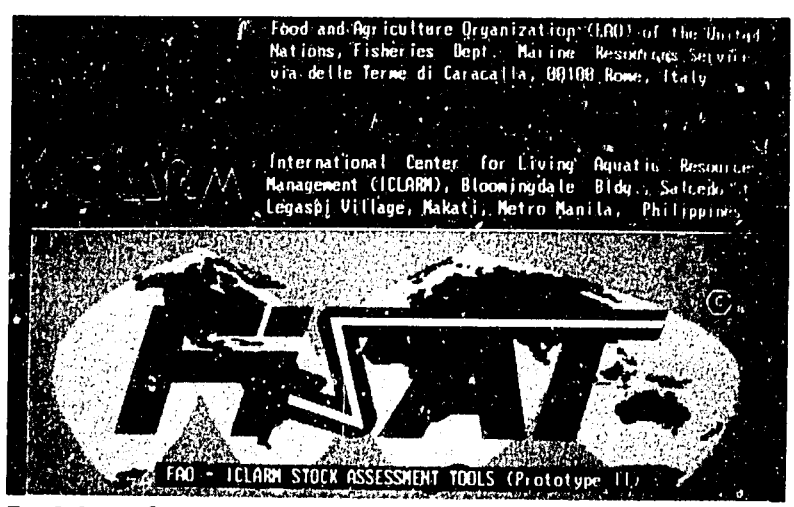

Fig. 3. Logo of FISAT, a joint FAO-ICLARM software for fish stock assessment.

FAO software LFSA and in ICLARM's Compleat ELEFAN plus new routines, and has progressed to a beta release, presently being evaluated by staff of FAO and of the Danish Institute for Fisheries and Marine Research (DIFMAR). The use of the beta-version of FISAT at the FAO-DANIDA Training Course in Stock Assessment and Management held in late 1991 in Suva, Fiji allowed identification of various problems which will be addressed in 1992.

Given the present heavy demand for some of the improved routines incorporated in FISAT and the need to evaluate some of its modules separately, a routine for constructing length-converted catch curves when growth is seasonal was released as a stand alone program called GOTCH.A.

In 1991, a new LL-GIS was developed, based on two previous packages for Brunei and Peru, respectively, and structured around a map of the EEZ of Sierra Leone, West Africa, where ICLARM has a project (see p. 40).

Project Title	:	Global Comparisons of Aquatic Ecosystems (ECOPATH)
Funding Institution	:	Danish International Development Agency (DANIDA)
Cooperating Institutions	:	International Council for the Exploration of the Sea (ICES); Danish Institute for Fisheries and Marine Research (DIFMAR); also numerous individual researchers in developed and developing countries
Duration	:	Four years beginning February 1990
Key Personnel ICLARM	:	Mr. Villy Christensen; Dr. Daniel Pauly; Ms. Sandra Gayosa; Ms. Carmela Janagap (until 1 June 1991)

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

A major part of the work associated with this project has up to now been centered around development and dissemination of the ECOPATH II software system for straightforward parametrization and balancing of steady-state ecosystem models. ECOPATH models describe the energy flows in ecosystems and have been used for systems as diverse as farming systems, aquaculture ponds, rivers, lakes, estuaries and oceans.

This approach is particularly appropriate for systems exploited by fisheries, which it puts into their ecological context (Fig. 4).

The activities in 1991 were centered around production of a new version (2.0) of ECOPATH II, released in June 1991, along with a much enhanced manual. In the following five months it was distributed to more than 200 persons or groups worldwide.

ECOPATH II has up to now been applied to some 50 ecosystems, descriptions of which have either been published or are under publication, all in close communication with the ECOPATH project staff at ICLARM.

The project has had numerous working contacts with scientists worldwide in the past year, most notably in connection with publication of a forthcoming volume on "Trophic Models of Aquatic Ecosystems". This volume includes models of a large number of ecosystems, and is a result of a Theme Session hosted in 1990 by D. Pauly and V. Christensen under the auspices of the International Council for the Exploration of the Sea (ICES). In addition, project staff have worked in close interaction with ICLARM's

rice-fish and farming systems group and encouraged the development of models of rice-fish and farming systems.

A test version of a new type of model (length-based multispecies virtual population analysis, LB-MSVPA) for fisheries management was developed and described. LB-MSVPA will allow design of management strategies based on analysis of fishing patterns (gear allocation) while simultaneously considering trophic interactions between fish populations. The model is derived from an age-based model now in the verge of being used for similar purposes in temperate areas. However, in contrast to its age-based ancestor, the new model describes the whole ecosystem, not just the fish populations. It is a generic model and hopefully will be applied throughout the tropics.

Project plans for 1992 are to undertake and publish a comparative analysis of the datasets in the 1990 ICES session mentioned earlier; prepare a new graphics-oriented version of ECOPATH; and provide training on international basis for scientists using the software.

The fisheries management model (LB-MSVPA) will be applied to the Bolinao reef flat fishery, northern Philippines, in close cooperation with the Marine Science Institute of the University of the Philippines. In addition, it is expected that work on a similar model for Lake Victoria, Central Africa, will be initiated.

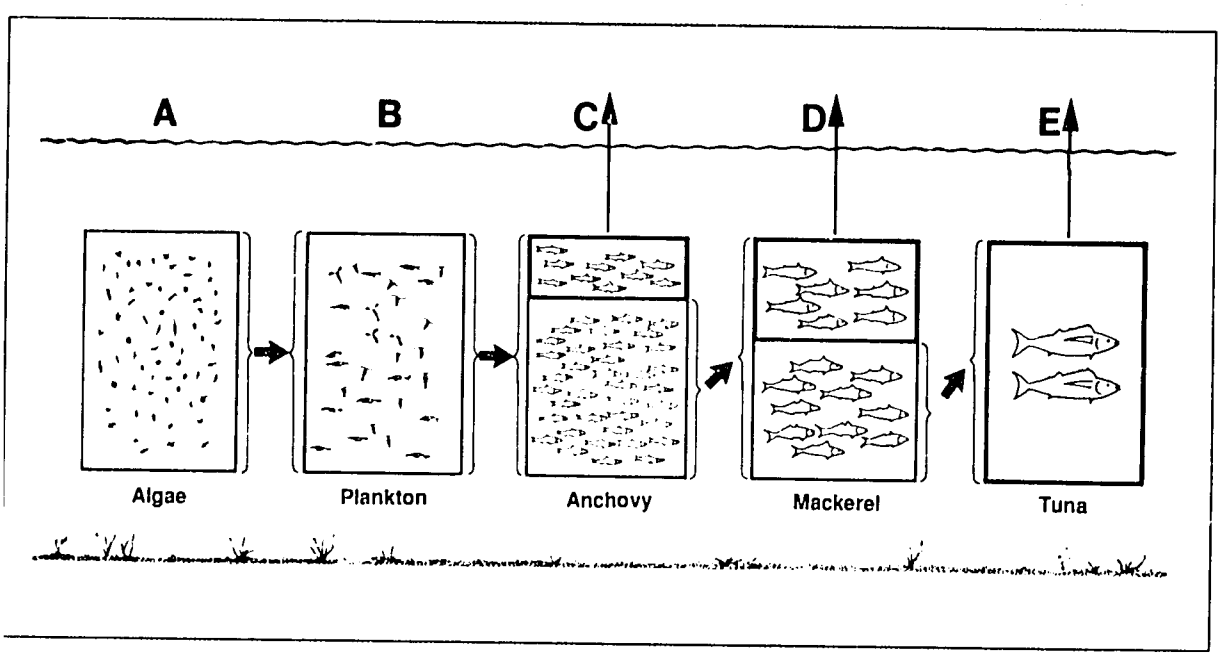

Fig. 4. Schematic representation of the differences between traditional "fisheries management", which looks only at the exploited parts of the fish stocks (boxes C-E), and ecologically-based "resource systems" management, which considers the constraints to production (i.e., the arrows between boxes) imposed by secondary (B) primary production (A) and predation (C/D; D/E). The latter approach is encouraged by and can be implemented through the ECOPATH II software.

Project Title		: Establishment of a Fisheries Database for the Development and Management of the National Fisheries off Sierra Leone
Funding Institution		: Commission of the European Communities (CEC)
Cooperating Institutions		: Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone (IMBO); Fisheries Division, and West Northwest Artisanal Fisheries and Community Development Programme (WNW AFCOD).
Duration		: Two years beginning April 1991
Key Personnel	IMBO	: Mr. P.A.T. Showers
	FD	: Mr. A.B.C. James
	WNW AFCOD	: Mr. C. Fournah
	ICLARM	: Dr. Jan Michael Vakily

Objectives

- To evaluate the present status of the fishery of Sierra Leone and the level of exploitation in both the commercial and small-scale sectors.
- To make recommendations on possible management strategies in the light of government priority to give preference to local fisheries, particularly small-scale and semi-industrial, over foreign fisheries.
- To devise a permanent system of fisheries data collection and computer-assisted handling of data for analysis and presentation, and to train Sierra Leonean personnel in their use.
- To publish the results of this work and to disseminate them in Sierra Leone, other countries bordering the Gulf of Guinea, and to agencies and institutions with interests in fisheries development, particularly those working in west African countries.

Results

The early emphasis in this project is on the design and testing of a comprehensive Fisheries Data Acquisition System (FIDAS), linking the large amount of available fishing data from both the small-scale and (foreign-dominated) commercial fisheries (Fig. 5) with various analytic tools or programs developed at ICLARM (notably FISHBASE) or by other organizations (Fig. 6). This system is now operative.

In 1992, emphasis will be put on the interpretation of these data using SIERRA, the low-level GIS developed at ICLARM to support this project, and other tools.

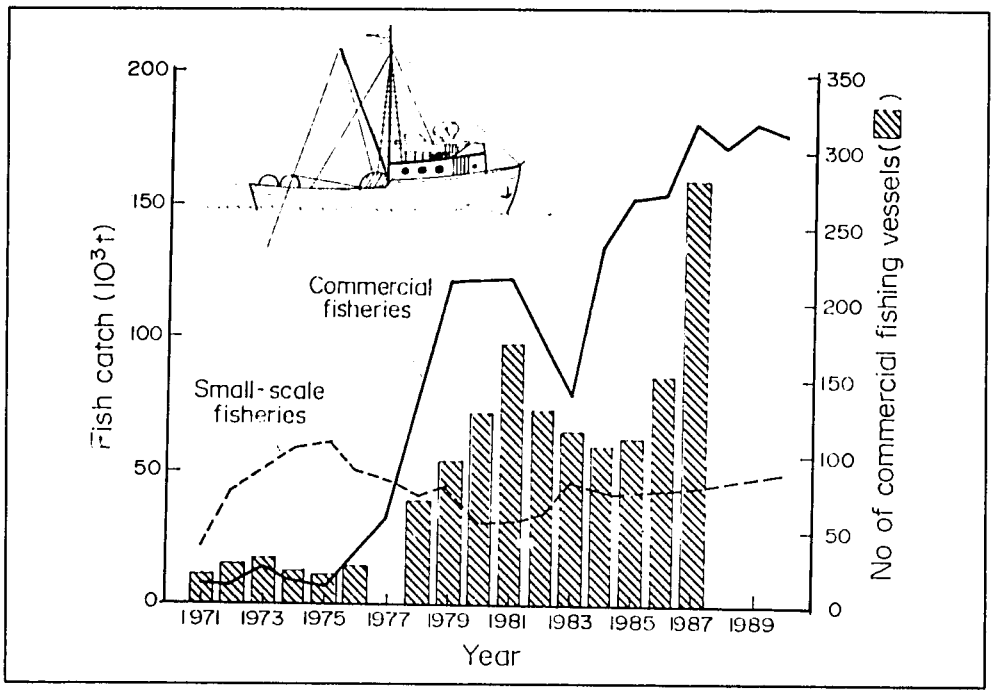

Fig. 5. Small-scale and commercial fisheries catches off Sierra Leone from the 1970s to the 1990s; note stagnating small-scale catches.

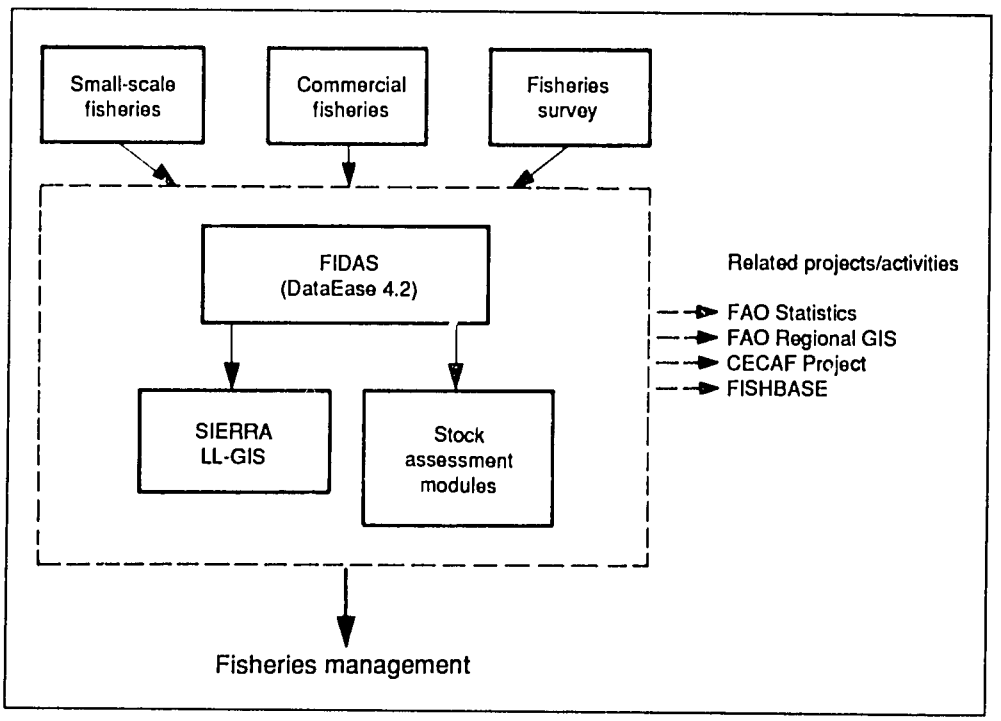

Fig. 6. Schematic representation of the Fisheries Data Acquisition System (FIDAS) and its linkages with other software and/or activities relevant to fisheries management in Sierra Leone.

Project Title		: Improved Management of Openwater Fisheries in Bangladesh
Funding Institution		: Ford Foundation, Bangladesh
Cooperating Institutions		: Ministry of Fisheries and Livestock, Bangladesh; Department of Fisheries, Bangladesh (DOF)
Duration		: Three years, beginning July 1991
Key Personnel	ICLARM	: Dr. Mahfuzuddin Ahmed
	DOF	: Mr. A.K. Ataur Rahman; Mr. Md. Mokammel Hossain

Objectives

- To determine suitable management options by testing alternative mechanisms for management of small-scale fisheries to achieve objectives such as redistributing fisheries benefits in favor of households directly dependent on fishing.
- To assist in the design of experimental approaches for implementation of a new management policy for openwater fisheries in Bangladesh that would emphasize active involvement of fishing communities and NGOs.
- To provide technical assistance and guidance to Bangladesh scientists on certain methodology of fisheries research.

Results

This project in collaboration with the Bangladesh Ministry of Fisheries and Livestock (MOFL) and Department of Fisheries (DOF) seeks to improve old exploitative modes of production and to ensure productivity and sustainability of publicly owned inland openwater fisheries under a new management policy.

In the first phase (1986-89), ICLARM provided technical assistance, training and research guidance for experimental implementation of a policy granting direct fishing rights to genuine fishers. This was done by replacing the policy of annual leasing out of fishing rights to highest bidders, who were invariably wealthy fish traders. Experiments in selected waterbodies indicate that the intended beneficiaries can be reached and that they will benefit from the new policy. This does, however, require a mix of management and financial inputs, infrastructure facilities, and institutional support.

In the second phase, the Government of Bangladesh, using ICLARM's technical assistance, intends to implement a mechanism through which these necessary inputs can be provided, i.e., through active involvement of fishing communities and NGOs.

A major output in 1991 under the current project theme is the publication of ICLARM's first technical report on Bangladesh fisheries entitled "A Model to Determine Benefits Obtainable from the Management of Openwater Fisheries in Bangladesh". This report provided a strong basis for adopting a rational management policy of exploitation of the openwater fisheries resources. There will be substantial inputs from biologists and socioeconomists in the coming years and substantial output on bioeconomic studies for management guidances will be produced.

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

Funding Institutions : Commission of the European Communities (CEC); Agence de coopération culturelle et technique (ACCT); Association des université partiellement et entièrement de langue française (AUPELF).

Cooperating Institutions : Food and Agriculture Organization of the United Nations (FAO); Zoologisches Institut und Museum (ZIM) Hamburg; Expert Center for Taxonomic Identification (ETI) Amsterdam; University of the Philippines, Marine Science Institute; Department of Fisheries, Malawi; Institute of Aquatic Biology (IAB) Accra; Dr. Fridtjof Nansen Project, Institute of Marine Research, Bergen (NAN-IMR) Bergen; Ecole nationale supérieure agronomique de Toulouse (ENSAT).

Duration : October 1988 to August 1992 (to be extended to August 1994)

Key Personnel

FAO	:	Dr. Kent Carpenter
ZIM	:	Prof. Wolfgang Villwock; Ms. Ulrike Sienknecht
ETI	:	Dr. Peter Schalck
UP/MSI	:	Dr. Ed Gomez; Ms. Emili Capuli
Malawi	:	Mr. B. Mkoko; Mr. Emmanuel Kaunda
IAB	:	Dr. Martin Odei; Ms. Mamaa Entsua-Mensah
NAN-IMR	:	Ms. Gabriela Bianchi
ENSAT	:	Dr. Jacques Moreau; Ms. Patricia Reyes-Marchant
ICLARM	:	Dr. Rainer Froese; Dr. Maria Lourdes Palomares (since October 1991); Dr. Daniel Pauly; Ms. Susan Luna; Ms. Crispina Binohlan; Ms. Armi Torres; Ms. Liza Agustin; Mr. Dominic Tioseco; Mr. Roberto Cada; Mr. Magnus Olsson Ringby

Objectives

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

Results

As of December 1991, substantial information on about 800 species, and nomenclature and distribution for a total of about 4,500 species have been entered into FISHBASE (Fig. 7). Several databases compiled by other institutions have been linked to the proper species name in FISHBASE and are now distributed together with FISHBASE:

SPECIESDAB - a database containing nomenclature, distribution and additional information on important marine species, compiled by the FAO Species Identification Programme;

INTRO - a database on international introductions of inland aquatic species, compiled by Dr. Robin Welcomme, FAO;

OXYREF - a database with 6,800 records on oxygen consumption of fishes, compiled by R. Thurston and P. Gehrke;

NAN-SIS - a database with occurrence and abundance records for thousands of species throughout the tropics, compiled by the Dr. Fridtjof Nansen Project, Bergen, Norway.

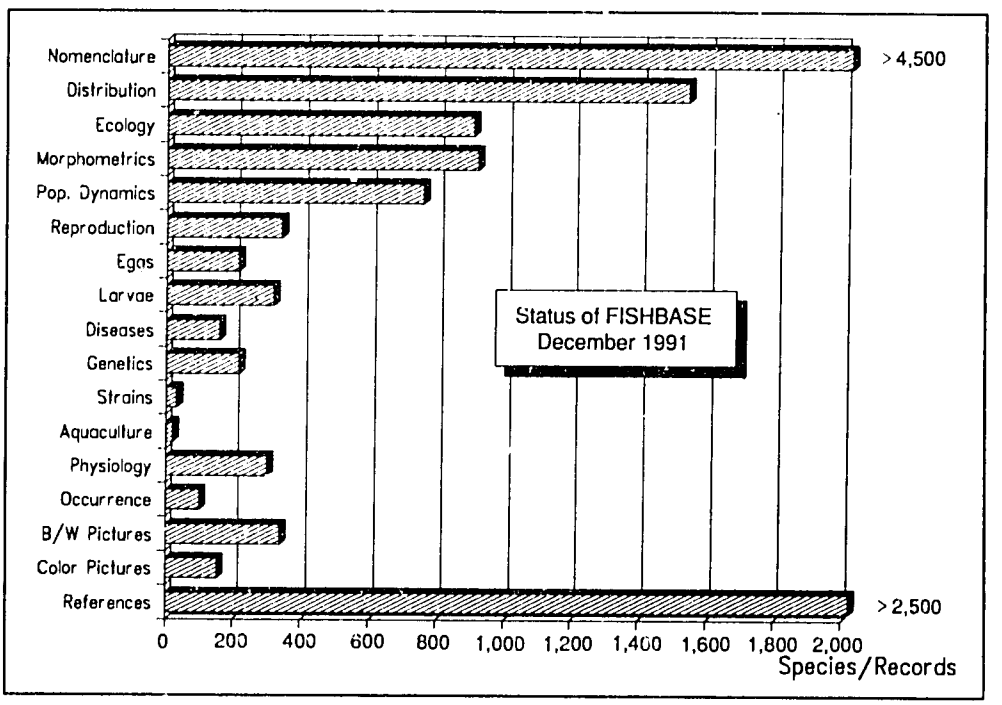

Fig. 7. Status of FISHBASE as of December 1991.

The project focused on the compilation of population dynamics data, now with more than 2,400 records for over 700 species, and on genetics with more than 1,700 records for about 200 species. One output of the latter dataset is a STRAIN REGISTRY for tilapiine fishes, which was presented as a poster at the Third International Symposium on Tilapia in Aquaculture (ISTA III) in Abidjan, Côte d'Ivoire (see p. 28).

The project signed collaboration agreements with the Zoologisches Institut und Museum (ZIM) Hamburg and the Expert Center for Taxonomic Identification (ETI) Amsterdam. Several other institutions expressed their

interest to cooperate with FISHBASE. Also many individual scientists from developing and developed countries offered to contribute data and to help check entries in the database.

The project established three regional outposts, with the University of the Philippines Marine Science Institute, the Fisheries Department, Malawi, and Institute of Aquatic Biology, Ghana (see photo), respectively. The outposts have started to produce checklists of fishes for their countries and are collecting locally available information on these species for inputting into FISHBASE.

The Study Group on FISHBASE of the International Council for the Exploration of the Sea (ICES) reviewed the FISHBASE project during its 1991 Statutory meeting in La Rochelle, France. It found the progress of the project encouraging and asked for inclusion of all available information on at least one stock managed by ICES into FISHBASE, in order to decide, at the 1992 statutory meeting, whether FISHBASE should be used as an information system for all 160 stocks recognized by ICES.

A first (English language) version of FISHBASE will be ready for distribution to collaborators in September 1992. The first "public" version, on CD-ROM, is planned to be available by the end of 1993.

The structure of FISHBASE, which involves entry of quantified information and of qualitative information through multiple choice fields, is ideally suited for straightforward "translation" into languages other than English. Thus, a grant from ACCT is being applied to the preparation of a French version of FISHBASE for release in 1993.

Project Leader Dr. Rainer Froese (center) with two FISHBASE outpost staff: Ms. Mamaa Entsua-Mensah, Institute of Aquatic Biology, Ghana, and Ms. Emmanuel Kaunda, Department of Fisheries, Malawi.

AQUACULTURE PROGRAM

Background

In 1991, as in recent years, ICLARM's Aquaculture Program has been focused on research for the development of better breeds of fish and of better low input, sustainable aquaculture systems. In freshwater, such systems are designed to be integrated with agriculture. The species chosen are widely farmed, opportunistic, microphagous fishes that feed low in the foodchain - on bacteria, plankton, benthos and vegetation - principally the African tilapias and Asian carps.

In marine waters, the previous focus on giant clams has broadened to include preliminary studies on pearl oysters and how ICLARM might complement national and regional initiatives on these and other molluscs. The prospects for reef ranching are beginning to be explored. This research on coastal aquaculture is based at the Coastal Aquaculture Centre (CAC) in the Solomon Islands and is presented in the chapter on the South Pacific Office to which the CAC belongs (see p. 95).

The need to ensure sustainability and evolvability of small-scale aquaculture binds together these interactive research themes. The required elements are the same as those that are now becoming well recognized in research for agricultural development: wise management of natural resources, care for the environment, conservation of biodiversity and equitable distribution of benefits among producers, consumers and their dependants. An exciting future prospect is that integration of aquaculture into farming systems, whether as a major or minor enterprise, can trigger new attitudes in farmers who thus begin, perhaps for the first time, to see prospects for synergism and resource flows among enterprises and consequent benefits.

In conducting strategic research for such development, the Program staff have learned that the concept of 'transfer of technology' is best abandoned. It connotes an outdated top-down approach in which technology 'packages', usually devised on research stations remote from farm conditions, are promoted via national extension services. For aquaculture, these services are often woefully inadequate (especially in Africa) and also tend to use outdated top-down methods, reaching very small numbers of selected, often atypically resource-rich farmers. Many countries have yet to develop effective aquaculture extension services for low-income farmers and have yet to realize that their crop and livestock farmers include many potential new entrants to aquaculture. The persistence of agriculture-aquaculture sectoral boundaries is counterproductive.

Therefore, the Program has increased its involvement in Farmer Participatory Research (FPR) with existing fish farmers (where present) and potential new entrants. FPR is an essential component of its testbed projects

and a means of generating and testing new ideas and research advances so that technologies will make sense to resource-poor adopters. FPR is an integral part of the Program's scientific research agenda. It is not extension *per se* or 'transfer of technology'.

Progress of Work

In 1991, there was increased interaction between the Program and other ICLARM Programs, particularly in whole systems research; for example, research on rice-fish socioeconomic research figured in the activities of the Asian Fisheries Social Science Research Network (AFSSRN); common research tools were applied to coastal and inland farming and fishing systems research; and, for ecological modelling, ECOPATH was applied to the analysis of inland aquaculture systems as well as to capture fisheries. Moreover, Program staff at headquarters and in the outreach projects based in Ghana and Malawi collaborated actively with the expansion of FISHBASE (see p. 43).

Genetics

Many developing countries are in need of improved fish breeds and more trained personnel to manage farmed fish stocks in an informed manner. So far there is no sustained applied fish breeding program anywhere in the tropical developing world and therefore no mechanism for learning by experience how to develop such programs to suit the needs of existing and new entrant fish farmers.

ICLARM's Genetic Improvement of Farmed Tilapias (GIFT) project, funded by the United Nations Development Programme and the Asian Development Bank, is the main Program activity. ICLARM's principal partners are the Institute of Aquaculture Research (AKVAFORSK), Norway, the National Freshwater Fisheries Technology Research Center of the Philippine Bureau of Fisheries and Aquatic Resources (NFFTRC/BFAR), the Freshwater Aquaculture Center of Central Luzon State University (FAC/CLSU) and the Marine Science Institute of the University of the Philippines (UPMSI). The GIFT project is a pioneering effort, based in the Philippines with outreach to other developing countries in Africa and Asia. Its focus is on the Nile tilapia *(Oreochromis niloticus)*. This species is an important component of small-scale aquaculture for many resource-poor farmers and, because of its short generation time, an excellent model species for the development of applied breeding methods. The research thrust is to develop methodologies and policy guidelines that can be adapted to tilapias and other species in national breeding programs. It is an example of how international collaboration can help to initiate national fish breeding programs.

In 1991, the GIFT project team built a base population from the best performing breeders of eight Nile tilapia strains, using data on breeding values from previous trials in a variety of farming systems, and set up the first experiment on selection from the base population.

The tilapia germplasm assembled and the genetically improved fish developed in the project will be made available as widely as possible, subject to strict environmental safeguards. The GIFT project will convene a formal

technical consultation in 1992 to discuss and develop protocols and safeguards for further development and dissemination of improved breeds. The strategy is to invite a small group of experts with experience in fish, livestock and plant breeding, representatives from ADB, FAO, NGOs, UNDP and concerned groups, and representatives from countries most likely to develop national breeding programs.

The year 1991 also saw the launching of research collaboration involving ICLARM, the Institute of Aquatic Biology (IAB) in Accra, Ghana, and the Zoological Institute and Museum of the University of Hamburg (ZIM/UH) in a project entitled Research on the Tilapia Genetic Resources of Ghana for their Future Conservation and Management in Aquaculture and Fisheries, supported by the Der Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ), Germany, through the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ).

Collaboration was also 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 (UCS), UK and the FAC/CLSU, Philippines, funded by the Overseas Development Administration (ODA), UK.

Integrated Farming Systems

In 1991, the Program staff working at headquarters and in the outreach projects in Bangladesh, Ghana and Malawi, established an ICLARM Integrated Farming Systems Group (IFSG) to coordinate their efforts and to exchange information and results on a more regular basis. The IFSG meets whenever outreach staff can visit Manila for briefings or staff meetings and otherwise communicates through correspondence, increasingly through e-mail.

The formation of the IFSG assisted the development of FARMBASE, a computerized farming systems database and analytical framework that links qualitative field methods to quantitative techniques and datasets. In June, the Danish International Development Agency (DANIDA) provided a Danish scientist, Mr. Jens Peter Tang Dalsgaard, to assist FPR data analysis and bioeconomic modelling and to join the group developing FARMBASE.

In May, ICLARM and the International Institute of Rural Reconstruction (IIRR) - an international NGO, with its main campus close to Manila and with activities in other developing countries, including Ghana, and common rural development goals with ICLARM - signed a Memorandum of Agreement to collaborate on research and training for the development of integrated farming systems. An ICLARM-IIRR workshop will be held early in 1992 to produce a Farmer-Proven Integrated Agriculture-Aquaculture Technology Information Kit.

In Asia, the program's efforts were centered on rice-based farming systems research. ICLARM and the International Rice Research Institute (IRRI) signed a Memorandum of Agreement to collaborate on strategic rice-fish research. ICLARM's Integrated Rice-Fish Group's (IRFG) activities were strengthened by support from the International Development Research Centre (IDRC) of Canada and the Overseas Development Administration (ODA) of the United Kingdom. The IRFG has activities in eight Asian

countries (Bangladesh, China, India, Indonesia, Malaysia, the Philippines, Thailand and Vietnam) and is part of the Asian Rice Farming Systems Network of IRRI. The ODA support is for ICLARM to work with FAC/CLSU on the development of bioeconomic models for different integrated rice-fish systems. The IRFG continued to gather data on the benefits of rice-fish integration, including the increased rice yields from the improvements to fertility and integrated pest management that fish can bring to the ricefield environment.

ICLARM published in 1991 a summary report of the workshop held in 1989 on the Environmental Impact of Golden Snail (*Pomacea* sp.) on Rice Farming Systems in the Philippines. This discussed the damage wrought to over 400,000 hectares of ricelands by the irresponsible introduction and subsequent spread of this exotic snail and summarized approaches for its control.

In Bangladesh, two projects were successfully continued: the aquaculture component of the USAID-funded Agricultural Research Project II and a project funded by the International Fund for Agricultural Development (IFAD) and DANIDA on the Socioeconomic Impact of a Fish Culture Extension Program on the Farming Systems of Bangladesh. The former is having an impact on literally thousands of small-scale farmers by developing low-cost, short-cycle aquaculture systems that produce fish for home consumption and sale from formerly derelict small waterbodies (ditches and ponds). The key has been to use species that can be grown cheaply and harvested in a few months - mainly Nile tilapia and silver barb *(Puntius gonionotus)*. These ideas are being extended by NGOs and government agencies to farmers, many of whom are new entrants to fish culture, including large numbers of women who work close to their homesteads.

The IFAD-DANIDA project operates on a narrower front comparing socioeconomic conditions in a target area, into which low input integrated agriculture-aquaculture technology has been introduced, with a control area that has not received such extension. The project's baseline surveys were completed in 1991. Its targets include the development of methodologies for assessing the impact of extension, that can be used widely in developing countries.

In Ghana, a collaborative project was started between ICLARM and the Institute of Aquatic Biology (IAB) to review the scope for development of smallholder aquaculture. The project is funded by the German BMZ and executed by ICLARM and GTZ. It uses a farming systems research approach and a 'farmer first' perspective. The IAB-ICLARM team is developing a framework which can be used in the future by other developing countries to determine their potential for smallholder aquaculture development. Information from surveys and interviews is added to that from maps and agricultural and fisheries production statistics and is stored and managed in a computer database linked to FARMBASE.

In Malawi, an ICLARM-GTZ project on research for the development of rural aquaculture was continued and further funding from Germany promised up to October 1994. Malawi provides leadership in inland fisheries and aquaculture for the 10 countries of the SADCC (Southern Africa Development Coordination Conference) subregion. The project pursues a combination of on-station and on-farm research and training of national scientists that is stimulating the expansion of smallholder aquaculture in

Malawi and assisting Malawi's SADCC-wide role.

ICLARM Director General, Dr. Kenneth T. MacKay, signed renewals of Memoranda of Understanding (MOUs) with the Malawi Ministry of Forestry and Natural Resources and the University of Malawi, and a new MOU with the Malawi Department of Research and Environmental Affairs (DREA). These agreements allow ICLARM to continue its aquaculture research activities in Malawi until 1996. The new MOU with the DREA covers any future expansion of ICLARM into activities as diverse as species conservation, genetic diversity, capture fisheries and lake coastal zone policy and resources management issues.

ICLARM also created two committees with its collaborators in Malawi, a Standing Committee on Research and a Standing Committee on Administration to share results rapidly and to circulate, discuss and prioritize workplans, research and development proposals. In November, Malawi's National Aquaculture Coordination Committee recommended that ICLARM coordinate a national research committee that would include representatives of all Malawi government and donor-assisted aquaculture projects in the country.

National Research Support

Networking

The Network of Tropical Aquaculture Scientists (NTAS) grew to 556 members from 86 countries and published three issues of its newsletter, Aquabyte, which will be incorporated into *Naga, the ICLARM Quarterly*, from January 1992. An Integrated Rice-Fish Group (IRFG) was further developed as part of the Asian Rice Farming Systems Network of IRRI.

Conferences

The major event of the year was the Third International Symposium on Tilapia in Aquaculture (ISTA III), convened on 11-16 November 1991 in Abidjan, Côte d'Ivoire, by ICLARM and the Centre de Recherches Océanographiques (CRO) under the Ministère ivorien de la recherche scientifique et de l'enseignement professionel et technique. ISTA III was sponsored by the Ministère français de la coopération et du développement; ORSTOM; l'Agence de coopération culturelle et technique (ACCT); le Centre technique forestier tropical (CTFT-CIRAD); le Centre technique de coopération agricole et rurale (CTA); and l'Institut de recherche agronomique (INRA). There were 183 participants from 29 countries. Over 90 papers were presented and there was a lively poster session and field trips to the Institut des savannes (IDESSA), Bouake and lagoon aquaculture research projects and farms near Abidjan. The conference was bilingual with simultaneous interpretation of all sessions. The proceedings will also be published in English and French. This was one of the largest and most successful aquaculture conferences held in Africa.

ICLARM also hosted in August 1991 a four-day workshop for the scientists of the USAID-funded Program for Science and Technology Cooperation (PSTC) sponsored by the Board on Science and Technology for

International Development (BOSTID), Office of International Affairs, National Research Council, Washington, DC. Some 38 participants, mainly PSTC grantees from Africa, Asia and Latin America attended the workshop. It had two sessions: 1) aquaculture and fisheries and 2) public health, focusing on schistosomiasis (bilharzia). The proceedings of the workshop will be published by BOSTID in 1992.

Education and Training

Education and training remained an integral part of the Program's activities and were closely associated with research. The mechanisms used ranged from production of training materials to on-the-job training of individuals or small groups and more formalized courses for larger numbers. For example, training under the tilapia genetics project in Ghana introduced counterpart scientists to new techniques and equipment and the ICLARM UNDP GIFT project (see p. 61) trained two geneticists from the Research Institute for Aquaculture No. 1, Vietnam, sponsored by FAO, in quantitative genetics methods. Training in Bangladesh in low-input integrated aquaculture involved hundreds of persons through Farmer's Days, rallies and linkages with NGOs (see p. 74). In response to a request from IDRC, ICLARM and IIRR organized training on agroecosystem analysis using Rapid Rural Appraisal (RRA) techniques for Southeast Asian Fisheries Development Center (SEAFDEC) and University of the Philippines researchers working on IDRC-funded projects.

Most of the Program's projects have training workshops within their scope of activities. For example, the GIFT project held its Fourth Training Workshop on Quantitative Genetics of Farmed Tilapias in the Philippines, from 19 to 24 August 1991. Twenty researchers from the project's collaborating institutions and five from other projects and institutions were trained in the estimation of genetic variances, correlations, heritability and breeding values for selecting individuals.

The Program's project summaries (p. 60-89) include details of training activities additional to these examples.

The Program's training publications have had a multiplier effect on training elsewhere. For example, a video produced from the ICLARM-GTZ Malawi project is being used in teaching in the University of East Anglia's School of Development Studies, Norwich, UK. A book, published in ICLARM's Education series entitled "Households, Agroecosystems and Rural Resources Management - A Guidebook for Broadening the Concepts of Gender and Farming Systems", based on studies in Bangladesh and funded by the Ford Foundation, is being used in training workshops and projects in Africa and Asia.

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 (e.g., for the International Foundation for Science) and responding to requests for information largely from

developing countries, for example, on sources of tilapia germplasm.

Dr. Ambekar Eknath was appointed to the Board of Directors of the International Association of Geneticists in Aquaculture, the body that convenes the ongoing series of International Symposia on Genetics in Aquaculture.

Dr. Clive Lightfoot was appointed to the Board of Directors of the Association for Farming Systems Research and Extension (AFSRE). He heads the Association's Steering Committee on Networking. The AFSRE is an international society organized to promote the development and dissemination of methods for and results of farmer participatory research and extension. Dr. Lightfoot also became the Executive Editor of the new Journal of the Asian Farming Systems Association (JAFSA) which was launched from ICLARM in 1991. This journal fosters a multisectoral approach to development so that fish farming enterprises, integrated with crop, tree, vegetable and livestock raising will gain much wider acceptance as a source of improved nutrition and livelihood.

Dr. Pullin accepted an invitation to join the External Evaluation Panel of the USAID-funded Pond Dynamics Aquaculture CRSP and continued to serve on the international panel advising the UNDP/FAO project on Sepik River Stock Enhancement in Papua New Guinea, as a member of the Indo-Pacific Fishery Research Commission's Working Group on Aquaculture, as a reviewer of the US National Research Council's Board of Aquaculture Report on Managing Global Genetic Resources - Fish and Shellfish, as a member of the editorial boards of four international journals and as ICLARM's contact person for the World Conservation Union (IUCN). Dr. Pullin also lectured at the Center for Development Studies of the University of Bergen and recorded material for the British Broadcasting Corporation (BBC) that was aired on the BBC World Service Programme, Farming World.

Meetings Attended, Papers Presented

Interdisciplinary Dialogue on Biotechnology: Reaching the Unreached, organized by M.S. Swaminathan Research Foundation, Madras, India, 21-26 January. (A.E. Eknath).

Paper presented:

Eknath, A.E. and R.S.V. Pullin. Applications of biotechnology in aquaculture.

FISHBASE-Malaŵi National Steering Committee, Lilongwe, Malaŵi, 11 January. (B.A. Costa-Pierce, R. Froese).

Workshop on "Evaluation of BAU-FSRDP Activities", Bangladesh Agricultural University, Mymensingh, Bangladesh, 15-16 January. (M.V. Gupta).

National Aquaculture Coordination Committee, hosted by CEC North and Central Regions Project, Mzuzu, Malaŵi, 16-17 January. (B.A. Costa-Pierce, R.P. Noble).

Paper presented:

ICLARM. Farming systems research and extension approaches of ICLARM.

International Foundation for Science Workshop on Aquaculture in Africa, Harare, Zimbabwe, 23-26 January. (F.J. Chikafumbwa, B.A. Costa-Pierce, A.A. van Dam).

Papers presented:

Chikafumbwa, F.J. and B.A. Costa-Pierce. Rates of napier grass (*Pennisetum purpureum*) additions to polyculture fishponds in Malaŵi.

Costa-Pierce, B.A. Research priorities in subSaharan Africa smallholder freshwater aquaculture.

Workshop on "Role of Social Scientists in Farming Systems Research", Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 28 January. (M.V. Gupta).

ALCOM/FAO Steering Committee Meeting, Mbabane, Swaziland, 19-22 February. (B.A. Costa-Pierce).

USAID/SHARED Workshop on The Role of NGOs in Promoting Rural Enterprise Development Lilongwe, Malawi, 22-25 April. (B.A. Costa-Pierce, R.P. Noble).

Video presented:

Noble, R.P. Aquaculture and the rural African farmer.

Pre-Test Meeting on Gender and Farming Systems, Joydebpur, Bangladesh, 4-7 March. (M. Ahmed, M.P. Bimbao, M.V. Gupta, C. Lightfoot).

National Aquaculture Coordination Meeting, hosted by ICLARM, National Aquaculture Centre, Domasi, Malawi, 25-26 April. (B.A. Costa-Pierce (Chairperson), R.P. Noble, F.J. Chikafumbwa, E.K.W.H. Kaunda, D.M. Jamu, C. Jamu).

4th International Symposium on Genetics in Aquaculture, Wuhan, China, 29 April-3 May. (B.O. Acosta, J.B. Capili, M.P. de Vera, A.E. Eknath, R.S.V. Pullin).

Papers presented:

Agustin, L.Q., J.M. Macaranas and A.E. Eknath. Use of RNA:DNA ratio as index of nutritional status of six Nile tilapia *(Oreochromis niloticus)* strains under different environments.

Bolivar, R., A.E. Eknath, H. Bolivar and T. Abella. Phenotypic correlations between growth and reproductive traits in individually tagged Nile tilapia *(Oreochromis niloticus)* of different strains: implications for planning selection programs.

De Vera, M.P. and A.E. Eknath. Predictability of individual growth rates in tilapia.

Eknath, A.E., M.M. Tayamen, M.P. de Vera, J.C. Danting, R. Reyes, E. Dionisio, J.B. Capili, H.C. Bolivar, T. Abella, A. Circa, H. Bentsen, B. Gjerde, T. Gjedrem and R.S.V. Pullin. Genetic improvement of farmed tilapias: the growth performance of eight strains of *Oreochromis niloticus* tested in different farm environments.

Macaranas, J.M., A.E. Eknath, L.Q. Agustin, R.R. Velasco, M.C. Ablan and R.S.V. Pullin. Genetic improvement of farmed tilapias. Documentation and genetic characterization of strains.

Reyes, R. and A.E. Eknath. Environmental effects on expression of genetic potential for growth in seven strains of Nile tilapia *(Oreochromis niloticus)* and their implications for applied breeding programs.

USAID/SHARED Agriculture NGO Task Force Committee, Lilongwe, Malawi, 7 May. (B.A. Costa-Pierce).

20th Annual Convention of the Philippine Society for Microbiology Inc., and the 2nd Asia-Pacific Biotechnology Congress, Los Baños, Philippines, 22-24 May. (R.S.V. Pullin).

Paper presented:

Pullin, R.S.V. and A.E. Eknath. Biotechnology in aquaculture.

Thirteenth Annual Conference of the Association for the Advancement of Science of Malawi, Lilongwe, Malawi, 23-25 May. (D.M. Jamu).

Paper presented:

Jamu, D.M. Use of firewood ash in small scale aquaculture.

USAID/SHARED Workshop on the Roles of NGOs in Promoting Agricultural Developmment and Natural Resource Management in Malawi, Blantyre, Malawi, 27-31 May. (B.A. Costa-Pierce, Presenter and Session Chairperson).

Paper presented:

Noble, R.P. and B.A. Costa-Pierce. Rural aquaculture technology development, transfer and roles of NGOs in Malawi.

International Center for Aquaculture, Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, Alabama, USA, Seminar series, 14 June. (D.M. Jamu).

Paper presented:

Jamu, D.M. Aquaculture development in rural Malawi.

Twenty-Second Annual Meeting of the World Aquaculture Society, San Juan, Puerto Rico, 16-20 June. (D.M. Jamu).

Paper presented:

Jamu, D.M. The culture of indigenous species using on-farm resources in Malawi, Africa.

National Aquaculture Coordination Meeting, hosted by ODA, Mulanje, Malawi, 11-12 July. (F.J. Chikafumbwa, B.A. Costa-Pierce, D.M. Jamu).

International Foundation for Science/Malawi Department of Research and Environmental Affairs Workshop on the Maintenance, Operation and Service of Scientific Equipment, Zomba, Malawi, 22 July-2 August. (D.M. Jamu).

BOSTID-ICLARM Aquaculture Workshop for PSTC/CDR Scientists, ICLARM, Manila, Philippines, 6-10 August. (B.O. Acosta, M. Ahmed, B.A. Costa-Pierce, C.R. dela Cruz, M.V. Gupta, C Lightfoot, K.T. MacKay, R. Noble, R.S.V. Pullin).

Papers presented:

Gupta, M.V. Low input technologies for rural aquaculture development in Bangladesh.

Noble, R.P. and B.A. Costa-Pierce. Aquaculture technology research for smallholder farmers in rural Malawi.

National Workshop on Fish Management in Bangladesh Agriculture, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 24-27 August. (M.V. Gupta).

ICLARM-IIRR Training on Agroecosystem Analysis, Cavite, Philippines, 26-27 August. (M.P. Bimbao, J.P.T. Dalsgaard, J. Nicolas, R.P. Noble).

Seventh International Ichthyology Congress, The Hague, Netherlands, 26-30 August. (R.S.V. Pullin).

Paper presented:

Pullin, R.S.V. and J.L. Maclean. Analysis of research for the development of tilapia farming: an interdisciplinary approach is lacking.

SARCCUS Subcommittee on Aquaculture, Liwonde, Malawi, 3-4 September. (F.J. Chikafumbwa, B.A. Costa-Pierce, D.M. Jamu).

ICLARM/Malawi Department of Fisheries/Department of Research and Environmental Affairs/University of Malawi Workshop on The History, Status and Future of Common Carp in Malawi, 12-13 September, National Aquaculture Centre, Domasi, Malawi (F.J. Chikafumbwa, B.A. Costa-Pierce, D.M. Jamu, E. Kaunda, O.V. Msiska, R.P. Noble, A.A. van Dam).

Papers presented:

Chimatiro, S. Analysis of the energy and nutrient status of selected integrated agriculture-aquaculture farms in the Zomba district.

Costa-Pierce, B.A. New introductions of common carp and impacts on native species, with reference to subSaharan Africa.

Jamu, D.M. Research into the sustainable development of alternative indigenous fish species for aquaculture in Malawi.

Msiska, O.V. The history of common carp introduction in Malawi.

Msiska, O.V. The status and performance of common carp aquaculture on estates.

Noble, R.P. The status and performance of common carp on smallholder farms in Zomba East, Malawi.

Workshop on Running a Small Library, Malawi Library Association, Blantyre, Malawi, 8-13 September. (C. Jamu).

USAID/SHARED Agriculture Task Force Committee Meeting, Blantyre, Malawi, 27 September. (B.A. Costa-Pierce, R.P. Noble).

Workshop on "Inland Aquaculture Development Strategies for Bangladesh", Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 29 September-1 October. (M.V. Gupta).

Paper presented:

Gupta, M.V. Potential for culture-based fisheries in Bangladesh.

2nd Meeting of the Asian Rice Farming Systems Working Group, Beijing, China, 30 September-4 October. (C.R. dela Cruz).

Paper presented:

dela Cruz, C.R., C. Lightfoot, M.P. Bimbao, J. Nicolas, J.P.T. Dalsgaard, R.C. Sevilleja, A.G. Cagauan and M. Halwart. Rice-fish farming systems research: methodology issues and future direction.

Workshop on CDS/ISIS, National Documentation Centre, Lilongwe, Malawi, 21-25 October. (C. Jamu).

National Aquaculture Coordination Meeting, hosted by MAGFAD, Zomba, Malawi, 1 November. (F.J. Chikafumbwa, B.A. Costa-Pierce, D.M. Jamu).

Eleventh Annual Symposium of the Association for Farming Systems Research-Extension, East Lansing, Michigan, USA, 5-10 October. (C. Lightfoot).

Third International Symposium on Tilapia in Aquaculture (ISTA III), Abidjan, Côte d'Ivoire, 11-16 November. (B.O. Acosta, M.A. Ahmed, M.P. Bimbao, J.B. Capili, F.J. Chikafumbwa, S. Chimatiro, B.A. Costa-Pierce, A.E. Eknath, M.V. Gupta, D.M. Jamu, E.K.W.H. Kaunda, C. Lhomme-Binudin, R.P. Noble, O.V. Msiska, M.L. Palomares, D. Pauly, M. Prein, R.S.V. Pullin, J.M. Vakily, R.R. Velasco)

Papers presented:

Acosta, B.O., E. Dionisio and A.E. Eknath. Growth and food conversion of wild and domesticated strains of *Oreochromis niloticus* fry. (poster)

Ahmed, M., M.P. Bimbao and M.V. Gupta. Economics of tilapia aquaculture in small water bodies in Bangladesh.

Bimbao, M.P. and M. Ahmed. Regional trends in production and prices of tilapia in the Philippines.

Capili, J.B. Mitochondrial DNA restriction endonuclease and isozyme analysis in three strains of *Oreochromis niloticus*.

Chikafumbwa, F.J. Use of terrestrial plants in aquaculture.

Chimatiro, S. Pumpkin and cabbage leaves as alternative inputs to maize bran in polyculture of *Tilapia rendalli* and *Oreochromis shiranus*.

Costa-Pierce, B.A. *Tilapia rendalli* fry production in tanks and hapas.

Eknath, A.E., J.C. Danting, M.P. de Vera, E. Dionisio and R. Reyes. A practical quantitative method of estimate relative reproductive performance during the routine production cycles in *Oreochromis niloticus*.

Gupta, M.V., M. Akteruzzaman, A.H.M. Kohinoor and M.S. Shah. Nile tilapia *(Oreochromis niloticus)* culture under different feeding and fertilization regimes.

Jamu, D.M. Liming of fishponds in subSaharan Africa: a comparative study of limed and unlimed ponds in Malawi.

Kaunda, E.K.W.H. Control of tilapia population dynamics: catchability estimates for simple harvesting tools tested in small-scale fishponds in Malawi.

Maluwa, A.O. Performance of *Oreochromis karongae* in fishponds in Malawi.

Msiska, O.V. A comparison of the growth performance of *Oreochromis karongae* in nature and aquaculture.

Noble, R.P. Utilization of on-farm resources for small-scale aquaculture in Africa.

Palomares, M.L. A general predictive model of the food consumption of tilapias.

Pauly, D. A new method for comparing the growth performance of fishes, applied to wild and farmed tilapias.

Pullin, R.S.V. World tilapia culture and its future prospects.

Velasco, R.R. Morphometric characterization of eight Philippine and African *Oreochromis niloticus* strains.

niloticus strains.

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Aquaculture Program Project Summaries

Project Title : Network of Tropical Aquaculture Scientists

Funding Institution : Unrestricted Core

Duration : Continuous from July 1987

Key Personnel ICLARM : Ms. Mary Ann 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

NTAS membership increased to 554 scientists representing 86 countries, while aquaculture research institutions receiving the Network newsletter, Aquabyte, increased to 120 representing 34 countries. The regional distribution of members, half of which are involved in tropical aquaculture research in Africa and Asia, is shown in Fig. 1. The Network has responded to numerous requests from members for literature searches, reprints and reference materials. Three issues of Aquabyte were published with increased material contributed by members.

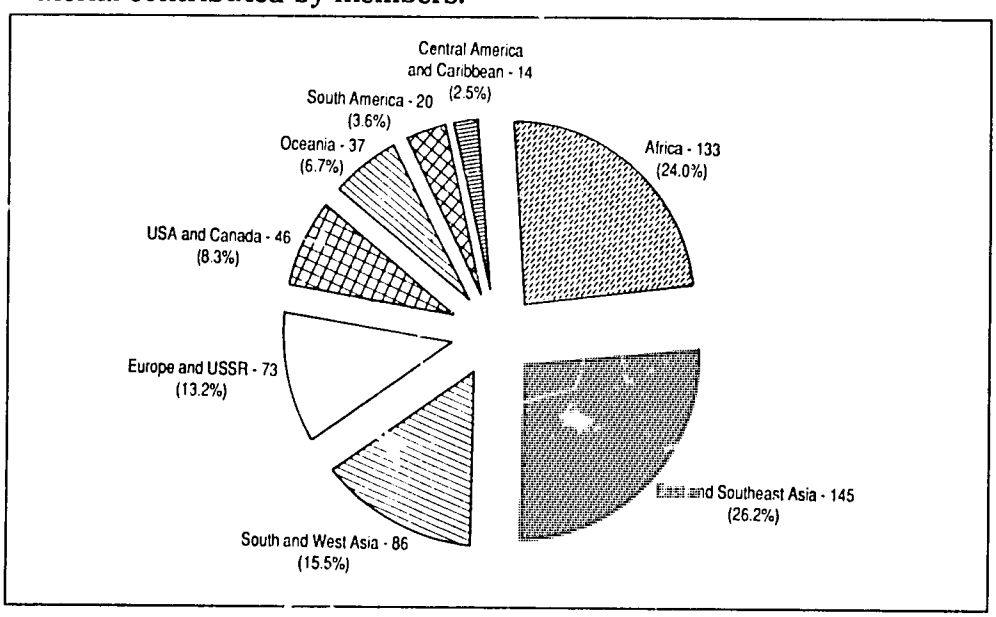

Fig. 1. Distribution of NTAS members: 554 members in 86 countries.

Project Title : Genetic Improvement of Farmed Tilapias

Funding Institutions : Asian Development Bank (ADB); Division for Global and Interregional Programmes of the United Nations Development Programme (UNDP/DGIP)

Cooperating Institutions : The National Freshwater Fisheries Technology Research Center of the Philippine Bureau of Fisheries and Aquatic Resources (NFFTRC/BFAR); the Freshwater Aquaculture Center of the Central Luzon State University (FAC/CLSU); the Marine Science Institute of the University of the Philippines (UPMSI); the Institute of Aquaculture Research of Norway (AKVAFORSK) through the Norwegian Center for International Agricultural Development (NORAGRIC/NORAD)

Duration : 1988 to 1991; extended up to June 1992

Key Personnel

NFFTRC/BFAR : Mr. Melchor Tayamen; Mr. Ruben Reyes; Mr. Marlon Reyes; Ms. Jodecel Danting[1]; Ms. Edna Dionisio; Ms. Felicisima Longalong; Ms. Teresita Gonzales; Mrs. Elizabeth Afan; Mr. Mar Danting

BFAR Satellite Stations :
a. Freshwater Demonstration Farm, Sto. Domingo, Bay, Laguna - Mr. Orlando Comia
b. Freshwater Fish Farm, San Mateo, Isabela - Mr. Hermogenes Tambalque
c. La Trinidad Fish Farm, Benguet - Mr. Jesus Astrero

FAC/CLSU : Ms. Remedios Bolivar; Mr. Tereso A. Abella[2]; Mr. Antonio V. Circa; Mr. Hernando Bolivar

UPMSI : Dr. Julie M. Macaranas; Ms. Maria-Josefa R. Pante; Ms. Carmen Ablan; Ms. Liza Agustin

AKVAFORSK: Dr. Trygve Gjedrem; Dr. Hans 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; Ms. Belen O. Acosta; Ms. Carmela C. Janagap

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[1]Currently studying for an M.Sc. degree at Institute of Aquaculture, University of Stirling, UK.
[2]Continuing studies for a Ph.D. degree at the University College of Swansea, Wales, UK.

Objectives

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

Results

The year 1991 has seen significant achievements for the project. Despite adverse natural events, i.e., further tremors following the July 1990 earthquake and typhoons, the project's activities, including those in remote test stations, were well maintained. The upgrading of the project's acquisition of computers, comprehensive statistical software (SAS OS/2), and access to a mainframe computer at AKVAFORSK (Norway), enabled the team to produce substantive outputs during the period. Ten papers were presented at two international conferences: six during the Fourth International Symposium on Genetics in Aquaculture, Wuhan, China, 29 April to 3 May 1991, and four during the Third International Symposium on Tilapia in Aquaculture, Abidjan, Côte d'Ivoire, 11-16 November 1991.

The project completed on schedule in August, third generation tilapia breeding experiments, following the establishment of the base population, to estimate the genetic parameters (heritability, genetic variances and correlations) of survival, growth and reproductive traits. The fourth generation experiment to estimate the magnitude of genetic gain (or response to selection) including the test release of selected fish in farmer participatory research began in August. Details of these three main achievements are given here, followed by summaries of training and outreach activities.

Building the Base Population

Following the successful completion of the two earlier experiments to estimate the magnitude of genotype X environment interaction and nonadditive genetic effects (heterosis), the team chose a simple purebreeding strategy commencing with a mixed base population and broad genetic variability as the best approach to genetic improvement of Nile tilapia in the Philippines. Based on their additive genetic performance, breeders from the 25 best performing purebred and crossbred groups (from the 64 groups evaluated in a complete diallele crossing scheme in eight different test environments) were chosen to build the base population.

Selective Breeding from the Base Population

An experiment was made to estimate the genetic parameters of survival, growth and reproductive traits. One hundred fifty breeding units (net cage hapas) in three sets (total 450) were set up in a nested mating design (one male mated to three different females) to produce 150 full-sib groups. Of the 150 full-sib families planned and actually produced, 27 were not tagged due to the low numbers of fish available at tagging time. However, 25,000

fingerlings were individually tagged and communally reared for 90 days in seven different environments. Tagged fingerlings of the commercial strain most commonly used by fish farmers ('Israel' strain) were also stocked in three different locations in Central Luzon to compare their growth performance. Genetic characterization at the various groups, through electrophoresis is in progress at UPMSI.

Significant results were as follows:

(i) The heritability estimates for body weight at harvest were consistent across all test environments. The average heritability value based on the sire component of variance was 0.23. This indicates a substantial additive genetic variance for growth rate in the mixed base population. The prospects for rapid genetic improvement for this trait through selective breeding are therefore very promising.

(ii) Heritability values for body weight at harvest based on the dam component of variance were high, averaging 0.53 across test environments. This may indicate a significant maternal genetic, nonadditive genetic or environmental effect common to full-sibs.

(iii) The heritability for survival, based on the sire component of variance was 0.08, indicating a significant genetic variance for this trait also. Survival at harvest of the base population was higher for the selected fish than the commercial 'Israel' strain. Correlation between body weight and survival based on the sire component was positive (0.2) indicating a favorable genetic correlation between these two important economic traits.

(iv) The growth performance of the Israel strain was poor, equal to the second lowest ranking full-sib group. The GIFT project's base population was about 60% faster growing than the Israel strain across the range of environments tested.

(v) Heritabilities for age at first spawning and size at first spawning, based on sire and dam components, were 0.04 and 0.72, and 0.24 and 0.29, respectively.

Selective Breeding Experiments, Including Farmer Participatory Research

The fourth generation experiment, to estimate the magnitude of genetic gain (or response to selection), began in August. A combined selection strategy was adopted. Breeders harvested following the termination of the third generation experiment (described above) were ranked based on breeding values estimated from a linear combination of information on individuals, their relatives (full-sibs and half-sibs), and heritability for growth performance. One-hundred males and 200 females were selected according to their estimated breeding values. These came from the 25 highest ranking families (out of the 123 families evaluated during the third generation).

For farmer participatory research, progeny from 75 full-sib groups (out of the 180 produced) were pooled and random samples were drawn for testing in 26 farm environments representing various farming systems: backyard fishponds, cages, rice-fish and semi-intensive systems, all operated by farmers. The aim was to compare the growth performance of the 'GIFT' fish with the commercial 'Israel' strain and the conventional 'Farmer' strains

in current use, communally stocked in equal proportions, in each of the different farming systems. The targeted date of completion of this experiment is April 1992.

Training

In addition to continuous hands-on training of project personnel and visitors, which has been a constant feature of the GIFT project since its inception, two training workshops were conducted: the project's Third Training Workshop on Quantitative Genetics of Tilapias in April - focused on data analysis and preparation of scientific papers for the Fourth International Symposium on Genetics in Aquaculture, Wuhan, China; and the project's Fourth Training Workshop, in August, following the termination of the third generation experiment and focused on estimation of heritability, breeding values and planning of the project's fourth generation experiment.

Three project staff are at present preparing their Master's theses dissertations.

Outreach to Other Countries

The project has established linkages with many national, regional and international institutions and has stimulated Malawian, Ghanaian and Ivorian scientists to expand work on the documentation of fish genetic resources, in preparation for future breeding programs. A further significant activity in 1991 was the visit of Dr. Eknath to the Indian Central Institute of Freshwater Aquaculture, Bhubaneshwar, Orissa, to assist its scientists in developing a research plan for the genetic improvement of rohu (*Labeo rohita*). This will lead to a substantial project, likely to be funded by NORAD, through a bilateral agreement between the governments of India and Norway.

Plans for 1992

The project was initially funded for a period of three years. Following on ADB review of progress in August 1990 and a request from ICLARM, the Bank agreed to a one-year extension. Moreover, the UNDP/DGIP granted one-year's additional supplementary funding until June 1992. UNDP/DGIP is now considering a proposal to support the project for a further five years, beginning in July 1992.

The GIFT project will convene a formal technical consultation in June 1992 to discuss and develop protocols and safeguards for developing and dissemination of improved breeds. A small group of experts with experience in fish, livestock and plant breeding, representatives from ADB, UNDP, FAO, NGOs, concerned groups, and representatives from countries most likely to develop national breeding programs, will be invited.

Project Title		: Research on the Tilapia Genetic Resources of Ghana for their Future Conservation and Management in Aquaculture and Fisheries
Funding Institution		: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Germany
Cooperating Institutions		: The Institute of Aquatic Biology (IAB) in Accra, Ghana; the Zoological Institute and Museum of the University of Hamburg (ZIM/UH)
Duration		: Planning phase, January - June 1991; project phase, July 1991 - June 1994
Key Personnel	IAB	: Dr. Eddie Kofi Abban; Mr. Francis Amevenku
	ZIM/UH	: Prof. Wolfgang Villwock; Prof. Lothar Renwrantz; Dr. Sabine Oberst
	ICLARM	: Dr. Ambekar E. Eknath; Dr. Roger S.V. Pullin

Objectives

- To establish a fish biochemistry and immunology laboratory at IAB.
- To train scientific and technical IAB staff in biochemical and immunological techniques.
- To apply these techniques to the investigation of genetic markers in wild populations of economically important, endemic tilapia species and in the monitoring of wild tilapia populations for genetic introgression caused by fish transfers: both applications to be aimed at the identification and conservation of valuable gene pools for future use in aquaculture and fisheries.

Results

During the first half of 1991, organizational meetings were held among the collaborators. The laboratory equipment required at IAB was ordered in Germany and the project activities started with two months' laboratory training for Dr. Abban and Mr. Joseph Ofori (then appointed the project staff from IAB) at ZIM/UH during August and September. Both were introduced to methods and equipment to be used for the project at IAB.

In mid-November, the laboratory equipment was installed and the training of IAB staff started (Mr. Amevenku and two technical assistants). Tilapia specimens used during the training came from sympatric populations of *Tilapia zillii* and *Sarotherodon melanotheron* from the estuaries of some West Ghanaian rivers. It is intended to investigate these rivers first and to continue with populations and species from the Volta River system later.

Drs. Abban and Oberst and Mr. Francis Amevenku (who replaced Mr. Ofori as an IAB project team member since October) attended the Third

International Symposium on Tilapia in Aquaculture (ISTA III) in Abidjan, Côte d'Ivoire.

The project is linked with the ICLARM/FAO FISHBASE project (see p. 43) and work at ZIM/UH has been initiated on inputting data for wild tilapia stocks and museum collections.

Project Title		: Asia-Africa Cooperation to Develop Aquaculture Technology
Funding Institution		: Fonds d'aide et de coopération (FAC) of the Government of France, Paris
Duration		: Continuous from 1988
Key Personnel	ICLARM	: Dr. Roger S.V. Pullin; Ms. Catherine Lhomme Binudin; 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

Activities in the French Government-supported project to date have concentrated on the provision of relevant information for African researchers. In 1991, Ms. Catherine Lhomme Binudin, a French national, continued a translation program including three issues of the feature 'Actualités Africaines' in *Aquabyte*, the newsletter of the Network of Tropical Aquaculture Scientists (NTAS) (see p. 60). There are now 72 francophone members of the NTAS from 19 countries. Aside from the regular translation activities, Ms. Binudin coordinated the organizational aspects of the Third International Symposium on Tilapia in Aquaculture (ISTA III).

ISTA III was held in Abidjan, Côte d'Ivoire in November 1991 and provided an excellent opportunity for further Asia-Africa exchange of information. There were 21 participants from Asia and 102 from francophone countries including 75 from 11 countries of francophone Africa. The proceedings of ISTA III will be edited by French, Ivorian and ICLARM editors and will be published in French and English by ICLARM and ORSTOM.

Plans were also made at ISTA III for study visits and training of francophone African scientists in Asia, supported by the projects. These will be implemented early in 1992 with visits to ICLARM and its collaborating institutions in the Philippines and Thailand.

Project Title		: FARMBASE
Funding Institution		: Unrestricted Core; Danish International Development Agency (DANIDA)
Cooperating Institution		: International Institute of Rural Reconstruction (IIRR)
Duration		: June 1991 - June 1993
Key Personnel	ICLARM	: Dr. Clive Lightfoot, Mr. Jens Peter T. Dalsgaard; Ms. Mary Ann P. Bimbao; Dr. Catalino dela Cruz; Mr. Jose Nicolas; Dr. Mahfuzuddin Ahmed; Dr. Modadugu Gupta; Dr. Mark Prein; Dr. Reg Noble
	IIRR	: Mr. Frank Fermin; Mr. Scott Killough; Dr. Julian Gonsalves

Objectives

- To improve the way farmers manage land and water resources through integration of aquaculture and agriculture.
- To develop participatory research procedures for farmers to integrate aquaculture into their farming systems and improve their resource management skills.
- To develop database software and an analytical framework for monitoring the impact on households and resource systems of integrating aquaculture into farming systems.

Results

Customized software was developed to initiate FARMBASE - a computerized database - for capturing data and information on integrated aquaculture-agriculture. FARMBASE links qualitative data collection and quantitative data analysis for bioeconomic and ecological modelling (see p. 38, ECOPATH) of integrated farming systems. Support from the Danish International Development Agency (DANIDA) facilitated the hiring of an expert to work full-time on developing FARMBASE.

The data entered into FARMBASE is generated from secondary sources, surveys and farmer participatory research undertaken in Bangladesh, Ghana, Malawi and the Philippines. Farmer participatory methods for constructing village maps and transects showing land and water resource systems and farm bioresource flow diagrams are being refined. Drawings by farmers serve the dual purposes of improved management of on-farm resources and primary data collection (Fig. 2).

There are three levels of data collection: the resource system level, e.g., upland, lowland, homestead, fishpond, etc.; the farm level; and the enterprise level. A distinction is made between external material inputs and outputs entering and leaving the farm, and internal material flows, i.e., on-farm recycling of crop and livestock residues. The latter indicate the extent, level

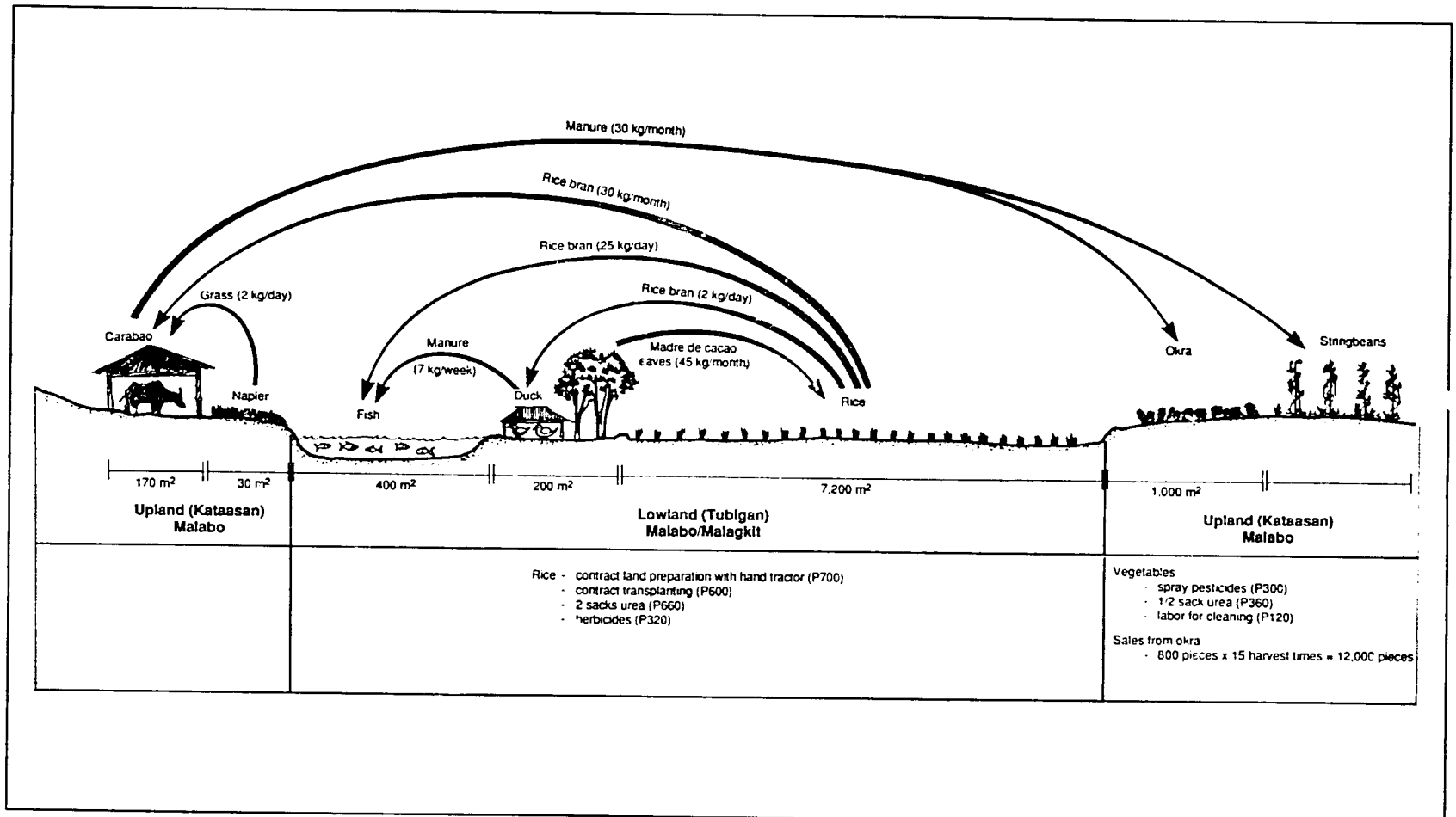

Fig. 1. Farm transect of Jose Mercado's farm in Barangay Pook Paliparan, Dasmariñas, Cavite, Philippines, September 1991.

of use and integration of on-farm resources and can point towards ways of improving overall farm systems management.

FARMBASE is being designed so as to capture the structure of individual farms as depicted via farmer-derived pictorial models.

Frank Fermin (IIRR) explains the importance of on-farm resource integration to farmers in Barangay Pook Paliparan, Dasmariñas, Cavite, Philippines.

FARMBASE's design and structure are developed using farmer participatory methods which involve discussions and consultations with farmers. Here Mary Ann Bimbao (ICLARM) consults with Leopoldo Martinez (IIRR farmer-cooperator) in Barangay Pook Paliparan, Cavite, Philippines, on FARMBASE structure.

Project Title		: Integrated Rice-Fish Group
Funding Institutions		: International Development Research Centre (IDRC) of Canada; Overseas Development Administration (ODA) of the United Kingdom
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)
Duration		: Continuous from February 1990
Key Personnel	FAC/CLSU	: Prof. Ruben C. Sevilleja; Prof. Arsenia G. Cagauan
	IRRI	: Dr. Virgilio R. Carangal
	ICLARM	: Dr. Catalino R. dela Cruz; Dr. Clive Lightfoot; Dr. Roger S.V. Pullin; Mr. Jens Peter T. Dalsgaard; Ms. Mary Ann P. Bimbao; Mr. Jose Nicolas

Objectives

- 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 fish in ricefields, including the effects of fish on rice growth.
- To develop bioeconomic models of rice-fish systems and to apply these in appropriate Asian countries.

Results

Activities of the Integrated Rice-Fish Group in Participating Countries

Efforts were focused on securing resources to sustain the activities of the Integrated Rice-Fish Group (IRFG). Proposals were developed to support IRFG coordination from ICLARM and research in the participating countries. Coordination and monitoring were started with visits to institutions in some of the participating countries (China, India, Indonesia, the Philippines and Vietnam) and participation in the annual meeting of IRRI's Asian Rice Farming Systems Network.

Rice-fish systems research is underway in the eight participating countries: Bangladesh, China, India, Indonesia, Malaysia, the Philippines, Thailand and Vietnam. In Bangladesh, there are trials on rearing fish in pens or cages installed in deepwater ricefields. China projects that by year 2000, its rice-fish farms will cover 2.47 million ha, compared to the present area of just over one million ha. India plans to expand rice-fish research in West Bengal, Uttar Pradesh and Orissa. Indonesia has expanded rice-fish

operations into a national program covering 14 provinces, with a target area of 46,000 ha for 1991-1992. In the Philippines, rice-fish culture will become part of a National Fisheries Outreach Plan which will begin in 1992. Thailand is extending rice-fish farming to all 17 provinces in the northeast. Vietnam has a substantial rice-fish research program. With these increasing interests, integration of rice with fish and other farm enterprises is likely to become a major activity in the improvement of low-input sustainable agriculture in Asia.

Ricefield Ecology

On-station studies in the IRFG were focused on ricefield ecology to investigate the beneficial effects of rice-fish integration and the mechanisms by which fish can contribute to increasing rice yields and enhance the ricefield environment. Researchers studied the effects of the presence or absence of Nile tilapia [*(Oreochromis niloticus)* as a monoculture or in polyculture with common carp *(Cyprinus carpio)*] and pesticides [a herbicide (butachlor); an insecticide (carbofuran); and molluscicides (triphenyltin hydroxide, aquatin and other organostannous compounds)] on rice nitrogen (N) uptake, weeds, floodwater pH, primary productivity and soil oligochaetes.

The presence of these fish had very little effect on rice N yields in these experiments but had demonstrable effects on controlling weeds, despite a high variability in the occurrence, composition and succession of weeds in plots stocked and unstocked with fish. For example, plots stocked with 12-22-g and 25-39-g common carp at 10,000/ha had less *Monochoria vaginalis* than controls (no fish) by 46 and 73%, respectively.

Primary productivity in the experimental ricefields was found to be lower than in pond or trench refuges. This emphasizes the significance of fish refuges as components of rice-fish integrated farming. They can maintain a higher primary productivity than ricefields throughout the rice growth period.

Also, fish were found to lower the pH of floodwater by up to 0.6 units. This indicates the potential of fish in preventing N loss through volatilization. It means that fish in ricefields can help keep floodwater alkalinity at lower levels, lessening the shift of ammonium ions to unionized ammonia with subsequent volatilization.

Modelling

Rice-fish ecological models are being constructed using ECOPATH II software and recent rice-fish data generated at FAC/CLSU. For economic models, templates for the analysis of farmers rice-fish data were tested on-farm and subsequently improved. The indicators chosen for economic analysis were: returns above variable costs; returns to labor and materials; rate of return to variable costs; and partial budget analysis. Graphical representation of these economic indicators and measures of dispersion (minimum and maximum values, standard deviation, and variance) were added. The templates are now ready for testing with data from other countries, such as Indonesia and Thailand. Extending the use of the templates for rice-fish systems that include crops other than rice (vegetables on dikes and others) is underway and a users' manual is in preparation.

Farmer Participatory Research Methodology

Development of research methodology for farmers to participate in the contruction and evaluation of economic models for different rice-fish systems is in progress. The project team is evaluating the effectiveness of farmers in generating data from their farms and surroundings. In the Philippines, nine selected farmers were shown how to construct village and farm transects and bioresource or material flows within their farms and how to collect monthly data, particularly on farm inputs and outputs and their values. So far, this scheme appears promising. The participating farmers have maintained their enthusiasm. Data collection procedures have now been refined and will be used in working with larger numbers of farmers.

Project Title		: Agricultural Research Project II (Supplement)
Funding Institution		: United States Agency for International Development (USAID)
Cooperating Institutions		: Bangladesh Agricultural Research Council (BARC); Bangladesh Fisheries Research Institute (FRI)
Duration		: May 1989 - June 1993
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 USAID-funded Agricultural Research Project II (Supplement) for strengthening its National Agricultural Research System to increase domestic food supply, small farm incomes and rural employment. One of the sectors to be developed through the project is aquaculture and this has been given priority by the GOB. ICLARM is assisting the planning and implementation of aquaculture research, training and extension.

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

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

Results

The major highlights of the year were the further evolution of low-input, sustainable aquaculture technologies for resource-poor farmers; organization of a three-day workshop on "Inland Aquaculture Development Strategies for Bangladesh"; training of a large number of extension workers and farmers; and the extension of project results to rural farmers by government extension agencies and NGOs. The project was itself extended up to June 1993, with additional funding from USAID. More details follow on specific activities.

Farmer Participatory Research

There are vast numbers of under- and unutilized seasonal small waterbodies accessible to smallholder farm families in rural Bangladesh. These offer opportunities to rural farm households for increasing fish availability and incomes. Hence, the project is concentrating on maximizing utilization of these waters, through adoption of aquaculture as an integrated farming enterprise, without conflict with other resource uses.

The project activities include farmer participatory research for development of sustainable, low-input aquaculture practices, appropriate to the farmers' resource base; training of trainers; and dissemination of proven technologies through government and NGO extension agencies, with adoption/impact surveys (Fig. 3).

Earlier on-station research had indicated the feasibility of producing 4-6 t/ha/year of fish through polyculture of carps, using oil cake and rice bran as supplementary feeds. In spite of its technical viability, the farmers were not able to adopt this technology due to the high cost of oil cake. In view of this, studies were initiated using only rice bran as a feed and fertilization of ponds using manures.

On-farm studies towards optimizing production from seasonal homestead ponds and ditches through culture of short-cycle species [Nile tilapia (*Oreochromis niloticus*) and silver barb (*Puntius gonionotus*)] using on-farm resources (cattle and chicken manure, composts and rice bran), proved that a saleable crop of fish can be grown in as little as three months. Subject to the availability of fingerlings, 2-3 crops of fish can be raised in 8-12 months. Two crops of *P. gonionotus* grown in eight months yielded a total of 2.5 t/ha, with a net benefit of US$2,677/ha. In ponds and ditches which retain water for more than four months, stocking of catla (*Catla catla*) or mirror carp (*Cyprinus carpio*) as additional species (4% of the population) along with silver barb resulted in these species contributing 16-21% of the gross production without affecting the growth of silver barb.

In drought-prone areas, farmers have been advised to dig ditches or ponds in or near ricefields to store and supplement water for irrigation. Experimental culture of short cycle species (Nile tilapia and silver barb) in such ditches prior to 'water harvesting', has produced 900-1,100 kg/ha in five months: an important way to increase farmers' incomes.

With the success obtained in utilizing seasonal waters for aquaculture, government agencies and NGOs are extending the technology to thousands of rural farmers. To assess the adoption/impact of silver barb culture and to identify further research needs, a survey of 600 farmers has been initiated.

Assistance to Farming Systems Research Institutes

ICLARM provided assistance to the Bangladesh Agricultural Research Institute, the Bangladesh Jute Research Institute and the Sugarcane Research and Training Institute towards incorporating aquaculture as an enterprise in their farming systems research in different agroecological zones. ICLARM also assisted the planning and implementation of on-station aquaculture research at the FRI. Work with the Bangladesh Jute Research Institute indicated the viability of raising Nile tilapia in jute retting ditches

after jute retting operations. Fish production of 1.1-1.2 t/ha was obtained from ditches in 4.5 months; a period that was formerly unproductive.

A three-day workshop on "Inland Aquaculture Development Strategies for Bangladesh" was organized in collaboration with BARC and was attended by over 120 scientists, planners and administrators. Recommendations of the workshop for inland aquaculture development were submitted to the GOB.

Training

ICLARM assisted the BARC and FRI in bringing out three training manuals (one in English and two in Bengali) and three extension pamphlets (in Bengali) on the culture of silver barb in seasonal waters, nursery pond management, and integrated poultry-fish farming, and in the production of an audiovisual slide show (in Bengali and English) on silver barb culture.

To comply with requests received from different agencies for training their trainers (extension workers) in low-input aquaculture practices, ICLARM assisted the BARC and FRI in organizing 10 training courses for a total of 121 extension workers and 122 farmers (Table 1).

Table 1. List of 1991 training activities conducted with ICLARM assistance under the BARC/USAID-supported Agricultural Research Project-II (Supplement) in Bangladesh.

Course	Date	Participants (no.)
Improved aquaculture management practices	11-14 March	Government extension officers (25)
Improved aquaculture management practices	17-23 March	NGO extension officers (25)
Nursery pond management	27 March-2 April	Nursery operators sponsored by NGOs (28)
Aquaculture management	3-6 April	NGO field extension workers (25)
Nursery pond management	7-12 April	Nursery operators (30)
Fish stocking and feeding practices	22-25 April	Farmers sponsored by NGOs (60)
Aquaculture management	4-7 May	NGO field extension workers (17)
Rice-fish farming	12 May	Subject matter specialists; Dept. of Agricultural Extension (6)
Fish farm management	1-26 June	Progressive fish farmers of Nepal (4)
Improved fish culture management practices	17-22 August	Government extension officers (23)

To demonstrate farmer participatory research results, a number of Farmers' Days were organized. These were attended by over 200 women who are adopting homestead aquaculture in the project area because of its simplicity and the benefits that it can provide in terms of fish for home consumption and additional cash income.

Project Review

The project was reviewed by a five-member team of experts appointed by USAID, and received praise for the activities undertaken and results achieved. To quote from the evaluation report, "the ICLARM Specialist has done an exceptional job of integrating the FRI, on-farm research and field level farming systems programs with wide scale impact. Perhaps, one of the most valuable impact has been to show the economic impact of less input projects, for small pond holders in Bangladesh".

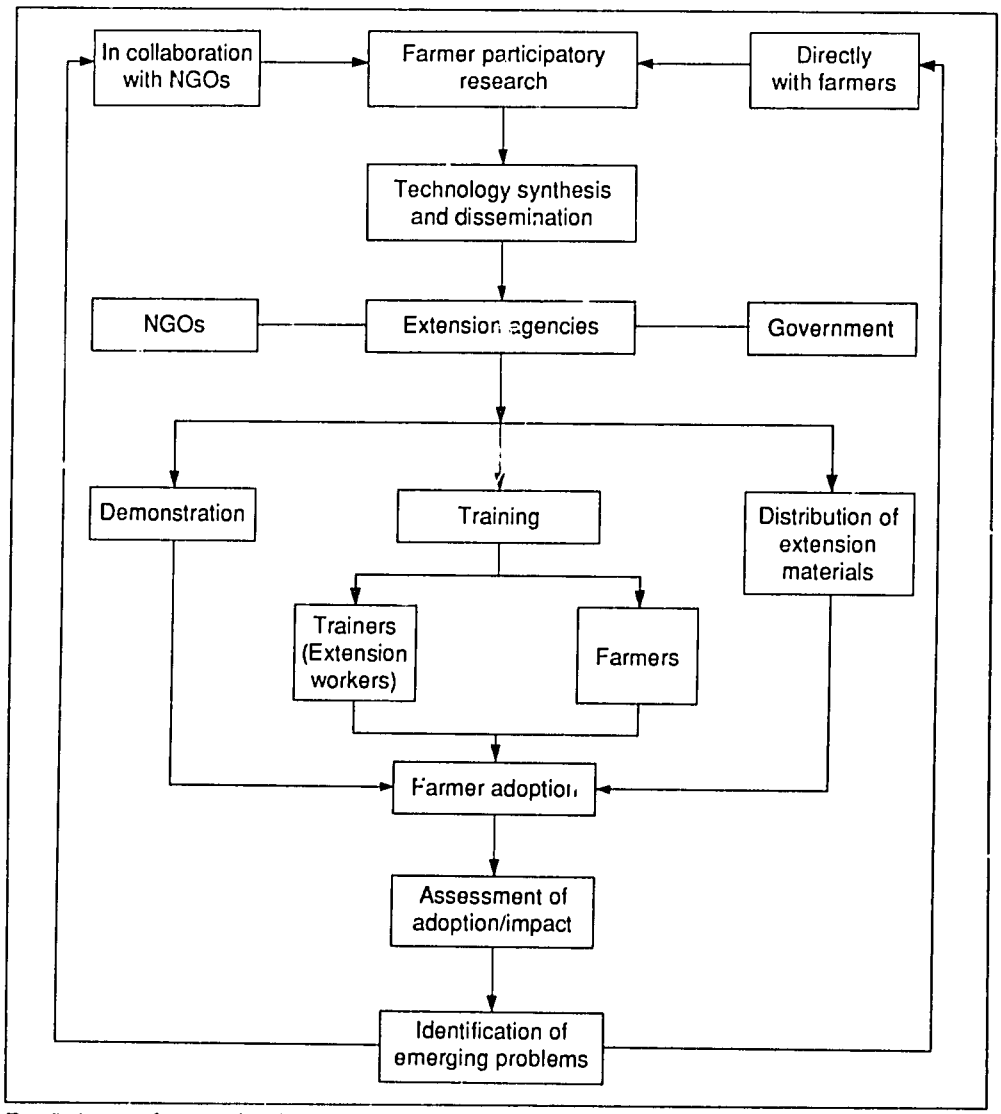

Fig. 3. Aquaculture technology development and dissemination mechanisms followed under the ICLARM-BARC-FRI-USAID project to integrate aquaculture into existing farming systems and to use formerly derelict small waterbodies in Bangladesh.

Small-scale pond aquaculture in Trishal, Mymensingh, Bangladesh. 1. Silver barb (*Puntius gonionotus*) harvested from a homestead pond. 2. Harvesting a seasonal pond during a farmer's rally. This and many other small seasonal ponds are operated by women. 3. A woman pond operator with some silver barb harvested from a seasonal ditch, to be used for home consumption.

4. Farmer cooperators in Tharkugaon, Bangladesh, display catla (*Catla catla*) raised in small homestead ponds through which aquaculture is integrated with other farm enterprises.

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

Objectives

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

- To identify appropriate fish culture and extension practices, with respect to cost-effectiveness and output efficiency in whole farm systems.
- To identify the most important factors affecting these systems.
- To determine the degree to which intensified extension affects adoption of aquaculture technology by farming communities.
- To evaluate changes in an area targetted for aquaculture extension by determining impact on various social groups in terms of traditional welfare indicators (income, employment, nutrition, education and participation).
- To provide guidelines for future policies and strategies of aquaculture extension appropriate for the farming systems of Bangladesh.
- To provide training on fish culture techniques, extension and socioeconomic research.
- To develop a framework that will serve as a practical tool to assess the socioeconomic impact of fish culture practices within the farming systems of Bangladesh and that can be used in other developing countries.

Results

The project team selected Kapasia as a target upazila (village area) and Sreepur as a control area. Both are to the north of Dhaka. The research program aims to study the impact in the target area of extension and

adoption of various aquaculture technologies. Technical assistance and training are being provided for the target upazila. The systems extended feature small pond culture of Indian carps, silver barb - locally called Thai sharputi or rajputi (*Puntius gonionotus*) - and Nile tilapia (*Oreochromis niloticus*).

Socioeconomic Research

Socioeconomic research required the development of methodologies for primary data collection by surveys and for compilation of secondary information. Significant progress was made in gathering primary data (Table 2) and profiles of the study areas were prepared from secondary data, including area, population characteristics and classification of households by farm type and occupation. This was followed by a waterbody survey which revealed wide variation in the density of small waterbodies and their availability (Fig. 4). Less than 15% of the ponds and ditches were reported regularly stocked with fish, although some forms of fish culture such as occasional stocking and harvesting were found in another 45%.

Table 2. Socioeconomic Impact of Fish Culture Extension in Bangladesh - data gathering activities in 1991.

Type of survey/study	No. of samples	Commencing date	Survey unit	Progress of work
1. Waterbody Survey	1,309	February	Pond/ditch	Draft Report
2. Market Listing	40	July	Village Market	Draft Report
3. Pond Record Keeping	257	July	Farmer Ponds	Data Collection Continuing
4. Benchmark Socio-economic Survey	391	August	Household	Data Processing
5. On-Farm Research	45	September	Farmer Pond	Data Collection Continuing
6. Resource Systems Maps and Transects	1	November	Village	Draft Village Resource Map
7. Market Survey	20	November	Sample Market	Data Collection Continuing

More ponds could be used for low-cost, semi-intensive aquaculture and fish production could be significantly increased without much investment. Pond owners/operators need, however, extension services, training and a steady supply of fry and fingerlings. One major constraint is conflict (actual and potential) among multiple owners and operators of ponds and lack of tenurial security for publicly owned waterbodies. Such waterbodies account for more than 70% of the total waterspace in the study area. New institutional arrangements are needed to retain joint access without lessening productivity.

Benchmark and follow-up studies and surveys were initiated during the year. As part of the benchmark studies, a household socioeconomic

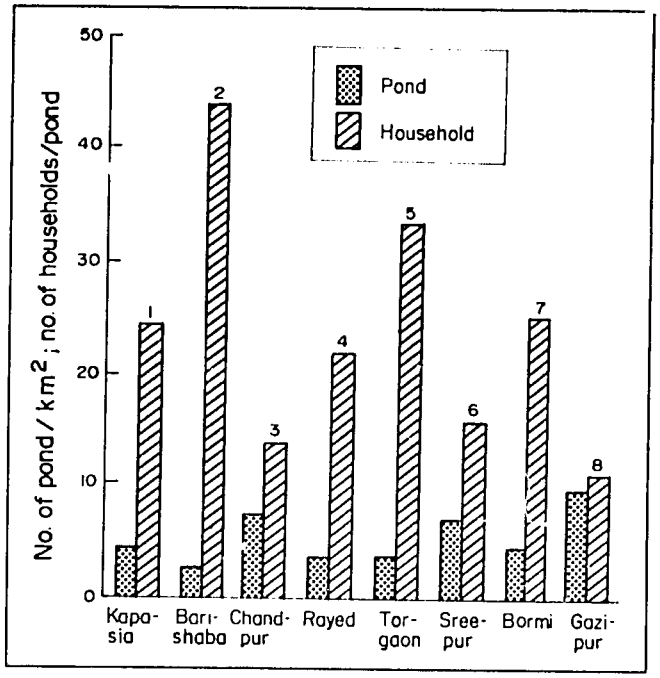

Fig. 4. Density of ponds (no./km²) and average number of households per waterbody in the study area: 1, target upazila (Kapasia); 2-5, four unions within the target upazila (Kapasia); 6-7, two unions with the control upazila (Sreepur); 8, control upazila (Sreepur).

survey was conducted among the pond owner/operator households of both target and control upazilas. The survey documented existing socioeconomic conditions, income and expenditure, resource allocation patterns and nutrition, prior to the extension intervention.

A two-phase survey of rural fish markets in the study upazilas was initiated. In the first phase, all markets were listed and observed to assess numbers of buyers and sellers, numbers of days of attendance, etc. In the second phase, sample markets were selected for a comprehensive survey of fish marketing. Data on the availability of different fish species, their sources and prices were included. Resource system maps and transects were prepared and pond record-keeping books distributed by the middle of the year. The books are being used to record input-output and income-expenditure data. They also serve as simple manuals for fish culture, containing basic techniques of pond preparation, stocking, feeding, fertilizing and management.

Regular monitoring of farm activities was launched toward the end of the year. The main objective is to assess labor and capital costs as constraints, thereby to determine the reallocation of resources that will be necessary for the adoption of aquaculture technology.

Technical Assistance

Extension services

Assistance to farmer cooperators in the extension target area was initiated. A number of activities were undertaken (Table 3): training, farm visits and demonstrations.

Using the information gathered during the pond and ditch survey, a preliminary selection of farmer cooperators was made at the beginning of the year. Farmers who own and operate conflict-free ponds and are willing to culture fish under the supervised scheme of the project were considered appropriate: 387 were chosen and divided into three groups in terms of technologies to be adopted, based on size, depth and water-holding period of the ponds, farmers' attitudes and resources. During the year, 25[illegible] ponds

Table 3. Training and extension activities during 1991.

Type/name of activities	Title	Duration	No. of participants	Origin of participants
1. Extension Staff Training	Aquaculture Technologies, Extension Methods and Problems	9-11 March	11	Upazila Fishery and Project Staff
2. Field Worker Training	Aquaculture Techniques and Its Applications	4-5 May	4	Project Staff
3. Farmer Training	Techniques of Fish Culture	24 April - 14 May	345	Cooperator Farmers
4. Extension Service	Assistance in Pond preparation and fingerling stocking	June-August	257	Cooperator Farmers
5. Extension Service	Pond Visits and Post-stocking management advise	Continuous (since August)	257	Cooperator Farmers
6. Demonstration and Rally	Demonstration of fish culture and discussion	25 October - 9 November	250	Cooperator Farmers
7. Training Program	Field visit to Mymensingh Aquaculture Project	29-30 December	3	UFO, Project Extension Officers

were covered under technical assistance and extension services through the project. Based on present estimates of standing stocks in their ponds, the total expected production and benefits from fish culture during the year 1991-92 should be about 64 t of fish - a net income of Taka 1.57 million.

Training

A three-day training program for extension workers on 'Aquaculture Technologies, Extension Methods and Problems' was organized in March. The participants included six project staff and five staff from the Directorate of Fisheries (DOF) working in Kapasia and Sreepur. A two-day training program, entitled 'Aquaculture Technique and Its Application' followed. Training on pond fish culture for farmer cooperators was organized during April-May: 345 farmers were trained in nine different batches. This training was conducted by the upazila fisheries officer, Kapasia and extension officers from the project: 303 farmers enlisted as possible cooperators. Pond demonstrations and farmer rallies were also organized. All 257 farmer cooperators from four selected village units (unions) of Kapasia engaged in fish culture through the project, assembled for demonstrations of polyculture and culture of silver barb and tilapia. The farmers that gave the demonstrations shared their day to day experiences with fellow farmers. The participating farmers observed the good growth of fish in the demonstration ponds. Posters and banners promoting fish culture were displayed during the rallies.

Project Title		: Research for the Future Development of Aquaculture in Ghana
Funding Institutions		: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmBH, Germany
Cooperating Institutions		: Institute of Aquatic Biology (IAB), CSIR, Ghana; Ghana Rural Reconstruction Movement (GhRRM), Ghana; International Institute for Rural Reconstruction (IIRR), Philippines; Institute of Renewable Natural Resources (IRNR), University of Science and Technology, Ghana
Duration		: June 1991 to May 1993
Key Personnel:	IAB	: Mr. Joseph K. Ofori; Mr. Ambrose Asamoah
	GhRRM	: Mr. David Yaw Owusu; Mr. Alex Baah
	IRNR	: Mr. Alfred Dassah
	IIRR	: Mr. Frank Fermin; Dr. Isaac Bekalo; Dr. Julian Gonsalves
	ICLARM	: Dr. Mark Prein; Dr. Clive Lightfoot; Dr. Roger S.V. Pullin; Ms. Grace Coronado

Objectives

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

Results

Farm studies were initiated and contacts established with representatives of local and international organizations. The past and current situation of aquaculture in Ghana was reviewed from published literature, interviews with key informants, and several visits to the Upper East, Northern, Ashanti, Eastern and Greater Accra regions.

Aquaculture in Ghana is practised by up to 2,000 farmers, mostly relatively wealthy, who have taken bank loans to finance the construction of their ponds with heavy machinery. Their ponds have often been poorly sited, designed and constructed. Moreover, they lack adequate knowledge of fish culture and conceive it as a single cash-generating enterprise, ignoring the possibilities for agriculture-aquaculture integration. They

produce around 300 t annually. The missing element in aquaculture development in Ghana could be the lack of integration between aquaculture and agriculture.

There could be potential for more farmers to adopt aquaculture in those areas of Ghana where there is adequate water to sustain operational fishponds on a year-round basis. Most farmers have small land holdings of less than 1.2 ha. Their main crops are maize, cassava and plantain. Shifting cultivation is common. With the increasing population of Ghana, this is leading to reduction of forest area and soil degradation. Initial field studies were performed using methods of farming systems research such as Rapid Rural Appraisal, resource-flow diagrams, farm transects, and farmer interviews to understand existing farming systems and to identify potential new entrants to integrated agriculture-aquaculture among small-scale resource-poor farmers. With the Ghana Rural Reconstruction Movement (GhRRM) and help from the International Institute for Rural Reconstruction (IIRR) in the Philippines, a plan of cooperation was drawn up for farmer participatory research in the Mampong Valley, Akuapem.

At IAB's Aquaculture Research and Development Center (ARDEC) in Akosombo, four ponds were rehabilitated and zero-input fish growth trials were initiated. The collection of secondary data on the geographical, biological, agricultural, socioeconomic and cultural factors that affect aquaculture development was initiated.

Most data collected within the project are handled, managed and will be analyzed through FARMBASE (see p. 68).

Seven IAB staff received training in microcomputer use. Three staff received training in farming systems research concepts and methods (concepts of integrated farming systems, farmer interviews, resource-flow diagrams and farm transects) at IAB and during field visits.

Project Title : Research for the Development of Tropical Aquaculture Technologies Appropriate for Implementation in Rural Africa

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

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

Duration : Planning phase, November 1985-April 1986; Startup phase, May 1986-October 1986; Main project, November 1986-October 1991; Project extended to October 1994

Key Personnel DOF : Mr. Boniface Mkoko; Mr. Brian Rashidi; Mr. Jaston Mtambo; Mr. Charles Makawa; Mr. Sloans Chimatiro; Ms. Mayesero Kapalamula

DREA : Mr. Orten Msiska

UM : Dr. Zimani Kadzamira; Dr. Elenemo Khonga; Dr. Leonard Kamwanja; Dr. Davis Ng'ong'ola; Dr. Emmanuel Fabiano; Dr. James Seyani; Dr. Sosten Chiotha; Mr. Aggrey Ambali; Mr. Jeremy Likongwe

MAGFAD : Dr. Thomas Gloerfelt-Tarp; Mr. Chris Bauer; Mr. Steve Langston; Mr. Achim Jancke

ALCOM/FAO: Mr. Boyd Haight; Mr. Niklas Mattson

ICLARM : Dr. Barry A. Costa-Pierce, Dr. Reg P. Noble; Mr. Anne A. van Dam; Ms. Chipo Jamu; Mr. Emmanuel Kaunda; Mr. Fredson Chikafumbwa; Mr. Daniel Jamu; Dr. Roger S.V. Pullin; Dr. Clive Lightfoot; Dr. Rainer Froese

Objectives

- To develop, through collaborative research with African scientists in biological and social sciences, aquaculture technologies appropriate to the prevailing conditions in rural Africa, with Malawi as a case study.
- To strengthen aquaculture research, training and education and information exchange among African and Asian institutions.

- To train African research and teaching personnel for supporting aquaculture research and national development.
- To conduct research at Malawi's National Aquaculture Centre (NAC) on fish species and aquaculture systems, using on-farm crop and natural plant residues widely available on smallholder farms in rural Africa.
- To complement efforts to extend low input sustainable aquaculture to African smallholders, by farmer participatory research and the development of methods for measuring impacts of their adoption of aquaculture.

Results

On-Station Biological Research

The project continued research at the National Aquaculture Center (NAC), Domasi, on the use of on-farm resources and combinations of these as pond inputs for smallholder aquaculture. Large datasets were obtained on the use of ash from household cooking fires, napier grass and other natural/agricultural waste vegetation, composts from maize stovers and the synergistic effects of these organic and inorganic fertilizers. These are now being analyzed by multivariate methods. Analyses will draw on results from 16 experiments now completed in 125 pond, 101 tank and 99 jar units.

Research continued on the reproductive biology and applied hatchery techniques for the species currently used in aquaculture in Malawi (*Tilapia rendalli, Oreochromis shiranus*) and for a new aquaculture species, *O. karongae*, a Lake Malawi species that may be synonymous with *O. saka* (expert advice is being sought on its affinities). It is termed here *O. saka/karongae*. It was found that *O. shiranus* seed production in 9-m² hapas could be increased significantly (to nearly 1,000 fry/month) by maintaining broodstock densities of 10 fish/m² at 2:1 female:male ratios. For *T. rendalli*, fry production in tanks was an order of magnitude lower than that for the mouthbrooding tilapias and was not influenced by the presence/absence of substrate. It was highest at a 1:1 female:male broodstock ratio.

O. saka/karongae showed strong seasonality in its onset of maturity; reproductive activity correlated with the onset of the rainy season (November to March). Moreover, *O. saka/karongae* fry production/female was very low. They were found to grow twice as fast in warmer lowlands (200 m altitude) than at Domasi (700 m). Nevertheless growth at Domasi was significantly greater than that of other tilapias currently farmed there and elsewhere in Malawi.

Rice-fish and other crop-fish culture systems were tested at the NAC. Rice yields were 1.0-2.4 t/ha and fish yields were 136-280 kg/ha/season. Vegetable plots that used fishpond mud and water yielded approximately 200 t/ha/year fresh weight of Chinese cabbage. An experimental site was developed to initiate research on "aquaforestry" integrated systems. Initial results will be reported in 1992.

Farmer Participatory Research

A farmer participatory research program was continued for testing aquaculture technologies and measuring the impact of integrated crop- and/or livestock-fish systems on the total farm environment.

On-farm monitoring of the performance of *O. saka/karongae* was initiated and is continuing in five farmers' club ponds. Farmers are determining the input regime, pond design and length of the experiment, while researchers are monitoring water quality, fish growth and, together with farmers, the fertilizer and feed inputs. Initial results seem to indicate that *O. saka/karongae* growth is very dependent on water fertility.

The initial performance of Malawi's first rice-fish ponds is being monitored in cooperation with 17 smallholder farmers who attended an open day on rice-fish at the NAC. Their rice yields ranged from 3 to 4 t/ha/year and fish production from 1.5 to 2.0 t/ha/year. These farmers have stimulated the spread of rice-fish culture among their neighbors.

Other technologies developed on-station at the NAC are being monitored as they become adopted on smallholder farms. For example, grass as a feed for herbivorous tilapias is now used by most farmers in the district where the project operates, following demonstrations at open days at the NAC in 1990-91.

The impact of aquaculture on farm and household environments is being assessed using FARMBASE (see p. 68). An initial qualitative analysis of resource systems in two contrasting agricultural areas is underway. Once completed, individual mapping of farms and quantitative time series analyses of resource flows on farms in these areas will be started.

Education and Training

The project staff supervised a number of students in a variety of topics (Table 4).

Table 4. Supervision of students by project staff during 1991.

Student	Degree	Institution	Subject	Supervisor
Mr. Sloans Chimatiro	M.Sc.	UM	Farming systems	F. Noble
Mr. Emmanuel Kaunda	M.Sc.	UM	Pond dynamics	B. Costa-Pierce
Mr. Mayesero Kapalamula	M.Sc.	UM	Labor supply/demand	A. van Dam
Mr. Charles Makawa	M.Sc.	Kuopio Univ., Finland	Supplemental feeds	B. Costa-Pierce
Mr. Orten Msiska	Ph.D.	UM	Systems development	B. Costa-Pierce
Mr. Frans van den Berg and Mr. Marten van Marwijk Kooij	M.Sc. M.Sc.	Agricultural Univ. of Wageningen, Netherlands	Aquatic ecology and extension methods	A. van Dam, B. Costa-Pierce, R. Noble

The project sponsored collaborative research with staff of the Departments of Biology and Chemistry of Chancellor College, UM, and with

the Departments of Animal Science and Rural Development of the Bunda College of Agriculture. In addition to graduate student supervision, Drs. Noble and Costa-Pierce supervised, at the NAC, research projects of undergraduates from Chancellor College. Mr. van Dam supervised undergraduate research projects on fish growth in and water quality of the Bunda College Dam, and on the farm system characteristics of 100 smallholder farms near Bunda. A classification of these farming systems will be made using multivariate statistics.

The project held training for technical assistants, extensionists and farmers, with Mr. Bauer and Mr. Chikafumbwa coordinating the participation of the FD, MAGFAD and ICLARM staff.

Five farmer open days were conducted at the NAC and attracted 92 farmers. Four training sessions were held for extensionists from Agricultural Development Divisions and the FD. The project had extensive interactions with the Malawi CEC and MAGFAD fish farming projects in these efforts.

Farming systems research was continued at the Bunda College of Agriculture under a collaborative project "Economics of Small-Scale Integrated Agriculture-Aquaculture Farming Systems". As part of this project, a farmer-to-farmer visit was organized for a group of farmers and agriculture extension officers from the Bunda College area to fish farmers in the Zomba area and to the NAC. During the visit, the group was introduced to new technologies and to the manner in which aquaculture fits into the whole farm.

Drs. Noble and Costa-Pierce again taught a course in Freshwater Biology at Chancellor College which included a number of field trips to the lakes of Malawi, the highlight of which was a scientific cruise on Lake Malawi for students. Mr. Aggrey Amball, who received an ICLARM scholarship to attend AIT (Thailand), returned to Malawi and took up a post as Lecturer in Fisheries at Chancellor College. Drs. Noble and Costa-Pierce collaborated with Mr. Amball and transferred to him their teaching/field activities in Freshwater Biology.

Information

The project helped to increase the flow of aquaculture information to the region through the project library at the NAC. In 1991, 316 library transactions occurred and 151 copies of ICLARM documents were distributed. In addition, book donations were made to Bunda College (43), Chancellor College (33) and the Department of Research and Environmental Affairs (33 titles). There were 45 enquiries to the project's Selective Information Service and 27 ASFA searches made for African researchers. Current acquisitions lists were distributed to 28 libraries or documentation centers. The project library grew to 904 volumes, 103 serials and 1,288 reprints.

The project sponsored a workshop on the "History, Status and Future on Common Carp in Malawi" which brought together all sectors of the aquatic science community in Malawi to discuss future action. The workshop was chaired by Mr. B. Mkoko, the Chief Fisheries Officer, Mr. O.V. Msiska, Principal Scientific Officer of DREA, and Dr. Costa-Pierce. After two days of presentations, working groups were formed to discuss options for the future use of this exotic species in Malawi: banning; phased withdrawal; continuation and enhancement. An overwhelming majority of participants

voted for the eradication of all stocks of common carp in Malaŵi at the earliest possible date.

In 1991, the project hosted senior visitors from GTZ, USAID, IDRC, NORAD, FINNIDA, ICEIDA, SIDA, JICA, FAO, IFS, Rockefeller Foundation, Pennsylvania State University (USA), University of Kuopio (Finland), University of Bergen (Norway), University of Stockholm, and the American Association for the Advancement of Science.

INFORMATION PROGRAM

The Information Program maintained its publication activities and provision of library and information services during 1991. In publications, the purchase of extra microcomputers and the software Pagemaker has enabled our artists to speed up the layout process, particularly of newsletters.

Also noteworthy was the end of the IDRC-funded Selective Fisheries Information Service which, in its two phases, ran for seven years and answered some 1,663 enquiries. Phase II, 1988-1991, was particularly productive and resulted in 71 published articles by project staff in the ICLARM library, who also answered 985 requests from clients during Phase II.

The Program Director, Jay Maclean, returned full-time to the program in April after two and a half years as Acting Director General of ICLARM, concurrent with his Information post.

Progress of Work

Library

The library, in its first full year as the Ian R. Smith Memorial Library and Documentation Center, continued to grow, with 52 new serial titles and 742 volumes of books and monographs.

Library acquisitions since 1987 are all computerized, facilitating searching for the 2,862 users during the year. Some 695 retrospective literature searches were conducted on the CD-ROM version of Aquatic Sciences and Fisheries Abstracts, a user friendly system which was usually operated by the researchers themselves after a few minutes training by library staff.

A fully indexed annual book catalogue was prepared and distributed to selected libraries. The library also continued to produce the new articles section of the Information Department in *Naga, the ICLARM Quarterly*. This current awareness service is widely used by *Naga* readers. There were 1,050 entries in 1991. This database is now computerized back to the first issue of *Naga*'s predecessor the *ICLARM Newsletter* in 1978 and is also regularly used by library visitors.

During 1991, the library's inhouse bibliographic databases grew by 2,241 items and now contain a total of 17,496 references.

Publications

There were several books published in 1991. These included two edited conference proceedings on "Aquaculture research and development in rural Asia" and the "Environmental impact of the golden snail (*Pomacea* sp.) on

rice farming systems in the Philippines" and Abstracts (in French and English) of the International Symposium on Tilapia in Aquaculture.

Also published were one Studies and Reviews (primary literature), a French translation of another, one Technical Report, two Education Series, one Bibliography, four issues of *Naga, the ICLARM Quarterly*, four issues of *Newsbriefs*, the 1990 Report and the Draft Strategic Plan. The Program also produced seven issues of the Network newsletters *Fishbyte, Aquabyte* and *AFSSRNews*. As a free service to the Asian Fisheries Society, the Program (i) continued to edit and publish Asian Fisheries Science (3 issues/year), a scientific journal on fisheries and aquaculture research, (ii) published the proceedings of the Fourth Asian Fisheries Society Nutrition Workshop, and (iii) published Asian Fisheries Science: A Profile, a study in which Program staff had participated.

Naga recipients in 1991 totalled 3,146 per issue. In 1992, *Naga* will incorporate all other newsletters produced at ICLARM headquarters (*Aquabyte, Asian Fisheries Social Science Network News, Fishbyte and Tropical Coastal Area Management*) which will swell both the size of Naga and its circulation.

Book exhibits. XVII Pacific Science Congress, Honolulu, 27 May to 2 June; Philippine Bookfair, Manila, 7-15 September; Frankfurt Book Fair, October.

Research

The Program has attempted from time to time research related to the use and impact of fisheries literature. The citation analysis thesis by Letty Dizon of two Philippine research journals was published in 1991 by the Fisheries Research Journal of the Philippines. Two other articles on previous research by Program staff, on citation behavior of Philippine scientists and their use of reprints, respectively, were also submitted.

Late in the year an analysis of the literature output of institutions similar to ICLARM - the International Agricultural Research Centers - began.

Library Training Conducted

Lecture-Demonstration on DIALOG Information Search and retrieval for De La Salle University Library Staff (8), De La Salle University, Manila, 13 March 1991.

Practicum on Special Library Services for a Student from the Institute of Library Science, University of the Philippines for a total of 50 hours starting 19 August 1991.

On-the-Job Training in UNESCO's micro CDS/ISIS System Software Package for the Chief Librarian/Fishery Biologist of Centro de Investigacao Pesqueira, Luanda, Angola, 25 October to 25 November 1991.

Meetings Attended

Seminar/Workshop for Librarians on Cataloging of Special Non-Book Materials, University of the East, Manila, 19-20 April. (E.B. Gonzalez).

Seventh Session of the Committee for the Development of Fisheries in the South China Sea, Hongkong, 22-25 July. (J.L. Maclean).

14th Program Committee meeting, Southeast Asian Fisheries Development Center (SEAFDEC), Manila, 24-27 September. (J.L. Maclean).

DIALOG Training, conducted by DIALOG Hongkong, Makati, Metro Manila, 20-24 October. (E.B.Gonzalez).

International Centers Week (CGIAR) Washington, DC, 28 October-1 November. (J.L. Maclean).

Publications

Aquisap, A.C., M.A. Carigma, P.B. Cariño, V.M.J. Castrillo, F.C. Gayanilo, Jr., M.E.S. Guzman, C.C. Janagap, J.L. Maclean, D. Pauly, E.T. Tech and R.M. Temprosa. 1991. Asian fisheries science: a profile. Asian Fish. Soc. Spec. Publ. No. 6, 45 p. Asian Fisheries Society, Manila.

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Maclean, J.L. and L.B. Dizon, Editors. 1991. ICLARM Report 1990. 151 p.

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Temprosa, R.M. 1991. ICLARM's Selective Fisheries Information Service: Project ADD (Analysis and Documentation Delivery), p. 29-42. *In* E.F. McDowell and S. Wiist (eds.) Breaking the barriers to the free flow of information. Proceedings of the 16th Annual IAMSLIC Conference, 2-5 October 1990, Seattle, Washington, USA.

Temprosa, R.M., M.J.M. Vega and A.P. Mendoza. 1991. Terminal Report, ICLARM's Selective Fisheries Information Service (SFIS) Phase II: Project ADD (Analysis and Document Delivery), March 1988-June 1991. Submitted to the International Development Research Centre (IDRC), Singapore and Ottawa, Canada. 45 p.

Vega, M.J.M. 1991. Who's working on freshwater cage culture? (an update). Naga, ICLARM Q. 14(1): 11.

Vega, M.J.M. 1991. Who's working on fishing gear design and construction for small-scale fisheries? Naga, ICLARM Q. 14(1):12.

Vega, M.J.M. 1991. Who's working on *Mugil* culture? Naga, ICLARM Q. 14(2):15.

Vega, M.J.M. 1991. Who's working on fishpond aeration? Naga, ICLARM Q. 14(3):16.

Information Program Project Summary

Project Title	:	Selective Fisheries Information Service Phase II: Project ADD (Analysis and Document Delivery)
Funding Institution	:	International Development Research Centre (IDRC) of Canada
Duration	:	March 1988 - June 1991
Key Personnel ICLARM	:	Mrs. Rosalinda M. Temprosa; Mr. Marcos Jose M. Vega; Ms. Adelina P. Mendoza; Ms. Matimtiman E. Cruz

Objectives

To extend the capabilities of the existing ICLARM Information Program to users in tropical developing countries as follows:

- 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 identified by trends in enquiries.

Results

The project ended during this year and the following is a summary of the whole Phase II project. A full report on the project is available free on request.

SFIS was a cooperative effort between ICLARM and IDRC. Phase II introduced new features to the Service: ADD, or Analysis and Document Delivery, were provided to "go the extra step" in assisting users. In Phase I, usually only a list of references was provided. In Phase II, key documents were also pinpointed and included in the "package." Further we analyzed the literature on important topics to give readers an idea of the size of their field and some contact addresses.

SFIS II was supported by appropriate library infrastructure, enhanced by the expertise of ICLARM's scientific staff to handle a range of technical enquiries and by the facility for online access to other international bibliographic databases available on the DIALOG system.

Implementing IDRC's new policy to promote the awareness of the need for researchers in developing countries to budget for information access to support their work, the project introduced a system of user-pays. It was a

flexible approach, requesting an exchange of literature, reports or photographs of research activities for information packages received if the user was, for one reason or another, unable to pay.

The user's response to charging for service was carefully monitored. As of 15 June 1991, an accumulated income of US$3,004 was posted. This amount was insufficient to make a project of this nature self-financing. The above income went into ICLARM's revolving fund for financing the continuation of parts of Project ADD.

We received 985 requests from 102 countries/territories between March 1988 and June 1991, of which 82% were from developing regions. On average, 27 enquiries were received monthly. Thirteen per cent of the enquiries received were user-paid while 56% were serviced for free and 24% availed of the exchange procedure from which we received 185 articles, 3 journals and 3 sets of photographs of research experiments. The other requests (7%) which were outside ICLARM's areas of expertise were referred to other information centers.

An analysis of enquiries received indicated that researchers were the number one users of the service followed by administrators, academic and library personnel, students and fishfarmers. The most requested topics were various culture systems, fish biology, and general information on fisheries and various crustaceans. The Project provided 19,298 citations/abstracts (9,645 pages), 28,397 xeroxed pages (2,204 titles) of key/requested references, 151 volumes from the duplicate collection of the library and 642 copies of various ICLARM publications including brochures.

A questionnaire postcard to assess quality, quantity, effect on project quality or general knowledge and assistance in locating other workers in the field, was sent with each information package. Respondents expressed a general satisfaction with the service provided: 86% rated the information very useful; 65% found the materials provided were most of what was needed; 50% indicated that the information provided background information only, while 43% perceived an improvement of project quality; 47% were led to new research ideas/projects and 47% perceived an improvement in subject knowledge without leading to new research ideas. Seventy-eight per cent were able to locate or communicate with co-workers in their fields of study as a result of their information package.

Short-term training in fisheries librarianship, database management, online searching and nontechnical library activities were conducted for 107 Filipino and 17 foreign groups and individuals. Cooperative information activities were strengthened with other specialized national, regional and international information centers. Electronic mail links with other international marine science libraries enhanced the Project's capabilities to carry out activities.

A current awareness service through the Information Department of *Naga, the ICLARM Quarterly*, was continued from Phase I of the Project and totalled 4,150 citations together with addresses of the senior authors. Selected libraries and institutions received three issues each of ICLARM library's Annual Book Catalogue. The Project also facilitated the sending of all available ICLARM publications to 11 libraries affiliated with the Agricultural Libraries Network (AGLINET).

The Project produced a total of 71 publications which consisted of bibliographies (3), minireviews (48), translations (2), reports (2) and articles on library/information science (16).

SOUTH PACIFIC OFFICE

The research of the Coastal Aquaculture Centre (CAC) culminated in the development of an effective farming system for giant clams during 1991. This paved the way for detailed analyses of the economic feasibility of giant clam cultivation, based on data accumulated over the past four years.

ICLARM's South Pacific Office (SPO) administers the CAC and is responsible for the development and coordination of all other ICLARM activities in the South Pacific Region.

The SPO and CAC operate under a formal collaborative agreement with the Government of Solomon Islands.

Nusa Tupe Field Station

Following completion of an agreement between ICLARM and the Provincial Government of Western Province, Solomon Islands, a new field station was constructed at Nusa Tupe, near Gizo, using funds provided by the Skaggs Foundation. Basic facilities were completed by March 1991, and consist of several small houses and a small workshop, store and "laboratory" Photovoltaic pumping and lighting systems are utilized.

The station is now ICLARM's primary venue for work on growout systems and also serves as a distribution point for giant clam seed in the Western Province. It will also be the focal point for future work on selective breeding and the main venue for hands-on training of small-scale giant clam aquaculturists.

The station is managed by a Scientific Assistant, working under the auspices of the UK Voluntary Service Overseas, supported by a Caretaker/ Foreman and a field hand. Additionally, the Solomon Islands Fisheries Division has assigned a Fisheries Officer to the Western Province to work at the station on a full-time basis.

Additional Hatchery Facilities

Six, fiberglass, 600-liter capacity, bottom-draining hatchery tanks were constructed at CAC headquarters, Guadalcanal, which allow up to 170 million eggs to be stocked. A set of sixteen 50-l outdoor larval culture bins were constructed for experimentation and permit a wide range of experiments on conditions affecting growth and survival in the nurseries.

The construction of a further eight 10-m^2 breeze block cement tanks for the early rearing of juveniles was completed. This additional tank capacity increases the tank volume to the limit of what can be realistically supplied with water by the present 10-cm pump. The tank and raceway area now served by this pump is 350 m^2.

A new seawater intake line has been laid into deeper water (18 m). The original pump intake line which was situated at 4 m depth is now used as a backup line. This will allow intake line change-overs to take place and thus prevent the build-up of fouling organisms.

The main generator and a backup were installed in a new ODA-funded generator building. This building also houses a battery bank and inverter system from which power for lighting and running essential items such as aerators can be drawn overnight while the generator is shut down.

The catamaran-style floating ocean nurseries (FONs) developed in 1990 were further developed and tested in the relatively exposed waters at the CAC. By the end of the year a total of 33 FONs, each carrying 1.5-2.5 m^2 of nursery trays were in service at the CAC and Nusa Tupe.

Recent Research

Giant Clam Cultivation Systems

The development of hatchery systems in 1991 concentrated on increasing clam spat density in the hatchery tanks by increasing the available nutrients and testing strategies to enable clams to go into the ocean nursery earlier than has previously been achieved.

It was confirmed that extra nutrients in the form of fertilizer enhanced growth and reduced postharvest mortality. Microfeeds did not improve growth rate to the same extent, but both treatments caused enhanced growth of fouling algae.

It was anticipated that it might be possible to move *Tridacna gigas* into FONs at 9 mm or less without unacceptable losses. Clams were moved from the tanks to the sea at sizes as small as 2.7 mm (3 months old). The smallest sizes suffered high mortality but clams of 3.5 mm or greater had a significantly higher biomass if grown in the sea in FONs than if left in unfertilized hatchery tanks. This has paved the way for a four-month hatchery cycle allowing three batches to move through each tank per year. This system should be equally applicable to other species of giant clams. Experiments are underway to compare growth and survival of 15 mm+ clams in FONs with those in cages on trestles on the seabed.

Total spat production over the year was 503,000 clams. Those ongrown in FONs at the CAC had consistent growth rates beyond 10 mm of 5 mm per month, although survival to harvest was quite variable (3-70%), depending on stocking size, fouling and infestations.

Other spat were transferred to Nusa Tupe and used in various growth and survival trials in FONs and cages in a variety of depths and habitats.

It has been shown that on the reef flat area, growth and survival performance of *T. gigas* is better in floating than in trestle cages, and these in turn are superior to bottom cages. These trials are being repeated in areas of greater water exchange on the reef slope, where it might be expected that the differences would be less. No consistent effects of stocking density have been demonstrated within the ranges tested - but this is probably because such effects will vary greatly according to the degree of fouling and local water exchange.

The stock at Nusa Tupe now totals around 35,000 giant clams, ranging in size from 2 mm to 250 mm.

By the end of 1991 a total of 22 village trials had been set up in the Solomon Islands, of which five were subsequently terminated. The sites represent a range of environmental conditions, including extensive shallow reef flat areas, seagrass, reef slopes, and sandy slopes adjacent to tidal channels. Trials are operated by individuals, families, men's and women's groups or associations, and Fisheries Division field staff. It is anticipated that a further 12 trials will be set up in the Western Province in 1992.

Simple box cages with integral concrete bases are used in the village trials, requiring maintenance twice a week. Survival of seed averages 30%, while growth rates average between 4 and 7 mm/month depending on the quality of the clams and the site.

Predation Studies

The first fifteen months of a collaborative investigation of predation on cultivated giant clams, funded by AIDAB, was completed in 1991. Work at the CAC and at collaborating institutions concentrated on the collection of data on identity, size and abundance of predators in clam farms and on experiments designed to study aspects of the biology, growth, consumption and species preference of predators. Taxonomic work has also been carried out on pyramidellid parasites and also on a new predatory turbellarian.

Work has been carried out to determine optimum cage designs and locations and to minimize losses from the largest and most destructive of these predators, such as fish, turtles and some crabs and gastropods.

Economics and Marketing

Consultancy reports were received dealing with iced and frozen storage of mantle and adductor and accompanying textural changes, drip losses, effects of prolonged storage, effects of cooking, the preparation of dried adductor and mantle and the range of bivalve and other molluscan preparations which are prepared and consumed in Southeast Asia and Japan. Additionally, work was done at CAC on the comparative morphometrics of tridacnids and on the chemical composition of the mantle and adductor muscle.

The CAC's three-part production system for *Tridacna gigas*, comprised of the land-based hatchery stage, the floating ocean nursery stage and the village-based farming stage was subjected to a preliminary economic analysis.

The analysis suggests that the production of large (45-cm) *T. gigas* as a village-based activity has limited immediate development potential in the Solomon Islands and major improvements in survival rates, or a radical reduction in seed costs, will be required alongside the development of new markets before any significant industry can be established. The same technology applied in other parts of the Indo-West Pacific region, such as the Philippines, would have much more favorable economic prospects.

Reef Fish Ranching and Marine Reserves

Work continued on a small project aimed at testing the effect of a small marine reserve on the abundance of fish and invertebrate stocks in adjacent reef areas and to examine the change in the composition and abundance of fish stocks in response to protection from harvesting. The work has been done on 4.5 ha of fringing reef and shallows fronting the CAC. Fishing is not permitted in this area, which is primarily used for maintaining giant clam broodstock and a giant clam ocean nursery system.

A trapping and mark-recapture program was carried out during June-July 1991 and September-October 1991 in the ICLARM marine reserve, utilizing Antillean Z- and double-chevron traps and a visual census of fish populations was carried out between October and December 1991.

Pearl Oyster Cultivation

Funding for Mark Gervis to undertake a short-term preparatory study on pearl oyster cultivation was provided by the British ODA/BDDP from November 1990 to March 1991 and resulted in the preparation of two documents, a bibliography and a review of the biology and culture of pearl oysters, the latter in co-authorship with N.A. Sims.

Preliminary spat collection trials were undertaken and sixty *Pinctada maxima* broodstock collected by staff of the Solomon Islands Fisheries Division are being held on racks at the CAC's reef for use in future work.

National Research Support

Networking

Activities of the Coastal Aquaculture Network continued. The Network seeks to enhance collaboration between institutions working in this field. In 1990, ICLARM entered into a formal Memorandum of Understanding with the Centre for Development Studies (CDS) of the University of Bergen to undertake collaborative studies on the economic, social and legal aspects of coastal aquaculture in the Indo-Pacific region. Dr. E. Hviding and Ms. K. Lievestad undertook a four-month study of socioeconomic factors affecting the current village-based giant clam ocean nursery trials, starting in October 1991.

A shipment of over two million *Tridacna gigas* pediveligers was made to the Marine Science Institute of the University of the Philippines in support of their program to re-establish stocks of this species in the Philippines. These initial shipments indicate that international transfers of larvae or early spat, preferably around 14-25 days old, are technically feasible.

Education and Training

Informal educational activities continued as a strong component of the work of the CAC, with numerous school groups visiting the Centre for visits

or to undertake assignments. Additionally, students from the Marine School of the Solomon Islands College of Higher Education visited the Centre.

The CAC also hosted a trainee from Western Samoa, supported by the FAO South Pacific Aquaculture Development Project, for practical training during a one week-stay at the Centre.

Mr. Toata Molea, Scientific Assistant/Graduate Trainee, continued his research at the CAC for the M.Sc. degree of the University of the South Pacific (USP). The program is executed under a collaborative arrangement with USP whereby ICLARM staff can be appointed as research supervisors. He received an equipment grant from the Asian Fisheries Society.

Advisory Services

Dr. J.L. Munro participated as an invited lecturer and panelist in the Training Course in Fisheries Management and Development, organized by the Commonwealth Secretariat and Organization of Eastern Caribbean States, St. Johns, Antigua (16-27 September 1991).

Program Plans

The conclusions which arose from the economic analysis confirmed that future research on giant clams at the CAC should be directed principally towards:

i) increasing both growth rates and stocking densities in the land-based nursery and thus reducing the unit cost of spat which are output to the floating ocean nurseries;
ii) improving survival rates in the ocean nursery stages either by technological improvements or by control of predators;
iii) selective breeding for improved growth rates and hardiness. An experimental program for 1992 has been designed with these above requirements in mind.

Additionally, it was concluded that product development work aimed at local processing of mantle and adductor muscle for domestic and export markets and at utilization of shells should be encouraged through the Solomon Islands Fisheries Division, all leading to improved "farm gate" prices.

Particular emphasis will be given to consolidating the progress made in the past years, to analyses of the accumulated data and to preparing reports for publication.

Predation studies will focus on completing all experiments in progress and determining the escape size for juveniles clams, on data analysis and on the production and dissemination of recommendations for clam farmers regarding predator control, including production of a poster. A working group will be convened in conjunction with the Seventh International Coral Reef Symposium in Guam in June 1992.

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.

The financial analysis of the production system used at CAC will be further refined and the viability of the system examined in relation to operating and capital costs in other countries of the Asia-Pacific regions.

Shipments of juvenile *H. hippopus* and *T. gigas* will be made to Western Samoa and the Philippines, respectively, for the purpose of re-establishing wild stocks. Inquiries have also been received from Vanuatu and New Caledonia where *T. gigas* is extinct.

Interest in pearl oyster cultivation has increased substantially during 1991. A pan-Pacific pearl oyster project has been proposed by James Cook University and implementation of a project has begun in the Cook Islands through a USAID-funded consulting group. Both organizations wish to participate in complementary research in order that as broad a field of research as possible is covered. Funding sources to begin the pearl oyster research program are still being sought.

Meetings Attended, Papers Presented

ACIAR Giant Clam Project, Project Leaders' Meeting. University of the Philippines, Marine Science Institute, Bolinao, Philippines, 25 February-1 March. (J.L. Munro, J. Hambrey, H. Govan).

South Pacific Forum Fisheries Technical Committee Meeting, Wellington, New Zealand, 22-26 April. (J.L. Munro).

Pacific Science Congress, Honolulu, Hawaii, 27 May-1 June. (J.L. Munro, P.E. Munro).

World Aquaculture Society, San Juan, Puerto Rico, 16-20 June. (J.L. Munro, P.E. Munro).

Paper presented:

Munro, J.L. Growth and survival of giant clam spat in floating ocean nurseries.

South Pacific Commission - Regional Technical Meeting on Fisheries, Noumea, New Caledonia, 5-9 August. (L. Gilkes).

Seminar-Workshop on Aquaculture Development in Southeast Asia and Prospects for Seafarming and Searanching. SEAFDEC Aquaculture Department, Iloilo City, Philippines, 19-23 August. (J.L. Munro).

Paper presented:

J.L. Munro. Ecological impacts of seafarming and searanching.

ACIAR - Giant Clam Project, Final Project Leaders' meeting. James Cook University, Townsville, Australia, 2-5 December. (M.H. Gervis and H. Govan).

Publications

Gervis, M. 1991. A bibliography of the pearl oysters (Bivalvia: Pteriidae). ICLARM Bibliogr. 11, 99 p.

Munro, J.L. 1991. Giant clams: food for thought. INFOFISH International 1/91:40-44.

Newman, L.J., L.R.G. Cannon and H. Govan. 1991. Clam killers: turbellarian predators or scavengers? Poster presented at the Australian Marine Sciences Association Meeting, Brisbane, July 1991.

Pearson, R.G. and J.L. Munro. 1991. Growth, mortality and recruitment rates of giant clams, *Tridacna gigas* and *T. derasa*, at Michaelmas Reef, central Great Barrier Reef, Australia. Aust. J. Mar. Freshwat. Res. 42:241-262.

South Pacific Office Project Summaries

Project Title : Giant Clam Mariculture Project

Funding Institutions : International Centre for Ocean Development (ICOD) in conjunction with Forum Fisheries Agency (FFA); Overseas Development Administration (ODA) of the United Kingdom; L.J. Skaggs and Mary C. Skaggs Foundation; Commonwealth Fund for Technical Cooperation (CFTC); Voluntary Service Overseas (VSO); United States Peace Corps (USPC); Asian Fisheries Society (AFS)

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

Duration : Indefinite, from 1986

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. Idris Lane; Mr. Toata Molea; Mr. Cletus Oengpepa; Mr. Thomas Shearer
GSI	:	Mr. Sylvester Diake; Mr. Hugo Tafea; Mr. Francis Tafuokalo
CDS	:	Dr. Edvard Hviding; Ms. K. Lievestad
UG	:	Dr. Patrick Sorgeloos; Mr. Peter Coutteau

Objectives

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

Results

Hatchery Systems

The development of hatchery systems in 1991 concentrated on increasing giant clam spat density in the hatchery tanks by increasing the available nutrients and testing strategies to enable clams to go into the ocean nursery earlier than has previously been achieved.

The CAC now has 76 *Tridacna gigas* and 20 *Hippopus hippopus* broodstock. Ensuring that spawnings occur when required is still not

possible. Further work on gonad ripeness, spawning seasonality and establishing a conditioning process is necessary if hatchery facilities are to be kept full at all times.

There were 12 spawnings of giant clams during the year, 11 of *T. gigas* and one of *H. hippopus*.

The protocol for larval rearing remained essentially the same as for 1990 except for two changes in the early larval rearing system employed; the replacement of chloramphenicol with streptomycin sulfate as a prophylactic antibiotic and the replacement of the dried algal feed *Tetraselmis suecica* with a modified freeze-dried yeast developed by the University of Ghent.

T. suecica is no longer commercially available. The protocol still allows the larvae to remain in plastic tanks until day 28 to ensure that tanks are stocked at precise densities with viable spat. The survival of juveniles to harvest has been highly variable ranging from 0.27 to 28.04%.

Algal overgrowth problems encountered in the first years of the project have been controlled to a high degree. The succession of algae that occurs in the tanks is better understood.

Trials with feed and fertilizer addition to the nursery tanks confirmed that fertilizing enhances growth rate and reduces postharvest mortality. Feeding does not enhance growth rate to the same extent as fertilizer but both treatments enhance algal growth. Detailed trials concerned with the effects of addition of nutrient and feeds are planned for 1992.

It was anticipated that it might be possible to move *T. gigas* into floating ocean nurseries at 9 mm or less without unacceptable losses. *T. gigas* were moved from the tanks to the sea at sizes as small as 2.7 mm (3 months old). The smallest sizes suffered high mortality but clams of over 3.5 mm had a significantly higher biomass if grown in the sea in floating ocean nursery cages than if left in unfertilized hatchery tanks. This has paved the way for a four-month hatchery cycle, allowing three batches to move through each tank per year. This system should be equally applicable to other species of giant clams.

H. hippopus have shown very good early growth rate and excellent survival. They merit more attention as a species to grow in conjunction with the *T. gigas*.

Spat production during 1990 was 503,000 clams; this figure includes those transferred to sea at around 3 mm.

Ocean Nursery Systems at the Coastal Aquaculture Centre

The routine during 1991 was for spat to be harvested from hatchery tanks at between 3 mm and 10 mm and allowed to settle in cages in raceways for 4 days prior to stocking in floating ocean nurseries (FONs). Stocking densities are normally between 5,000 m^{-2} (10-mm seed) and 15,000 m^{-2} (3-mm seed). Clams have been routinely graded at this stage. Cages are inspected and cleaned at least twice weekly. Predators are removed, trays cleaned and repaired and moorings and fastenings inspected. After three months the cages are brought ashore for thorough cleaning and measuring, and sometimes grading, before returning to FONs or shipping or Nusa Tupe. Those which remain at the CAC are harvested after a further six months prior to shipping to village trials or Nusa Tupe.

Growth rates at the CAC are very consistent, averaging close to 5 mm/month for clams over 10 mm. Survival between stocking to harvest at 30-40 mm is very variable. Spat stocked at 10 mm or more have generally achieved survival rates between 30 and 70%; those stocked at 3 mm show rates between 3% and 20%. The known causes of mortality are varied, including algal fouling (especially a problem for smaller clams), flatworm infestation and *Cymatium* infestation.

Growth and survival comparisons between clams grown in the FONs and those kept in hatchery tanks have been undertaken, and show a marked superiority in the former. Experiments have recently been set up to compare growth and survival of >15 mm clams in FONs with that in cages on trestles on the seabed.

A total of 509,000 spat were stocked in the CAC ocean nursery in 1991 (Fig. 1), at sizes between 2 mm and 12 mm and a total of 134,000 were harvested for shipping to Nusa Tupe and the village trials.

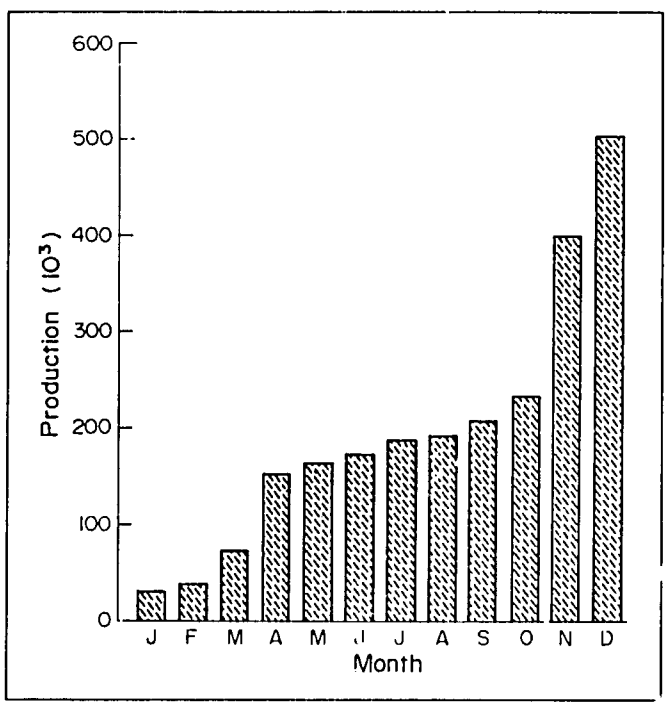


Fig. 1. Cumulative monthly production of juvenile clams for 1991.

Nusa Tupe Ocean Nursery and Growout

At Nusa Tupe, small spat (<20 mm) are normally stocked in FONs, and transferred to trestles, or occasionally bottom cages at 30-40 mm. Above 100 mm they are transferred to the exclosures. Routine husbandry involves the removal of predators (mostly cymatiid snails) and cleaning of the cages at least twice weekly.

Growth rates average 2-4 mm/month in trestle and bottom cages, 3-5 mm/month in FONs, and 5-6 mm/month in the exclosures. Tagging of individual clams has so far revealed individual growth rates of 0-6 mm/month in cages, and 0-10 mm/month in exclosures, with the majority falling in the range of 3-7 mm/month.

Survival rates have ranged between 10% and 50% for clams grown from 10-12 mm to 30-35 mm, and from 20% to 60% for clams grown from 35 to 100 mm. As yet, few data are available for the larger clams.

It has been shown that on the reef flat area, growth and survival performance of *T. gigas* is better in floating than in trestle cages, and these in turn are superior to bottom cages. These trials are being repeated in areas of greater water exchange on the reef slope, where it might be expected that the differences would be less. No consistent effects of stocking density have been demonstrated within the ranges tested - but this is probably because such effects will vary greatly according to the degree of fouling and local water exchange. Most stock has now been moved further out towards the Nusa Tupe reef slope where it is hoped that better water exchange will result in improved performance.

As of the end of December 1991, 113,000 clams ranging in size from 2 mm to 70 mm had been sent from the CAC to Nusa Tupe. Current stocks stand at around 35,000, ranging in size up to 300 mm.

Village Ocean Nursery Trials

As of the end of 1991 a total of 22 village trials had been set up in the Solomon Islands, of which 5 had been subsequently closed down. It is anticipated that a further 12 trials will be set up in the Western Province in 1992.

The sites represent a range of environmental condition, including extensive shallow reef flat areas, seagrass, reef slopes, and sandy slopes adjacent to tidal channels. Trials are operated by individuals, families, men's and women's groups or associations, and Fisheries Division field staff.

Half meter square box or basket shaped cages folded up from 1/2", 3/4", or 1" galvanized weldmesh or "copra" mesh, with an integral cement base are now used routinely in the ocean nurseries. They are moderately priced, quick and simple to build, easy to handle, and so far are lasting well. They are normally placed on the seabed in an area of good water exchange. If the bottom is very silty or if water exchange is weak, the cages are raised off the bottom using trestles built from steel or mangrove stakes.

Villagers are advised to clean cages and remove predators (mostly cymatiid snails) at least twice weekly. When clams reach 100 mm or more, ICLARM or Fisheries Division staff help with the erection of an exclosure to which the clams are transferred. Villagers are advised to continue to remove predators and clean the exclosure on a weekly basis.

Survival of the clams at village sites is very variable. Seed is normally provided at 30-50 mm, and survival through to 100 mm has ranged between zero and 85% with a median value around 30%. Nonetheless the villagers remain enthusiastic, and there is much local interest in the project.

Growth rate is also very variable, dependent upon the quality of the clams and the site. The highest average growth rates (up to 7 mm/month) have been achieved with batches of highly selected clams at sites on or close to the reef slope, adjacent to channels with moderate to strong tidal currents.

Economics and Marketing

Consultancy reports were received dealing with iced and frozen storage of mantle and adductor muscle and accompanying textural changes, drip losses, effects of prolonged storage, effects of cooking, the preparation of dried adductor and mantle and the range of bivalve and other molluscan preparations which are prepared and consumed in Southeast Asia and Japan. Additionally, work was done at the CAC on the comparative morphometrics of tridacnids and on the chemical composition of the mantle and adductor muscle.

The CAC's three-part production system for *Tridacna gigas*, comprised of the land-based hatchery stage, the floating ocean nursery stage and the village-based farming stage was subjected to a preliminary economic analysis.

A review of current markets suggested, on a conservative basis, that the established Taiwanese export market for the adductor muscle of large clams (>45 cm shell) would bring a return to an average Solomon Island producer of US$1.00-1.73 per clam. None of the established markets for the whole *T. gigas* meat or the mantle meat would bring a positive return, mainly because of costly handling and transportation. Pickled products looked worthy of further investigation and, assuming that large *T. gigas* mantle meat could effectively compete with products made from smaller species, might bring in US$1.00-1.40 for a 45-cm clam.

The potential value of the shell is difficult to establish. Recent enquiries from a Korean firm suggest that there might be potential for larger shell (at least 45 cm) both for ornamental purposes and as a raw material for the manufacture of game tokens, and they have taken a sample of 200 kg of *T. gigas* shells for trial processing.

The economic analysis suggests that the production of large *T. gigas* as a village-based activity has limited immediate development potential in the Solomon Islands and major improvements in survival rates, or a radical reduction in seed costs, will be required alongside the development of new markets before any significant industry can be established. The same technology applied in other parts of the Indo-West Pacific region, such as the Philippines, would have more favorable economic prospects.

Project Title		: A Collaborative Investigation of Predation on Cultivated Giant Clams (Tridacnidae: Bivalvia)
Funding Institution		: Australian International Development Assistance Bureau (AIDAB)
Cooperating Institutions		: James Cook University of North Queensland, Australia (JCU); University of the South Pacific, Suva, Fiji (USP); Silliman University, Dumaguete, Philippines (SU); Marine Science Institute, University of the Philippines, Quezon City, Philippines (MSI)
Duration		: Two years, from 1990
Key Personnel	ICLARM	: Dr. John L. Munro; Mr. Hugh Govan
	JCU	: Dr. J.S. Lucas
	USP	: Dr. Alison Haynes
	MSI	: Dr. Edgardo D. Gomez
	SU	: Dr. Hilconida Calumpong

Objectives

- To collect and identify predators on juvenile giant clams.
- To establish the identities of giant clam predators occurring in the widest possible range of Indo-Pacific habitats.
- To investigate the predatory behavior, predation rates and species and size selection by the predators.
- To elucidate the basic biology and ecology of the major predators.
- To utilize the results of these investigations for the formulation of recommendations concerning habitat selection for giant clam ocean nursery and growout areas and for the design and construction of ocean nurseries.
- To formulate recommendations for the control of giant clam predators.
- To compile a handbook for the identification of giant clam predators.

Results

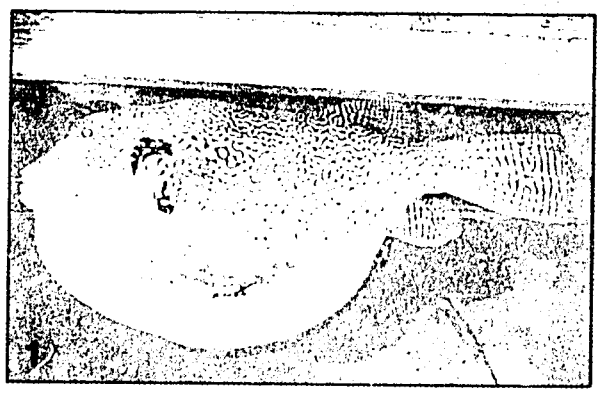
Work at the collaborating institutions concentrated on the collection of data on the size and abundance of predators in giant clam farms and experiments designed to study aspects of the biology, growth, consumption and species preference of predators. Taxonomic work has also been carried out on pyramidellid parasites and also on a new species of turbellarian predator.

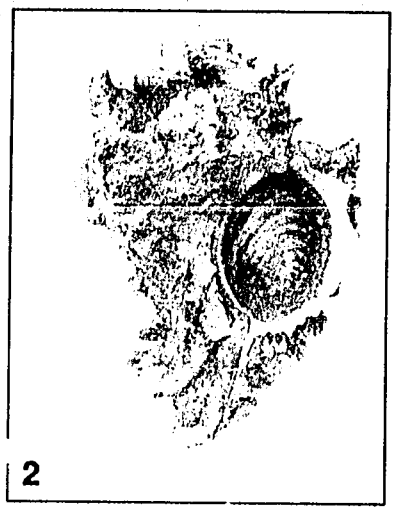
A list of animals identified as predators of giant clams at the collaborating institutions is shown (Table 1). Clams are protected by cages or nets from the largest and most destructive of these predators such as fish, turtles and some crabs and gastropods. In order to minimize losses due to predators, work has been carried out to determine optimum cage designs and locations.

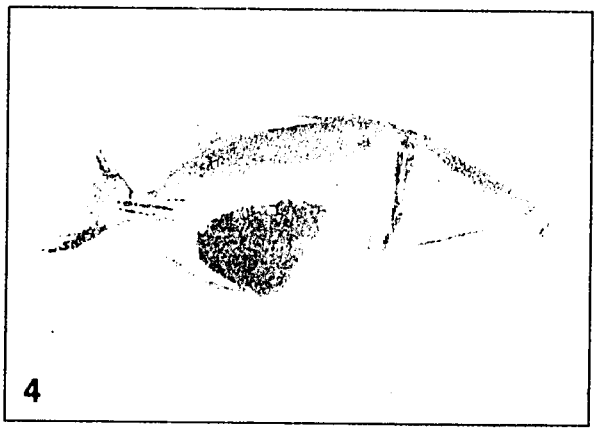
Table 1. List of animals known to prey on tridacnid clams.

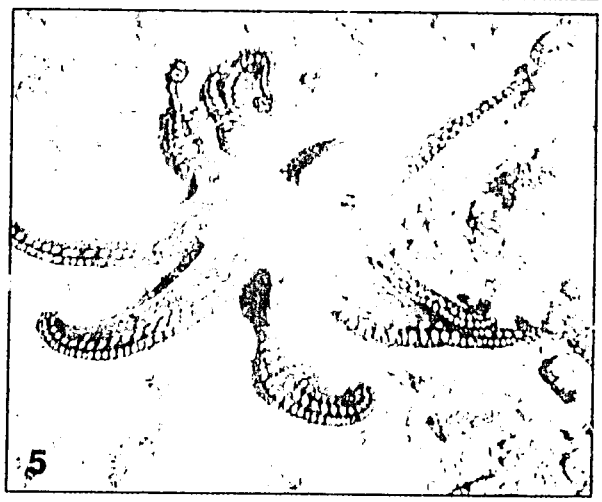
Family or class	Species
TURBELLARIA (flatworms)	
Stylochidae	*Stylochus* sp.
GASTROPODA	
Buccinidae (whelks)	*Cantharus fumosus*
Costellariidae (mitres)	*Vexillum plicarium, V. cruentatum?*
Ranellidae (tritons)	*Cymatium aquatile, C. muricinum, C. nicobaricum, C. pileare, C. vespaceum?*
Fasciolariidae (tulip shells)	*Pleuroploca* sp.
Muricidae (murexes)	*Chicoreus brunneus, C. microphyllum, C. ramosus, Cronia fiscella, C. margaritícola, C. ochrostoma, Morula granulata, Thais aculeata*
Pyramidellidae	*Tathrella iredalei, Turbonilla* sp.
Volutidae (volutes)	*Melo* sp.
CEPHALOPODA	
Octopodidae	*Octopus* spp.
CRUSTACEA	
Diogenidae (hermit crabs)	*Dardanus deformis, D. lagopodes, D. pedunculatus*
Gonodactylidae (mantis shrimps)	*Gonodactylus* sp.
Portunidae (swimming crabs)	*Thalamita* spp.
Xanthidae	*Atergatis* spp., *Carpilius convexus, C. maculatus, Demania alcalai, Leptodius* cf. *sanguineus, Lophozozymus pictor,* cf. *Zosimus aeneus*
OSTEICHTHYES	
Balistidae (triggerfish)	*Balistapus undulatus, Balistoides* sp., *Pseudobalistes, Rhinecanthus* sp.
Lethrinidae (emperors)	*Monotaxis grandoculis*
Labridae (wrasse)	*Choerodon* spp., *Cheilinus* sp., *Halichoeres* sp.
Tetraodontidae (pufferfish)	*Canthigaster valentini, Tetradon stellatus*
CHONDRICHTHYES	
Carcharhinidae (sharks)	"reef sharks"
Myliobatidae (eagle rays)	*Aetobatis narinari*
REPTILIA	
Chelonidae (turtles)	*Eretmochelys imbricata*

Of the remaining predators, by far the most widespread and destructive are ranellid gastropods of the genus *Cymatium*. Other commonly reported predators are muricid gastropods, hermit crabs, brachyuran crabs, octopus, turbellarian flatworms and parasitic pyramidellid gastropods.









Some giant clam predators: 1) pufferfish, 2) gastropods, 3) crab, 4) triggerfish, 5) octopus, 6) flatworm, and 7) *Cymatium muricinum*.

Results suggest that *T. gigas* and *T. derasa* are more susceptible to predators than *Hippopus hippopus*. Crabs and fish are capable of consuming large numbers of clams but these are not a problem with larger clams and can be excluded using cages. However, cymatiid gastropods can feed on all sizes of clams and kill relatively large ones (up to 20 cm). They are capable of settling in nursery cages during their larval stages, whereupon they commence a phase of rapid growth during which they consume large amounts of clam tissue.

Growth, consumption and incidence of *Cymatium* have been studied at the CAC in order to establish factors affecting their abundance, such as seasonality, cage type and cage location. Over one year more than 4,000 juvenile *Cymatium* spp. were recovered from 30-70 m^2 of cage area. These were estimated to have consumed around 20,000 20-mm juvenile *T. gigas* prior to their detection and removal.

A number of organisms were found to bore into the shells of cultured clams. On occasions this action can cause clam mortality but more often it weakens and deforms the shell. The organisms involved include sponges, algae, polychaete worms and fungi. Treatment of these borers with dilute formalin appears to be successful.

Work continued on methods for control of the various predators including freshwater or saline dips, the use of trestles, traps, nets and routine checks. A variety of organisms have been screened for their potential as biological control agents of the principal pests. A species of hermit crab shows promise in controlling pyramidellids at the MSI and juvenile *Cymatium* spp. at the CAC. A number of specialist gastropod predators are also being screened at the CAC.

A new species of flatworm found to prey on clams in the floating ocean nursery at the CAC is being described and will be named *Stylochus matatasi*, meaning "eye of the sea" in a local language.

Project Title		: Coastal Aquaculture Network
Funding Institution		: Unrestricted Core
Cooperating Institutions		: Various institutions in Australia, the South Pacific, Southeast Asia and the UK
Duration		: Indefinite, from 1987
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

A shipment of over two million *Tridacna gigas* pediveligers was made to the Marine Science Institute of the University of the Philippines in support of their program to re-establish stocks of this species in the Philippines. These initial shipments indicate that international transfers of larvae or early spat, preferably around 14-25 days old, are technically feasible. Ecologically it is sounder than the transfer of settled juveniles or adult clams because the chance of transfer of disease organisms is much smaller and predators and parasites can be completely eliminated. Transport costs are also much lower.

Strong contacts were maintained with the cooperating institutions. CAC staff participated in meetings of the ACIAR-funded Giant Clam Project in February and December and continued close linkages with many of the participating scientists.

Project Title : Reef Ranching Research Project

Funding Institution : South Pacific Regional Environmental Programme, South Pacific Commission (SPC)

Duration : 1989-1992

Key Personnel ICLARM : Dr. John L. Munro; Ms. Lucy Gilkes

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

The concept of reef ranching systems for fish or other reef invertebrates is closely linked with the assumption, based on scientific observation, that coral reef animals are relatively sedentary and seldom move far from their "home" reef.

The current work of this project is primarily directed to testing the hypothesis that reef fishes of interest to the project will not move far from relatively circumscribed areas and if recruits were added to the system, then recruits would remain in the locations of their introduction.

A trapping and mark-recapture program was carried out during June-July 1991 and September-October 1991 in the 4.5-ha marine reserve fronting the CAC, utilizing Antillean Z- and double-chevron traps baited with either sweet potato and coconut or chunks of tuna held in wire mesh boxes or net bags. Fish in good condition were tagged and always returned to within 10 m of the trap position and the traps were reset in the same place each time. A total of 179 fish from 37 species were tagged and a total of 23 fish were recaptured.

Additionally, a visual census of fish populations was carried out between October and December 1991 in the CAC reef and the area of fringing reef lying to the west and bordering the CAC site. The visual census showed that there were no significant differences in the total numbers of individuals or species between the CAC reserve and the adjacent reef. However, the CAC reef had a significantly higher number of individuals and species of Lutjanidae, Haemulidae and Pempheridae.

The average rate of recapture of tagged fish was relatively high for certain species but were, in some cases, based on a few tagged individuals. The overall number of tagged and recaptured fish was low and because of this, no population estimates for the dominant species in the trap catches have been made.

Project Title : Status of Cultivation of Pearl Oysters in the Indo-Pacific Region: A Review

Funding Institution : Overseas Development Administration (ODA) of the United Kingdom

Duration : 14 months, to December 1991

Key Personnel ICLARM : Mr. Mark H. Gervis; Dr. J.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 into English.
- 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

Funding for Mr. M. Gervis to undertake a short-term preparatory study on pearl oyster cultivation was provided by the British ODA/BDDP. The funding ran from November 1990 to March 1991 and resulted in the preparation of two documents, a bibliography of pearl oysters and a review of their biology and culture. The review will be coauthored by Mark Gervis and Neil A. Sims, Research Director of Black Pearls, Inc.

Interest in pearl oyster cultivation increased substantially during 1991. A pan-Pacific pearl oyster project has been proposed by James Cook University and implementation of a project has begun in the Cook Islands through a commercial consultancy group. Both organizations wish to participate in complementary research in order to broaden the field of research as much as possible. Funding sources to begin the pearl oyster research program are being examined.

Pinctada margaritifera on a longline in the Cook Islands. Photo by N. Sims.

ADMINISTRATION AND FINANCE

In the history of any organization, certain periods of time will always be remembered for events and/or circumstances that permanently and very significantly change the character of that organization. ICLARM has had several such periods.

In 1984-85, the financial situation of the Center was such that the Center was very close to insolvency. Staff members who were already with the Center then will never forget the measures that were being considered - employee lay-offs, asset disposals, salary cuts and even the termination of Center operations. Although time has very kindly started to heal these memories, the entrepreneurial spirit and dogged determination brought forward by staff to overcome these stresses remain to this day.

Another such period was the illness and subsequent death of Dr. Ian R. Smith, ICLARM's Director General, in 1988-89. Though a painful and trying period for all, the experience served to establish very firmly the organization's concern for employee welfare and service to the world's poor - the ideals that Dr. Smith will always be remembered by.

This year, 1991, saw the start of another such period when the Center, much larger now in terms of staff, budgets, projects and operating locations, was forced to formulate and articulate its strategic plan. The process of strategic planning, started in late 1990, was long and difficult. The efforts to arrive at a concensus were oftentimes painful and taxing on the Center, its trustees and its staff. In the process, ICLARM had to face the realities of its weaknesses, take or plan for the corrective actions necessary to overcome these weaknesses, identify what the Center could contribute and decide where to focus its limited resources.

This period is expected to influence the Center's values of institutional accountability and service to clients. Although there is, among ICLARM staff, some anxiety that an emphasis on accountability would result in the bureaucratization of management systems, it will be the responsibility of ICLARM's senior management to develop management systems that provide successfully the accountability but, at the same time, maintain the flexibility and responsiveness that have been an ICLARM strength for so long. As these systems evolve during this period of transition, a management style that is uniquely ICLARM is expected to emerge and successfully carry the Center forward in attaining the strategic objectives it has established for itself.

Administration

Dr. Kenneth T. MacKay, appointed Director General by the ICLARM Board in late 1990, officially took his post in Manila on 1 April 1991. Among the initiatives taken in 1991 were the following:

- The creation of a Research Committee initially composed of all Program Directors, to assume the responsibility of reviewing and approving research proposals and plans.
- The creation of an Administration and Management Committee to prepare recommendations for necessary changes in management systems and to address various administrative issues.
- Identification of the need for and the allocation of Center resources towards the strengthening of administration and administrative support services.
- The initiation of a comprehensive review of Center compensation policies and practices.
- The formalization of the practice of annual staff meetings.
- Identification of the need for an organizational unit at ICLARM headquarters to plan and oversee ICLARM's activities in support of national research system strengthening.
- Identification of new sources of financial support for ICLARM.

Board of Trustees

At the start of the year, Dr. M.S. Swaminathan announced that he had been elected Chairperson of the Board of Trustees of the International Irrigation Management Institute (IIMI) based in Sri Lanka. It was therefore with much regret that he was allowed to resign from the ICLARM Board in the middle of his second term.

The year also saw the retirement, from ICLARM's Board of Trustees, of Mr. Roy Jackson (member since 1982, Chairperson since 1985), Mr. Alban Gurnett-Smith (member since 1982) and Dr. James Storer (member since 1983). Fondly referred to as the "Blue Whales" on ICLARM's Board, these trustees ended their final terms with the 1991 Annual Meeting. Elected Chairperson at the same meeting was Dr. Peter Larkin.

New trustees elected to a first term (three years) at the end of 1991 Annual meeting were:

a) Dr. Dayton L. Alverson: Owner/President of Natural Resources Consultants, Inc., Seattle (1980 to present).
b) Dr. Barry Keith Filshie: Officer-In-Charge, Commonwealth Scientific and Industrial Research Organisation (CSIRO), International Relations Centre, Australia (1983 to present).
c) Dr. Cornelia Nauen: Senior Fisheries Cooperation Officer, Commission of the European Communities (1990 to present).

Trustees elected to a second and final term to end in 1994 were Dr. Agustin Ayala-Castañares, Dr. Peter Larkin, Dr. Edgardo Gomez and Dr. Philipp Muller.

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 Malawi - 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. Kenneth T. MacKay: ICLARM - Director General
13. Dr. David Adolph Philipp Muller: South Pacific Forum Fisheries Agency - Director (1981 to present). ICLARM Board Member since 1989.
14. 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.
15. Dr. Monokumbu S. Swaminathan: Indian 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.

1991 Board Meetings

In 1991, the Center's trustees held the following meetings:

- Program Committee Meeting - 1 to 3 April 1991.
- 16th Annual Meeting of the ICLARM Board of Trustees - 4 to 5 April 1991.
- Nominating Committee Meeting - 3 April 1991.
- Finance and Management Committee Meeting - 4 April 1991.
- Executive Committee Meeting - 25 to 26 October 1991.

During the year, the Board focused most of its efforts on three major activities - overseeing the preparation of the ICLARM Strategic Plan; overseeing the development of new organizational structures and management systems for the Center; and initiating programs to improve the effectivity of the Board.

Board Officers and Committees, 1991-1992

BOARD OFFICERS (1991 and 1991-92)

1991:

Chairperson	- Mr. Roy I. Jackson
First Vice Chairperson	- Mr. Senen Bacani
Second Vice Chairperson	- Mr. Alban F. Gurnett-Smith
Secretary	- Mr. Basilio Rodriguez, Jr.
Treasurer	- Dr. Roger S.V. Pullin

1991-92:

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

BOARD COMMITTEES

1. ***Executive Committee***

Functions:

- To implement and execute the policies and decisions laid down by the board.
- To exercise the powers and perform the duties delegated by the Board.
- To act for the Board between Board of Trustees meetings on matters requiring immediate attention.

Members:

1991:	Mr. Roy I. Jackson - Chairperson Mr. Senen Bacani Mr. Alban F. Gurnett-Smith Dr. James A. Storer Dr. M.S. Swaminathan Dr. Martin Bilio Dr. Kenneth MacKay
1991-92:	Dr. Peter Larkin - Chairperson Mr. Senen Bacani Dr. E.A. Huisman Dr. Zimani Kadzamira Dr. Martin Bilio Dr. Kenneth MacKay

2. *Finance and Management Committee*

Functions:

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

Members:

1991:	Dr. James A. Storer - Chairperson Mr. Roy I. Jackson Mr. Senen Bacani Mr. Alban F. Gurnett-Smith Dr. M.S. Swaminathan Dr. Martin Bilio Dr. Kenneth MacKay
1991-92:	Dr. E.A. Huisman - Chairperson Dr. Peter Larkin Mr. Senen Bacani Dr. Zimani Kadzamira Dr. Martin Bilio Dr. Kenneth MacKay

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:

1991:
Dr. Martin Bilio - Chairperson
Dr. Agustin Ayala-Castañares
Dr. Peter A. Larkin
Dr. Edgardo Gomez
Dr. Philipp Muller
Dr. Kenneth MacKay

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

4. *Nominating Committee*

Functions:

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

Members:

1991:
Dr. M.S. Swaminathan - Chairperson
Dr. Agustin Ayala-Castañares
Dr. Zimani Kadzamira
Dr. Keishi Amano
Dr. Hannah R. King
Dr. Kenneth MacKay
Alternates:
Mr. Alban F. Gurnett-Smith
Dr. Peter A. Larkin

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

Center Finances

Total revenue for the Center registered a 12% growth in 1991 over 1990 revenues. Much of this growth came from additional unrestricted grants in 1991. In spite of this growth and a small surplus, the Center's liquidity deteriorated largely as a result of delays in grant disbursements combined with an increased demand for cash due to its expanding operations.

1991 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)
Canadian International Development Agency (CIDA)

2. Restricted Support

Activity	Sources of 1991 Support
ADB/ICLARM-IRRI/CLSU Cooperative Research on Rice-Fish Farming Systems	Asian Development Bank (ADB)
ASEAN Coastal Resources Management Project	United States Agency for International Development (USAID)
Asian Fisheries Social Science Research Network III	International Development Research Centre (IDRC) of Canada
Atlas of the Freshwater Fishes of Africa	Agence de coopération culturelle et technique (ACCT)
Bangladesh Aquacultural Research Project III	United States Agency for International Development (USAID)
Bellagio Environment Conference	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
BOSTID-ICLARM Aquaculture Workshop for PSTC/CDR Scientists	National Research Council (USA)
Collaborative Development of a Database on Fisheries Resources by ICLARM and FAO Fisheries Department	Food and Agriculture Organization (FAO)
A Collaborative Investigation of Predation on Cultivated Giant Clams (Tridacnidae, Bivalvia)	Australian International Development Assistance Bureau (AIDAB)
Conference on Waste Management in the Coastal Areas of the ASEAN Region: Roles of Governments, Banking Institutions, Donor Agencies, Private Sector and Communities	ASEAN-Canada Centre (CAC)

Conference on Waste Management Problems in the Coastal Areas of the ASEAN Region	Asian Development Bank (ADB)
Directory for Education and Training Opportunities	Food and Agriculture Organization (FAO)
Establishment of a Database for Aquatic Organisms of Current and Future Potential Importance in Developing-Country Fisheries Development (I)	Commission of the European Communities (CEC)
Establishment of a Database for Aquatic Organisms of Current and Future Potential Importance in Developing-Country Fisheries Development (II)	Commission of the European Communities (CEC)
Expansion of Giant Clam Production: Coastal Aquaculture Centre	Forum Fisheries Agency (FFA)
Experiments in New Approaches to Managing Open Water Fisheries in Bangladesh	Ford Foundation, Bangladesh
Farming Systems Research (FSR) Methodologies Workshop for a Bangladesh Research Scientist and Publication of a Training Manual on Gender Issues on FSR	Ford Foundation, Bangladesh
Genetic Improvement of Farmed Tilapia (Phase I)	United Nations Development Programme (UNDP)
Genetic Improvement of Farmed Tilapia	International Bank for Reconstruction and Development (IBRD)
Genetic Improvement of Tilapia Species in Asia	Asian Development Bank (ADB)
Geographic Information System for Coastal Area Management and Planning	International Development Research Centre (IDRC) of Canada
Giant Clam Conservation and Cultivation Booklet	Greenpeace Foundation
Global Comparisons of Multispecies Trophic Modelling	Danish International Development Agency (DANIDA)
INFOTERRA Special Sectoral Source (FAO)	Food and Agriculture Organization
Interregional (Asia-Africa) Cooperation in Aquaculture	French Government
Multivariate Analysis in Aquaculture: Selected Cases from Research and Production-Oriented Tilapia Culture	Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ)
Network of Tropical Fisheries Scientists (FAO)	Food and Agriculture Organization

ODA Giant Clam Project Phase III (ODA)	Overseas Development Administration
Pearl Oyster Study (ODA)	Overseas Development Administration
The Peruvian Upwelling Ecosystem: Modelling and Management	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Reef Reserve Effects on Fish and Invertebrate Populations, Guadalcanal, Solomon Islands	South Pacific Commission (SPC)
Research Collaboration between ICLARM and the Institute of Aquatic Biology	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Research Grant to T. Molea to Study the Effects of Various Zoothanthellae Strains on the Growth and Survival of Giant Clams	Asian Fisheries Society (AFS)
Research in Rice-Fish Farming (ODA)	Overseas Development Administration
Research on the Development of Tropical Aquaculture Technology Appropriate for Implementation in Rural Africa (Phase III)	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Research on the Tilapia Genetic Resources of Ghana for Their Future Conservation and Management in Fisheries and Aquaculture	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Research Program on the Impact of Fish Culture within the Farming Systems in Bangladesh	International Fund for Agricutural Development (IFAD)
Rice-Fish Asia Network (CLSU-FAC/ICLARM)	International Development Research Centre (IDRC) of Canada
Rider to the Contract on the Establishment of a Database (FISHBASE) for Developing-Country Fisheries Development	Commission of the European Communities (CEC)
Selective Fisheries Information Service Centre (IDRC) of Canada	International Development Research
Sierra Leone West Northwest Artisanal Fisheries and Community Development Research Cooperation between IMBO and ICLARM	Commission of the European Communities (CEC)
Socioeconomic Study of the Impact of a Fish Culture Extension Program on the Farming System in Bangladesh	Danish International Development Agency (DANIDA)
Software Stock Assessment Project (FAO)	Food and Agriculture Organization

Strategic Plan Development for ICLARM Centre (IDRC) of Canada; United Nations Development Programme (UNDP)	International Development Research
Study of the Puttalam/Mundal Lake Estuarine System and Associated Coastal and Estuarine Waters	Swedish Environmental Research Institute (SAREC)
Third International Symposium on Tilapia in Aquaculture (ISTA III)	French Government
Training of J.P.T. Dalsgaard	Danish International Development Agency (DANIDA)

STATEMENT OF REVENUES, EXPENSES AND FUND BALANCE
(in US$)

	1991	1990
Revenues		
Grants	4,491,707	3,940,613
Consultancy and service fees	30,234	51,464
Publications	34,713	24,698
Overhead income	171,399	195,165
Interest income	23,126	36,543
Insurance and other expense refunds	4,388	3,983
Miscellaneous	11,626	15,892
Total	4,767,193	4,268,358
Expenses		
Aquaculture	1,956,157	1,821,766
Capture Fisheries Management	750,079	598,169
Coastal Area Management	750,650	917,452
Library & Information Services	228,158	191,447
Strategic Planning	185,344	
Administration & Finance*	769,498	705,631
Capital Expenses		40,558
Translation loss (gain)	(80,485)	
Total	4,559,401	4,275,023
Excess (Deficiency) of Revenues over Expenses	207,792	(6,611)
Fund Balance at Beginning of Year	117,547	124,158
Fund Balance at End of Year	325,339	117,547

*Includes capital expenses.

ICLARM STAFF

Director General

Kenneth T. MacKay, Ph.D.

Coastal Area Management Program

Chua Thia-Eng, Ph.D.	Director

ASEAN/US COASTAL RESOURCES MANAGEMENT PROJECT

Chua Thia-Eng, Ph.D.	Project Coordinator
Louise A. Fallon-Scura, Ph.D.	Resource Economist
Heng L. Thung, Ph.D.	Coastal Zone Planner
Peter Burbridge, Ph.D.	Consultant
Gregor Hodgson, Ph.D.	Consultant
Richard Tobin, Ph.D.	Consultant
Geronimo T. Silvestre, M.A.	Fisheries Resource Expert (Brunei Darussalam)
Zoraida N. Alojado, M.S.	Systems Analyst
Len R. Garces, M.S.	Project Specialist
James N. Paw, M.Aq.	Project Specialist
Michael D. Pido, M.S., M.P.A.	Project Specialist
Ma. Jessica Madeleine L. Dalusung, A.B.	Research Assistant
Socorro C. Guerrero, A.B.	Project Assistant
Marie Sol M. Sadorra, B.S.	Project Editor
Germilina B. Dizon, B.S.	Project Accountant
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Rachel C. Atanacio	Project Artist
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Cherryl C. Roxas, B.S.	Clerk/Typist
Edwin G. Rodriguez, B.S.	Clerk

ASIAN FISHERIES SOCIAL SCIENCE RESEARCH NETWORK

Louise A. Fallon-Scura, Ph.D.	Coordinator (part-time)
Herminigildo M. Montalvo, M.S.	Research Associate
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Capture Fisheries Management Program

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Jose Padilla, Ph.D.	Postdoctoral Fellow
Annabelle Cruz-Trinidad, M.A.	Program Assistant
Felimon C. Gayanilo, Jr., B.S.	Research Associate
Francisco S.B. Torres, Jr. B.S.	Research Assistant I
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
Edwin M. de Guzman, B.S.	Programmer

FISHBASE

Rainer Froese, Dr.rer.nat.	Associate Scientist
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Susan M. Luna, B.S.	Research Assistant I
Liza Q. Agustin, M.S.	Research Assistant I
Crispina B. Binohlan, M.S.	Research Assistant I
Estelita Emily D.C. Capuli, B.S.	Research Assistant I
Armi G. Torres, B.S.	Research Assistant I
Dominic S. Tioseco, B.S.	Programmer
Maria Teresa G. Cruz, B.S.	Project Secretary
Roberto N. Cada	Artist
Magnus Olsson Ringby	Artist

SOCIOECONOMIC VALUATION OF COASTAL RESOURCES OF SOUTHWESTERN LATIN AMERICA

Max Agüero, Ph.D.	Project Director
Exequiel González, M.S.	Project Coordinator
Carlos Olivares, Computer Engineer	Project Analyst/Programmer
Fanny Torres, B.S.	Project Assistant
Marisol Ruiseñor, 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

Ximena Malinarich	Research Assistant/Economics
Octavio Barrios	Research Assistant/Programming

SIERRA LEONE WEST NORTHWEST ARTISANAL FISHERIES AND COMMUNITY DEVELOPMENT RESEARCH COOPERATION BETWEEN THE INSTITUTE OF MARINE BIOLOGY AND OCEANOGRAPHY AND ICLARM

Jan Michael Vakily, Ph.D.	Project Leader

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.	Program Secretary
Marissa W. Manela	Program Secretary

GENETIC IMPROVEMENT OF FARMED TILAPIAS

Ambekar E. Eknath, Ph.D.	Associate Scientist II
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INTEGRATED FARMING SYSTEMS

Clive Lightfoot, Ph.D.	Senior Scientist
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AFRICA AQUACULTURE PROJECT

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RICE-FISH FARMING SYSTEMS RESEARCH

Catalino R dela Cruz, Ph.D.	Project Leader

BANGLADESH AGRICULTURAL RESEARCH PROJECT

Modadugu V. Gupta, Ph.D.	Project Leader
Bijoy B. Debnath	Secretary

SOCIOECONOMIC IMPACT OF FISH CULTURE EXTENSION PROGRAM ON THE FARMING SYSTEMS OF BANGLADESH

Mahfuzzudin Ahmed, Ph.D.	Project Leader
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Md. Aynul Islam, M.Sc.	Research Officer II
Mujibur Rahman, M.Sc.	Research Officer III
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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

RESEARCH COLLABORATION BETWEEN ICLARM AND THE INSTITUTE OF AQUATIC BIOLOGY, GHANA

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Grace Coronado, B.S.	Research Assistant/ Programmer

Information Program

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Reynaldo A. Damalerio	Library Aide

South Pacific Office
Coastal Aquaculture Centre

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John B. Hambrey, Ph.D.	Affiliate Research Scientist
Graham F. Usher, M.Sc.	Affiliate Research Scientist
Patricia E. Munro, Ph.D.	Affiliate Research Scientist
Mark H. Gervis, M.Sc.	Affiliate Research Scientist
Hugh Govan, B.Sc. Hons.	Assistant Research Scientist
Lucy Gilkes, M.Sc.	Affiliate Assistant Research Scientist
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Francis Tafuokalo, D. Trop. Fish.	Fisheries Officer, Fisheries Division, GSI

Administration and Finance

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Remedios C. Apostol, C.P.A.	Chief Accountant
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Marietta D. Veneracion	Administrative Assistant
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Alfredo F. Diaz, Jr., B.S.	Systems Specialist
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Germilina B. Dizon, B.S.	Accountant II
Irma C. Reyes, C.P.A.	Accountant II
Ofelia A. Celestino, C.P.A.	Accountant II
Milagros Irene F. Robel, C.P.A.	Accountant I
Grace Marie F. Miranda, B.S.	Accountant I
Elsa T. Bibiano	Accounting Clerk
Noel A. Villanueva	Programmer
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