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**ICLARM REPORT
1981**



Frontispiece: Thai seafood on display in a road-side café, Bangkok. ICLARM is assisting coastal aquaculture development in Thailand.

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ICLARM REPORT

1981

Edited by

Jay L. Maclean

1982

**INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT
MANILA, PHILIPPINES**

ICLARM Report 1981

Edited by JAY L. MACLEAN

1982

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*Cover: San Miguel Bay (Philippines) project team member, Francla Yater,
Interviews fishermen. The multidisciplinary, small-scale fisheries project
is described on p. 59.*

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INTRODUCTION

At the time of preparation of our first report, covering March 1977 to March 1980, ICLARM had only just completed its establishment phase, and there were 10 projects underway in the program areas. Since then, although only one new scientific staff appointment has been made, many more projects have begun to be implemented. In fact, seventeen projects have been completed since the last report. They range from important conferences, the proceedings of which will become benchmarks in the scientific literature, to the large San Miguel Bay project, Philippines, the first such multidisciplinary study of a fishery in Southeast Asia, which will undoubtedly become a model for future tropical fisheries field projects.

All these projects have been carried out or supervised by seven tenured and three fixed-term professional staff. Their performance is more than creditable; it says a great deal for the enthusiasm and capability of these scientists. ICLARM's support staff are to be congratulated also for their efficient and uncomplaining service with sometimes long hours and short deadlines to handle project reports.

The on-going and upcoming projects total 14, which include country case studies on developments and production economics, marketing, establishment of research networks, and controlled reproduction of several fish species.

As an administrator, I have been gratified to see ICLARM's cooperative project activities and linkages broadened this year to include the Canadian International Development Research Centre; FAO; CSIRO, Australia; the United Nations University, Tokyo; the Indonesian Agency for Agricultural Research and Development; the Asian Development Bank; the Taiwan Council for Agricultural Planning and Development, and the German Agency for Technical Cooperation.

In this report we have recorded the activities of ICLARM from April 1980 through December 1981. They have expanded from the Philippines, where earlier projects were concentrated, to Australia, Egypt, India, Indonesia, Israel, Kuwait, Mexico, Peru, Taiwan and Thailand.

ICLARM has begun to fulfill its international role and I am confident that we will be serving tropical, developing countries for many years to come.

ZIAD H. SHEHADEH

ICLARM 1981

ICLARM is nearly five years old. Incorporated in the Philippines in March 1977, it has grown almost to maturity. Almost, because its projected complement of 12 permanent scientific appointments has not yet been realized. There are now eight permanent professional staff members at headquarters in Manila. The Center has developed what the Executive Committee of its Program Advisory Committee recently described as the distinctive ICLARM "flavor."

The special role for ICLARM as conceived by its founders is being fulfilled through an integrated program that is complementary to the development programs of other agencies yet distinctive in terms of its contribution.

ICLARM's unique "flavor" is a blend of activities and relationships resulting from its non-governmental, independent, international status. The elements contributing to the ICLARM approach are:

- Multidisciplinary Research
- Broad Application of Research Programs
- Cooperation with Appropriate Institutions
- Unique Patterns of Project Execution
- Flexibility

Activities of the integrated farming project, which began in 1978, illustrate ICLARM's approach. Integrated farming was picked because of the potential it offered throughout the developing countries, and because it had nevertheless been scarcely documented at the research level. The project began as a biological study. In its second year, an international conference was held to document existing practices worldwide. In its third year, economists from both ICLARM and the cooperating institutions where the research was being carried out at Central Luzon State University, Nueva Ecija, Philippines began an evaluation of the project to sort out an optimum system design. In its fourth year, contributions from ICLARM's stock assessment project resulted in a mathematical approach to evaluate pond performance in space rather than in time. This method has allowed accurate assessment of many pond parameters over a short period of time.

Other new elements related to the project include a review of sewage and wastewater in aquaculture and a planned conference on detrital systems. That project was centered on tilapia, internationally recognized now as one of the prime aquacultural commodities with the greatest potential for worldwide development. ICLARM's recent and ongoing contributions to tilapia research also include an international conference on their biology and

culture, a review of applied genetics experiments, biological research projects on genetic improvement, fry production and saltwater culture, as well as economic studies on their production and marketing in the Philippines and Taiwan.

Milkfish, another prime aquacultural commodity, are also receiving multidisciplinary treatment, with current projects on production economics, marketing and socioeconomic aspects in the Philippines and Taiwan.

ICLARM's growing involvement in aquaculture economics also prompted a joint conference on this subject held in 1981. Other new aquaculture activities are being carried out, by request, in Egypt, Israel and Thailand.

ICLARM's Traditional Fisheries Program, like the Aquaculture Program described above, has followed a systematic approach. A review of traditional fisheries research has led to several country-specific reviews of small-scale fisheries, an international conference on alternative energy in fisheries, and a major, multidisciplinary, research project of the fisheries and fishing communities of San Miguel Bay, Philippines, a study including biological, sociological and economic elements.

The Resource Development and Management Program has exhibited the same ICLARM approach—a review of the theory and management of tropical fisheries led to the current research and training project on tropical stock assessment; an international conference of experts (ICLARM-CSIRO Workshop on Tropical Stock Assessment) has provided directions for future work in management-oriented fisheries and given impetus to the development of a network of tropical fisheries scientists.

There are other elements that contribute to the ICLARM flavor. In aquaculture, species groups are treated on a commodity basis; research activities span key areas of these industries and include studies of trends and development prospects in Israel and Taiwan. A growing decentralization of effort is also becoming a significant feature of ICLARM's research as a result of rapid expansion of cooperative activities with developing country institutions. There were three professional researchers in field positions during 1980-81; there will be six in 1982. It is a consequence of the policy to work with appropriate, existing institutions, wherever they may be located, and of ICLARM's widening international role.

ICLARM's experience in conducting research in developing countries is leading increasingly towards long-term involvements with cooperating institutions. Much of the research is of an extended nature, while long-term association provides a basis for continuity to the institutions involved. This approach is an important element in the institution-building component of research projects. In plans for 1982 and beyond, the strengthening of developing country institutions is a high priority objective.

This report period has also seen a surprising increase in requests for advice and training. ICLARM has responded where possible and is looking towards organized involvement in presently deficient areas of fisheries training.

Finally, ICLARM's projects are formulated in recognition of national goals and priorities. The fisheries priorities of developing countries are development-oriented. Development- and/or management-related projects are seen to be clearly in the public interest; regional and international banks and donor organizations react favorably to them. On the other hand, research is generally neither obviously beneficial nor appealing to governments or funding agencies. The result is that developments often outpace the research base needed to support them.

ICLARM was founded on the need for an international, non-governmental organization to fill the research gap, as well as to seek new research areas that might lead to more rapid development. This approach has proven a successful formula in attracting a large number of cooperating institutions in many countries and a growing level of support from donors.

Highlights

Several projects that have had special significance internationally deserve additional comment.

In aquaculture, the integrated farming project has generated interest elsewhere in the Philippines, as well as in Kenya and Mexico. Some results have already been applied by the International Institute of Rural Reconstruction, near Manila, Philippines, to a small-scale pond project.

The beginning of a project with the Thailand Government in late 1981 on coastal aquaculture of bivalve molluscs marked the implementation of ICLARM's largest project to date in terms of both budget and field staff. The results will have wide application throughout tropical Southeast Asia.

At a joint ICLARM/IDRC (International Development Research Centre) workshop on aquaculture economics in Singapore, June 1981, principal investigators from four ICLARM projects presented papers on their research (milkfish economics in Taiwan and the Philippines, catfish economics in Thailand, and integrated farming economics in the Philippines). That meeting was the culmination of these activities. ICLARM is continuing work with each of the four groups involved on other aspects of aquaculture economics.

In the Traditional Fisheries Program, a major event was the successful completion of field work for the multidisciplinary study of the fisheries of San Miguel Bay, Philippines. The work involved four research teams, studying biological, economic and sociological aspects of this multi-gear, multi-species fishery. The study will have wide application throughout Southeast Asia.

Of broad importance has been the change in attitudes among government planners regarding traditional fisheries. During 1981, in one Southeast Asian country after another, recognition has been emerging that answers to the question of alleviating the poverty of small-scale fishermen lie not in new technology but in resource management that addresses the question of allo-

cation among competing sectors of the industry and in encouraging alternative income-generating activities, particularly low-investment aquaculture enterprises. This recognition was quite apparent at a workshop sponsored by USAID in Manila in November, 1981, where Philippine government officials indicated a clear understanding of problems related to small-scale fishermen.

These attitudes vindicate the direction of ICLARM's work in this field. They coincide with the conclusions of ICLARM's 1979 review of traditional fisheries research needs and with the results of research in San Miguel Bay, where an already fully exploited fishery is expected to support a growing population.

The development and application of a series of microcomputer programs for analysis of length-frequency data were the highlights of research in the Resource Development and Management Program. Four programs were developed which allow objective estimates of growth parameters to be extracted from nearly any sound set of length-frequency data, tropical or otherwise, even in cases where growth strongly oscillates seasonally and when recruitment occurs several times per year. The programs allow rapid estimation of the most important parameters in stock assessment, including fishing and natural mortalities more reliably than previous methods.

In support of the technical program areas, ICLARM's Information Service has expanded its activities to keep pace with the increasing volume of publications and its growing involvement in meeting the fisheries information needs of developing countries. Events associated with the change from a passive, in-house Information Service to a more active, regionally oriented service highlight the section's activities in the report period. Informal linkages with FAO, IDRC and SEAFDEC have been strengthened in the area of information retrieval. Services for professional staff have been upgraded by acquisition of a teletype facility which provides a direct connection to overseas computer databases. Contributions to the literature by ICLARM and project personnel have increased substantially. Various promotional methods are being adopted to insure wide dissemination of these publications.

On the following pages a list of all current ICLARM projects, completed, ongoing and programmed for 1982, is presented. Details of the projects are given after the respective Research Program outlines.

LIST OF ICLARM PROJECTS

Aquaculture Projects Completed in 1980-81	Cooperating Institution(s)
Applied Research on Integrated Animal-Fish Farming (Philippines) (3 years, Jan 1978-Jan 1981)	The Freshwater Aquaculture Center (FAC) of the Central Luzon State University (CLSU), Muñoz, Nueva Ecija, Philippines
Milkfish Production Economics (Philippines) (18 months, June 1979-Sept 1981)	Bureau of Agricultural Economics (BAEcon); Fishery Industry Development Council (FIDC)
Genetic Improvement of Tilapia Broodstock in the Philippines (2 years, 1 June 1979-31 Aug 1981)	The Freshwater Aquaculture Center (FAC) of the Central Luzon State University (CLSU), Muñoz, Nueva Ecija, Philippines
Catfish Production Economics (Thailand) (18 months, Aug 1979-Dec 1980)	Kasetsart University Research and Development Institute (KURDI), Bangkok
Production and Marketing of Milkfish in Taiwan (12 months, June 1980-May 1981)	Research Institute of Agricultural Economics, National Chung Hsing University, Taichung, Taiwan
Conference on the Biology and Culture of Tilapias (International) (2-5 Sept 1980)	The Rockefeller Foundation
Economics of the Milkfish Resource System in the Philippines (12 months, Sept 1980-Aug 1981)	United Nations University, Japan
Economics of Aquaculture Research Workshop (2-5 June 1981)	International Development Research Centre (IDRC), Singapore

Aquaculture Projects 1982	Cooperating Institution(s)
Economics of Integrated Farming (18 months, Jan 1980-June 1982)	Central Luzon State University (CLSU), Philippines
Mass Production of Tilapia Fry (2½ years, beginning 1 July 1980)	The Freshwater Aquaculture Center of Central Luzon State University, Philippines
Controlled Reproduction of Commercially Important Fishes (2½ years, beginning Aug 1980)	New Jersey Marine Science Consortium; USAID (Cooperative Marine Technology for the Middle East); Egyptian Academy of Scientific Research and Technology; Israel Oceanographic and Limnological Laboratory
Evaluation of Mariculture Potential of Tilapia (3 years, beginning May 1981)	Council for Agriculture Planning and Development (CAPD), Taiwan Executive Yuen,
Aquaculture Trends and Development Prospects: Country Case Studies (Taiwan case study began in mid-1981)	National Chung Hsing University, Taichung, Taiwan and Agricultural Production Technology (Israel) Ltd., Jerusalem, Israel
Milkfish Production Dualism: A Socioeconomic Perspective (18 months, beginning July 1981)	Bureau of Agricultural Economics (BAEcon) and the Bureau of Fisheries and Aquatic Resources (BFAR), Philippines. Project is funded by UNDP/FAO through a grant to ICLARM.
Technical Assistance for Applied Research on Coastal Aquaculture. Phase I: Mollusc Culture (18 months, with possible extension for 18 months)	Department of Fisheries, Ministry of Agriculture and Cooperatives, Government of Thailand and the German Agency for Technical Cooperation
Intensive Mariculture of Tilapia (Kuwait) (1 year, with extension for additional 2 years possible)	Kuwait Institute for Scientific Research (KISR)
Tilapia Marketing: Philippines/Taiwan (12 months, beginning early 1982)	To be determined

**Traditional Fisheries Projects
Completed in 1980-81**

Skipjack and Traditional Fisheries: A Solomon Islands Case Study
(2 years, Nov 1978-Nov 1980)

The Rockefeller Foundation

Malaysian Small-Scale Fisheries: A Research Review
(2 years, Aug 1979-July 1981)

Faculty Members from Universiti Sains, Penang, and Universiti Malaya, Kuala Lumpur

Small-Scale Fisheries of San Miguel Bay, Philippines: A Multidisciplinary Analysis
(2 years, Sept 1979-Dec 1981)

Institute of Fisheries Development and Research (IFDR) of the University of the Philippines College of Fisheries; United Nations University (UNU); and the Philippine Council for Agriculture and Resources Research (PCARR)

Workshop on Appropriate Technology for Alternative Energy Sources in Fisheries
(16-21 Feb 1981)

Co-sponsored with the Asian Development Bank (ADB), Manila

**Traditional Fisheries Projects
1982**

Indonesian Small-Scale Fisheries: Research Review and Synthesis
(9 months, Oct 1981-June 1982)

Directorate General of Fisheries (DGF) and Marine Fisheries Research Institute (LPPL), Jakarta

Fisheries Social Science Research Network
(6 years, 1983-1988)

ICLARM, IDRC, and 2-3 selected national institutions

**Resource Development and
Management Projects
Completed in 1980-81**

Tropical Stock Assessment Research and Training Project, Philippines. (To be continued in 1982 under the "Management-Oriented Tropical Fisheries Research Network.")
(Continuous from July 1979)

Cooperating Institution(s)

Predominantly in-house study, with informal linkages with (colleagues in) various research institutions.

ICLARM/CSIRO Workshop on the Theory and Management of Tropical Multispecies Stocks (12-21 Jan 1981)

Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Fisheries and Oceanography, Cronulla, Australia

Resource Development and Management Projects 1982

Cooperating Institution(s)

Management-Oriented Tropical Fisheries Research Network

Department of Fisheries and Universities in Indonesia, Thailand, Malaysia, Philippines and Fiji

- a. Philippines—The Status of Philippine Fishery Resources
 - b. Indonesia—Community Dynamics of Indonesian Multispecies Demersal Stocks
 - c. Thailand
 - d. Malaysia
 - e. Fiji
- (2 years for each country)

Network of Tropical Fisheries Scientists
(Continuous, starting in 1982)

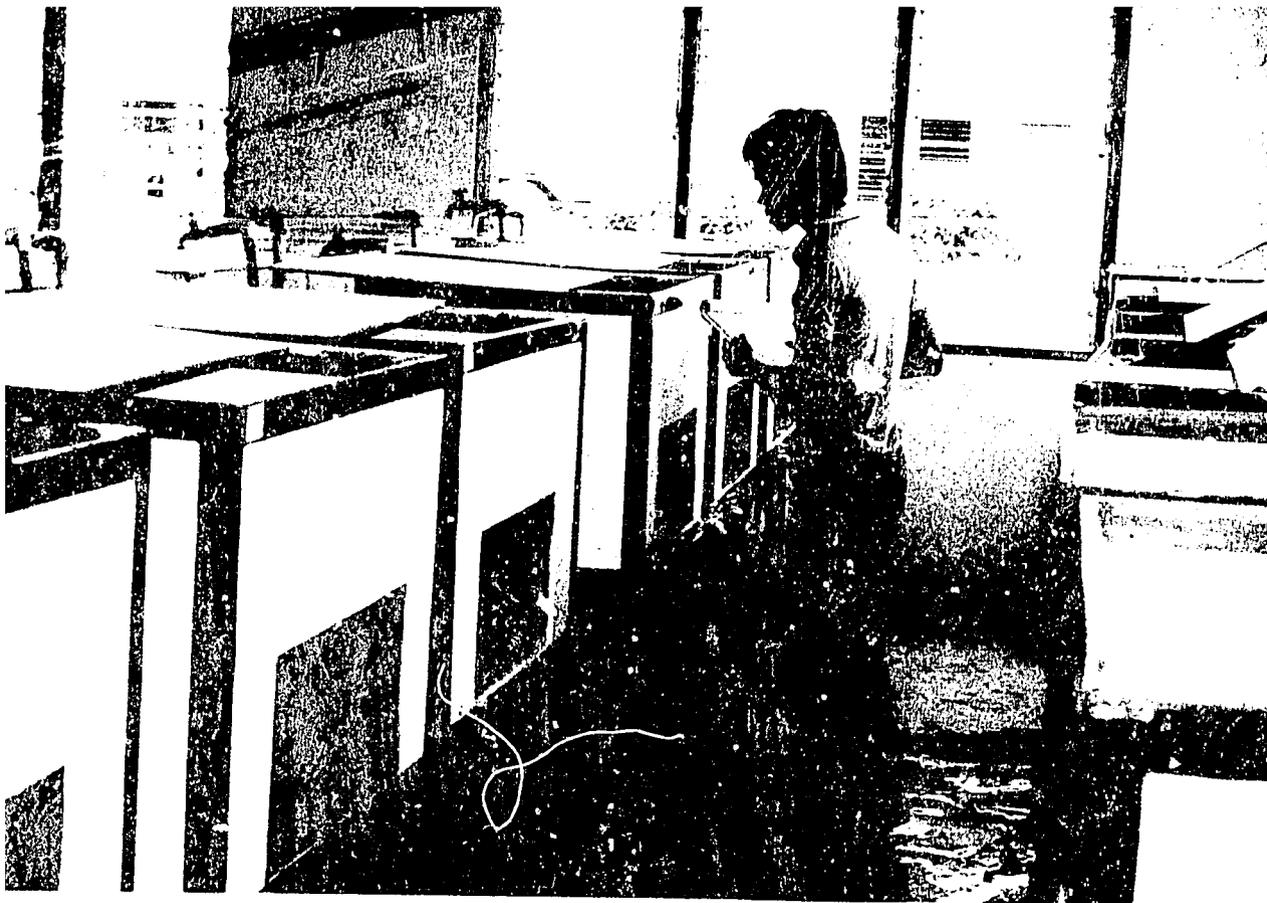
Project based on linkages with scientists working in different institutions and occasional technical workshops

**Education and Training Project
(Additional to Training Elements in Other Programs)**

Cooperating Institution(s)

Graduate Study Program in Aquatic Resources

The Philippine Council for Agriculture and Resources Research (PCARR), Los Baños, Laguna, Philippines



Aspects of ICLARM's tilapia work. Above: Nestor Jacaban checks broodstock tanks of the genetic improvement project at Central Luzon State University, Philippines. Below: participants at the international conference on tilapia biology and culture, Bellagio, Italy.



AQUACULTURE PROGRAM

Program Overview

Expansion of tropical aquaculture in the developing countries is proceeding on the basis of extension, training and demonstration programs and investment projects. The assumption is made that technologies exist that are suitable for introduction into new situations and that these technologies are adequate for rapid expansion of aquacultural production. In many instances this has proven to be the case.

There is, however, a poorly understood element in the development of tropical aquaculture that is critical for safeguarding the future of the industry—applied research. The danger inherent in neglecting this critical component of development is that expansion of production and opportunities for intensive management will be limited eventually by poor understanding of the biology and requirements of cultured animals. The promise, on the other hand, is that research can lead to more intensive management, innovative production methods and major improvements in production efficiency, as has taken place with animal husbandry.

Expansion and intensification of traditional systems call for reliable sources and greater supplies of seed, greater use of supplementary and/or nutritionally complete feed, and methods to prevent and control diseases. Meeting these needs through controlled production of seed stocks, formulation of feeds and control of diseases, presupposes a knowledge of breeding habits and physiology, nutritional requirements as well as pathogens and immune mechanisms of cultured species. With few exceptions, this knowledge does not exist for many species of interest to developing countries.

The promise of increasing efficiency through research has important implications in light of production trends in the developing world. The most rapid increases in aquacultural production in developing countries are occurring with species such as tilapia, milkfish, shrimp and carps that are well suited to intensive culture, including the application of recent research results relating to reproduction, nutrition and disease control. The entrance of large commercial producers into the production field is perhaps the most important recent development in aquacultural production. Without exception, commercial firms are utilizing or seeking new technology permitting greater efficiency of production. Many of these firms are well aware of the benefits of more efficient production and are conducting their own research programs.

Advances in research in the developing countries during the past decade have been modest at best due mostly to discontinuity of effort, modest allocation of funds to research and lack of a mechanism to help remove these constraints without compromising development efforts.

The biological element of ICLARM's aquaculture program continues to focus on the research needs identified above, in connection with tilapias, mullets, milkfish and carps, and on ways and means of insuring continuity of research effort at reasonable cost.

Research is being reorganized into a commodity-oriented approach, based on the above species groups, while maintaining the disciplinary focus on the principal basic research needs—reproduction, nutrition, genetics, pathology. In the execution of research, this approach will be implemented through initial heavy emphasis on the most promising commodity group, the tilapias.

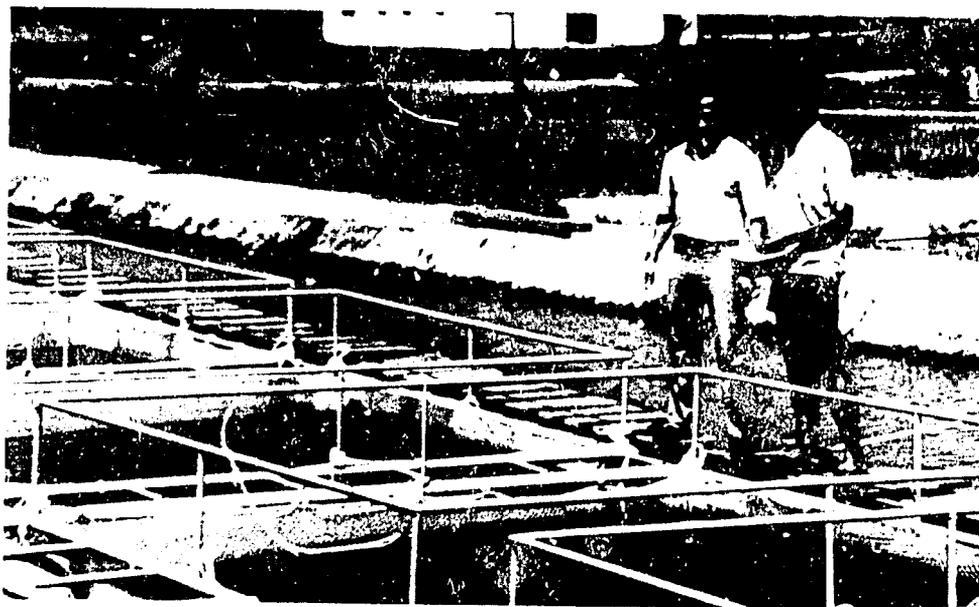


Map legend: Activities by Aquaculture Program staff during the Report period have spanned the globe: ● Project; ▲ Conference; ■ Advisory service.

Tilapias possess an impressive range of attributes that make them well suited for culture. They are best described as omnivorous species, and show excellent growth rates on low protein diets, whether from natural aquatic production or supplementary feed. They tolerate wide ranges of environmental conditions, show little susceptibility to disease and are amenable to handling and captivity. Most important of all, they enjoy wide acceptance as food fish because of their high palatability and history of use. With all these advantages, tilapia are likely to become the prime domesticated species for tropical fish culture.

Mullets are second in importance in ICLARM's Aquaculture Program. Rapidly increasing interest in mullet is apparent in Asian countries such as Thailand, Philippines, Burma, India and Taiwan; in certain Latin American

countries such as Brazil, Colombia and Mexico; and in Middle East and African countries such as Israel, Egypt, Greece, Cyprus, Saudi Arabia and Nigeria. This situation reflects recognition of the potential importance of mullet, and of the role of salt- and brackishwater aquaculture in future production.



ICLARM's saltwater culture of tilapia project (details p. 42).

Non-biological issues are becoming increasingly important in aquaculture, and there is consequently a growing awareness among biologists and social scientists that cooperation among the various disciplines is necessary at all stages of the development process. Our recent economic studies of aquacultural systems, for example, indicate that there are wide variations in productivity and profitability among farmers of a given species.

The socioeconomic issues that need attention include:

- Equity and distribution of benefits from growth of aquaculture.
- Technology transfer and constraints to increased productivity and profitability, particularly on small farms.
- Impact of international development aid for aquaculture on investment trends, equity of benefits, and international trade in aquaculture products.
- Externalities and competition with other (rural) sectors for inputs and markets.

Progress of Work, 1981

Biological aspects of the aquaculture program focused on two major themes with research priorities reflecting key problem areas of the aquaculture program—integrated farming and (tilapia) seed production.

Integrated farming

The integrated farming research project conducted at Central Luzon State University (CLSU) will be finalized in 1982 and in large part will be taken over by the Freshwater Aquaculture Center of that institution. While research on integrated systems will be pursued by ICLARM in other locations, the shifting of major responsibility for field trials to CLSU represents a positive step in terms of the institution's interest and capability to continue this research.

The important contributions of this project are:

- Documentation of production rates and cost-benefit relationships for pig-fish and chicken-fish systems.
- Establishment of optimum manure loading levels and stocking levels for the tilapia-carp and tilapia-carp-snakehead species combinations.
- Demonstration of economically viable procedures with outstanding yields.

On-going analysis of data relating detailed chemical and biological parameters of the systems is expected to increase understanding of means for improving the efficiency of the system.

Preliminary work on induced spawning and larval rearing of the snakehead, a useful predator in the integrated systems with tilapia, has been successful. Techniques developed for spawning snakehead on demand in captivity will increase opportunities for their production.

Tilapia

As ICLARM's research approach in aquaculture has moved from a disciplinary to an interdisciplinary, commodity orientation, a network strategy for coordinated research on critical problem areas for each species will become more important. Such a network is already in place for research on tilapia. It includes institutions in the Philippines, Taiwan and Kuwait and is likely to expand during the coming year.

A project on genetic improvement of tilapia broodstock, funded by the Rockefeller Foundation, was completed in 1981. The spawning performance, growth, survival and some biochemical characteristics of several species and hybrids were documented in this study. Selected aspects of this research will continue to be a part of the tilapia research network.

A new project on mass production of tilapia fry, initiated during 1981, is designed to address the critical shortage of fry being experienced by growers in several countries as they attempt to expand production. Techniques being tested include early removal of fry from brooding females, improved systems for fry rearing, more rapid "recycling" of females, inducement of early breeding, and use of females only at their most productive ages.

Comparative studies of growth of two promising tilapias grown commercially in Taiwan, "red tilapia" and *Sarotherodon aureus*, in freshwater,

brackishwater and seawater were also initiated in 1981 with the Council for Agricultural Planning and Development in Taiwan. This is the beginning of a major effort to identify species, strains and/or hybrids that grow rapidly and can be cultured economically in saltwater.

Mullet

Interest in mullet in tropical countries is growing as its potential as a culture fish and a migratory fish with potential for aquatic ranching becomes more widely recognized. ICLARM collaborative research on mullet extends to Egypt where preliminary work on the reproduction and larval culture of *Mugil cephalus* and *M. capito* is being done through the Cooperative Marine Technology Program for the Middle East sponsored by the U.S. Agency for International Development. In the Philippines, ICLARM has been advising the Bureau of Fisheries and Aquatic Resources (BFAR) and the Cagayan Integrated Agriculture Development Project in their studies of a mullet occurring in northern Luzon with interesting potential for culture and aquatic ranching. Efforts are also underway to assist the Department of Fisheries, Thailand, to establish a broodstock of *M. cephalus*.

Biology-related work on milkfish during the year was limited to advisory services provided to the Government of Indonesia in relation to their plans to strengthen programs and facilities for research on controlled breeding of this species.

The *Economics* section of the aquaculture program has focused on the microeconomics of existing aquaculture production systems and of experimental systems. Three such projects that were initiated in 1979 and 1980 were completed in 1981. These included studies on the production economics of catfish (*Clarias batrachus*) in Thailand and milkfish (*Chanos chanos*) in the Philippines, and of seed procurement, production and marketing of milkfish in Taiwan. Preliminary results of these projects were presented by the respective investigators at an aquaculture economics workshop co-sponsored by the International Development Research Centre (IDRC) and ICLARM in Singapore, 2-5 June 1981. The workshop was useful in identifying appropriate tools for economic analysis of aquaculture systems and in encouraging cooperative research between biologists and economists.

The Philippine milkfish study, conducted jointly with the Bureau of Agricultural Economics (BAEcon) and the Fishery Industry Development Council led to grants to ICLARM from the United Nations University (UNU) and UNDP/FAO. ICLARM has prepared a commissioned monograph, to be published by UNU, on the economics of the entire milkfish resource system from fry gathering to marketing.

UNDP/FAO has provided an 18-month grant to ICLARM to examine the socioeconomic and institutional constraints to adoption of more intensive farming techniques by Philippine milkfish producers, and to prepare training materials on aquaculture economics and farm business management for the

extension officers of the BFAR. This project was initiated in July 1981 in cooperation with BAEcon and BFAR.

Program of Work, 1982

Biological research planned for 1982 continues to address the four major aquacultural commodities of importance to tropical developing countries, the tilapias, mullets, milkfish and carps, and to maintain focus on integrated agriculture-aquaculture systems. ICLARM is placing major emphasis in 1982 on tilapia. Research emphasis will be expanded to include other members of the "group of four" as funding permits.

Reviews of both genetic research and nutritional research of tilapias will be conducted to focus attention on research needs. In addition to the Philippine research on technology for mass production of tilapia fry, the evaluation of strains for salinity tolerance in Taiwan is being expanded and a new production-oriented phase of the work in saline waters begins in Kuwait in January 1982. The project involving selection at CLSU will be structured on the basis of the previous broodstock development project, as well as of a special commissioned study designed to identify most fruitful research approaches from a geneticist's viewpoint. These interactions, combined with the institutional contacts developed during the integrated farming project, tilapia conference and on-going tilapia studies, will link ICLARM effectively to a number of other institutions with active research programs on tilapia. Additional research on incubation systems and egg transportation in cooperation with the University of the Philippines has been proposed.

Mullet will take a secondary place to tilapia in ICLARM's near-future research. Project personnel will maintain active involvement in the mullet reproduction and hatchery development activities in Egypt. In Southeast Asia, ICLARM will continue to encourage mullet research with orientation toward either pond culture or management and possible stock enhancement of natural stocks for ocean ranching.

For the economically important species of carps, a new research activity has been proposed that will strengthen research on carp hatchery technology to improve production and help alleviate seed supply problems in Southeast Asia.

Emphasis on integrated farming research is moving towards determining the role and potential of detrital systems and organic waste recycling in aquaculture. A Conference on Detrital Systems in Aquaculture is planned to explore uses of agricultural and food processing wastes as sources of organic detritus in aquacultural systems. A series of major reviews on these subjects will be prepared in 1982 to provide core material for the Conference.

A new cooperative project with the Government of Thailand and the German Government began in Thailand in December 1981. Initial research

on shellfish marketing and market potential will be followed by strengthened research efforts at Thai research stations and the transfer of advanced shellfish culture technology to the producers. Applications of this research to other tropical countries wishing to expand their shellfish production will be important and the project is viewed as a model which may be replicated elsewhere with appropriate modifications.

Economic research will continue to be an integral part of the Aquaculture Program with many activities interacting with biological research. Further economic analysis of integrated farming systems will continue with CLSU to include chicken-fish combinations and systems under various land, labor and capital constraints. Researchers at National Chung Hsing University, having completed the Taiwan milkfish study, are beginning a country case study of aquaculture trends and development prospects. A similar study of aquaculture trends has been initiated in Israel.

Finally, in line with ICLARM's focus on tilapia, a study on the economics of various tilapia production techniques and of the marketing structure and potential will be initiated in the Philippines and Taiwan during 1982.

In the long term, the key to addressing the socioeconomic problems of aquaculture development is to insure continuity of involvement of a small number of aquacultural economists in developing country institutions. Discussions have been initiated with IDRC to develop support for a network of fisheries social science research that would include socioeconomic issues in aquaculture.

- Project Title* : Applied Research on Integrated Animal-Fish Farming
- Cooperating Institution* : The Freshwater Aquaculture Center (FAC) of the Central Luzon State University (CLSU), Muñoz, Nueva Ecija, Philippines
- Duration* : Three years, January 1978-December 1981
- Key Personnel* ICLARM : Drs. Kevin Hopkins and R.S.V. Pullin
CLSU : Dr. Emmanuel M. Cruz

Rationale and Objectives

Interest in the use of animal manures in aquaculture has increased in recent years. Although integrated animal-fish farming has a long history in Southeast Asia, production methods are not well documented, and formal experimentation is just beginning. The objectives of this project were: (1) to design a fish polyculture system to maximize fish yields using only animal wastes as inputs (no inorganic fertilizers or supplemental feed); (2) to determine the optimum pig and poultry stocking rates per unit area of freshwater fish pond; (3) to clarify the economics of the methods developed (see also Economics of Integrated Farming project, p. 35); and (4) to design and package a technology for the use of integrated farming appropriate to rural development in the Philippines.

Results

(i) Pig-fish systems

There are two fish production cycles in each pig-growing cycle because tilapia reach market size for Central Luzon (> 60 g) in 90 days, whereas pigs take 180 days to reach market size from 10-15 kg weanlings. In pig-fish experiments, two fish stocking levels, 10,000 and 20,000 fish/ha, were used. Tilapia (*Sarotherodon niloticus*) was the primary species comprising 85% of the fish stocked; common carp (*Cyprinus carpio*) made up another 14%; and snakehead (*Channa striata*), a predator, comprised the remainder. In addition to being useful food fish, the snakehead controlled tilapia recruitment while the carp benefitted the system by disturbing the bottom. Pig numbers of 40, 60, 80, 100, 120 and 140 pigs/ha of pond were tested. The response of

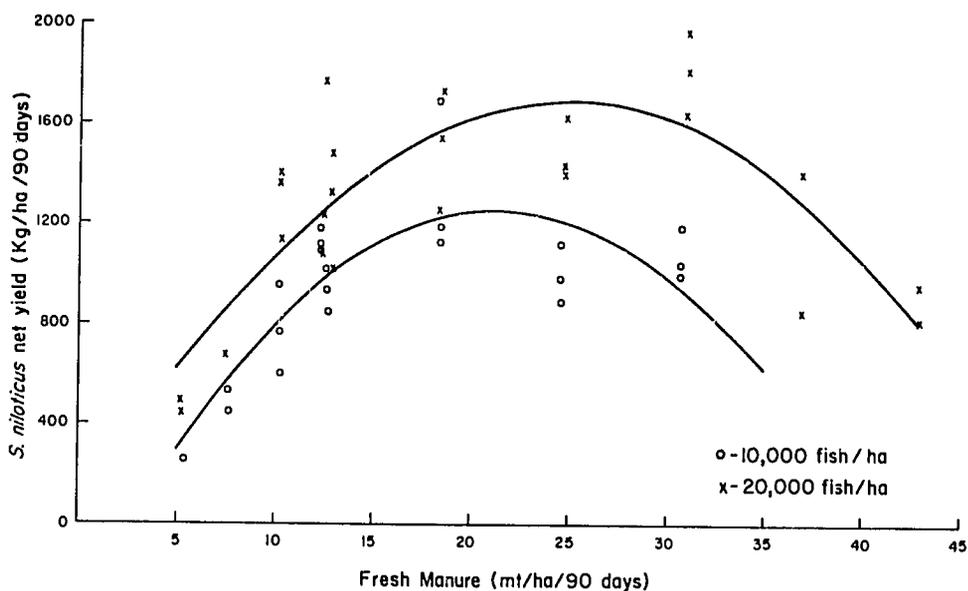


Fig. 1. Net yield of *S. niloticus* in 90 days in ponds receiving untreated pig manure.

S. niloticus to manure input is illustrated in Fig. 1. The highest tilapia yield of approximately 1,700 kg/ha/90 days was attained with 20,000 fish/ha and 25 t of fresh manure/ha (equivalent to 83 pigs for the second 90-day period).

Also, a 180-day experiment was conducted using 100 pigs/ha. At a stocking level of 20,000 fish/ha, the yields of marketable fish averaged 3,450 kg/ha/180 days, which was not significantly different from the yield attained with two 90-day periods. However, over 2,000 kg/ha of small tilapia recruits were also harvested during the 180-day cycle because the numbers of predators, which were sufficient during the 90-day cycles, were inadequate during the latter part of the 180-day cycle.

(ii) Poultry-fish systems

In chicken-fish experiments, broiler chickens were raised in cages to give manure loading from populations of 1,000, 3,000 and 5,000 chickens/ha of pond water. Mixed-size flocks were used with the largest 1/3 of the flock harvested and replaced by chicks every 2-3 weeks. Fish were raised for one 90-day period at 20,000 fish/ha. The combined net yields of tilapia, carp and snakehead from initial trials were 1,758 kg/ha/90 days with 1,000 chickens/ha, 1,814 kg/ha with 3,000 chickens/ha and 1,845 kg/ha with 5,000 chickens/ha. More recent chicken-fish data are still being analyzed.

In duck-fish experiments, two manure loading levels, 750 and 1,250 ducks/ha, were used, combining 180-day Pekin duck production cycles with two 90-day fish production cycles. Again, the best yields were obtained using 20,000 fish/ha, for example 1,690 kg/ha from a 750 duck/ha manure loading during the second 90-day period of duck culture. Duck-fish experiments

were discontinued in mid-project because of duckling supply problems and the limited local market for Pekin ducks.

This project included economic analyses of animal-fish systems. The following general conclusions were made for pig-fish systems:

- With large numbers of pigs and/or limited pond area, 100 pigs/ha will maximize total revenue and profit.
- When the number of pigs is limited, 53 pigs/ha will maximize profit for gravity-fed water systems and 67 pigs/ha will maximize profit for pumped water systems.
- The internal rate of return is maximized by using 100 pigs/ha for systems with limited pond area, or by using $80 \pm$ pigs/ha for systems with limited numbers of pigs.

Analysis of chicken-fish system economics will continue through 1982 and the FAC will continue integrated farming pond aquaculture research. Emphasis will be placed on increasing fish yields, possibly through aeration and on fine-tuning the pig-fish and chicken-fish systems to meet the needs of Filipino producers and consumers.

Preliminary results of the poultry-fish and pig-fish experiments have been published as ICLARM Technical Reports 2, 1981. A final report is in preparation.



Pig effluent was flushed directly into the fish ponds.



Poultry manure also enhanced fish yields.

- Project Title* : Milkfish Production Economics, Philippines
- Cooperating Institutions* : Bureau of Agricultural Economics (BAEcon);
Fishery Industry Development Council (FIDC)
- Duration* : Eighteen months, June 1979-September 1981
- Key Personnel* ICLARM : Dr. Kee-Chai Chong
BAEcon : Ms. Maura Lizarondo
FIDC : Ms. Virginia Holazo

Rationale and Objectives

Although the Philippine national average production of milkfish is 600 kg/ha/year, there are large differences in yields both between and within provinces. These yields range from 200 to over 1,000 kg/ha/year, suggesting that some ponds are poorly utilized and that a substantial increase in milkfish production could be achieved.

The economically efficient combinations of inputs can be determined through an examination of the functional input-output relationships and comparison with the existing or projected price structure for inputs and outputs. This type of analysis had not previously been carried out in the Philippines.

The objectives of the study were to estimate the input-output relationships of milkfish farming in the Philippines, to determine whether producers are economically efficient in their choice of input levels and to evaluate the possible economies of scale through production cost analysis.

The project had two phases. First, data were collected from producers in seven provinces using standard recall-survey techniques. Second, to reduce memory bias, a farm record-keeping system was initiated with a smaller number of producers in the same provinces. The first phase was the source of data for the input-output production function analysis which has been completed, and the second phase was the source of data for the cost analysis, which is continuing.

Results

The survey interviews of 324 producers and the record-keeping are now complete. Analysis of the data collected by the survey shows that there is wide variation in the rate of application of inputs, and wide variation in out-

put as a consequence. For example, producers in Bulacan Province applied an average of 2,483 kg/ha/year of organic fertilizers (primarily chicken manure) and produced an average of 1,033 kg/ha/year of milkfish, compared to only 456 kg/ha/year of organic fertilizers applied in Masbate, producing 104 kg/ha/year. Out of 11 explanatory variables specified in nationwide production functions of the Cobb-Douglas form, seven variables (age of pond, organic and inorganic fertilizers, fry and fingerling stocking rate, miscellaneous operating costs and farm size) explain 40% of the variation in output. Given current input and output prices, profits of producers could be increased if they increase their fry stocking rate and their application of organic and inorganic fertilizers.

Final results of the project will be published jointly by the three cooperating institutions in 1982 in ICLARM's Technical Reports Series. A follow-up study on constraints to technology transfer in the milkfish sector is now being implemented under the Brackishwater Aquaculture Development and Training Project of UNDP and the Bureau of Fisheries and Aquatic Resources, Ministry of Natural Resources, Philippines, with the cooperation of BAEcon (see p. 45).



Chicken manure, bagged in the shed above, and other manures, even guano from bats, are used to fertilize milkfish ponds. However, this study found the application rates generally too low to be effective.

- Project Title* : Genetic Improvement of Tilapia Broodstock in the Philippines
- Cooperating Institution* : The Freshwater Aquaculture Center (FAC) of the Central Luzon State University (CLSU), Muñoz, Nueva Ecija, Philippines
- Duration* : Two years 1 June 1979-31 August 1981
- Key Personnel* ICLARM : Dr. Ching-Ming Kuo
 CLSU : Tereso Abella

Rationale and Objectives

The questions of seed quality and genetic improvement of tilapia have received little attention and require additional, basic research. Little is known about the genetics of the existing Philippine stocks, but it is safe to assume that interbreeding between species has taken place in natural waters.

In tilapia culture, preference is often given to the culture of males because of their superior growth rate. All-male tilapia stocks are obtained through sex reversal, hybridization, or manual sorting. Success in production of all-male progeny by hybridization has been inconsistent, however, because of genetic differences among the broodstocks. The key to a successful breeding program is the production of improved broodstock; the avoidance of genetic "contamination" from outside sources is crucial.

The objective of this project is to evaluate existing stocks of tilapias in the Philippines and to capitalize on any species/hybrid with superior survival, growth, or reproduction performance. The study will lead to continued improvement of tilapias suitable for culture in specified environments.

Results

The work was focused on (1) the description of the existing broodstock of tilapia strains/hybrids electrophoretically and morphologically, (2) determination of the compatibility of inter- and intraspecific breeding, and (3) the survival and growth performance of the fry and fingerlings of selected tilapia strains and hybrids. Strains examined were three varieties of *Sarotherodon aureus* and four strains of *S. niloticus* (details in Table 1).

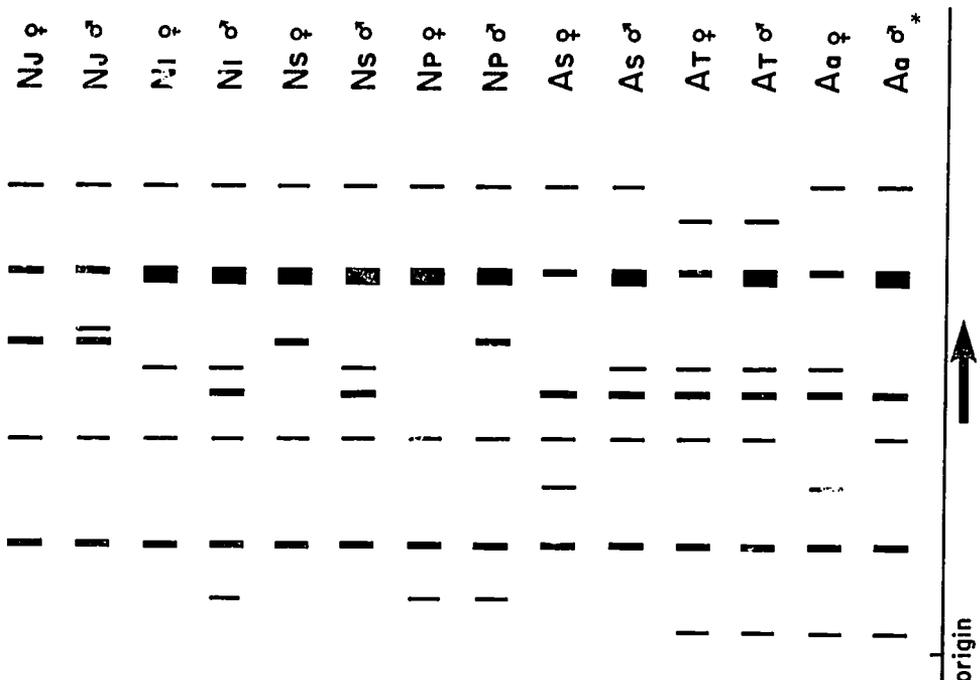
Seven meristic characteristics were examined. Few distinct differences were observed between sexes of the same species, or between the species and

strains examined. However, some differences in numbers of dorsal spines and numbers of scales along the lateral line were noted. In preliminary analysis of 15 morphometric characteristics, all *S. aureus* strains show pronounced sexual dimorphism while only the Singapore strain of *S. niloticus* showed sexual dimorphism.

An electrophoretic study on the serum, muscle and eyelens proteins of the tilapia species, strains and hybrids was completed. Examples of serum protein profiles for species/strains of both sexes are shown in Fig. 1. No sexual differences in the protein bands were observed. Due to logistic difficulties, the progress of the isoenzyme study was hampered, but will be completed in 1982.

Cross-breeding experiments were conducted in both the dry and the wet seasons in the Philippines. The compatibility of the intra- and interspecific crosses was determined by the success of breeding. The success of cross-breeding was generally higher during the dry season than during the wet season although some crosses performed better in the wet season. Both sexes of *S. aureus* from Auburn show the highest compatibility of inter- and intraspecific hybridization.

The progenies of intra- and interspecific crosses of tilapia were evaluated for growth and survival in plastic pools for 60 days, followed by another 90-day period in suspended net enclosures. The progenies from some *S. niloticus* strains ($N_p \times N_p$ and $N_s \times N_p$) exhibited most rapid growth during the first two-month period. The best growth was observed for $N_p \times N_p$ for



Electropherogram of serum proteins of tilapia species and strains. *Species notation as in Table 1 (over).

the 5-month period, reaching 39.10 g in weight. The potential of *S. niloticus* (Philippines strain) is further enhanced by their adaptation to the local environment and by aggressive feeding behavior.

The survival of progeny groups in the present tests ranged between 80.1% and 94.0% in the two-month growing period following fry release. Survival of most progeny groups during the subsequent 3-month growing period in suspended net enclosures ranged between 84.7% and 100%.

Success of tilapia culture will undoubtedly depend upon a reliable supply of quality seed which is fast-growing and tolerant to adverse environmental conditions.

Table 1. Summary of reproductive performance of tilapia species and strains.

Cross† (♀ × ♂)	No. fry/spawning	No. fry/spawning/100 g female body wt.	No. fry/100 g Mean ± S.E(N)*
N _p × N _p	423-1,694	236-1,116	590 ± 128 (6)
N _j × N _j	222- 780	422-1,080	680 ± 60 (12)
N _j × N _p	541- 855	718- 956	814 ± 60 (4)
N _p × N _j	505-1,167	615-1,230	923 ± 115 (5)
N _s × N _s	338-2,027	310-1,048	734 ± 169 (4)
N _p × N _s	202-1,591	102- 612	378 ± 81 (5)
A _a × A _a	223-1,006	151-1,237	550 ± 160 (6)
N _p × A _a	546-1,121	512- 970	697 ± 69 (8)
N _j × A _a	227-1,805	119-1,431	535 ± 169 (8)
A _a × N _p	288-1,346	133- 673	392 ± 148 (4)
A _a × N _j	495-1,694	282- 913	592 ± 74 (9)
A _t × A _t	446- 749	780-1,511	1,129 ± 213 (3)
A _s × A _s	320- 703	275- 767	474 ± 107 (4)
N _j × A _s	423- 552	779- 950	865 ± 86 (2)
N _j × A _t	346	580	580 ± 0 (1)
N _j × N _j	124	161	161 ± 0 (1)
A _t × N _j	322	605	605 ± 0 (1)
A _a × N _j	315	379	379 ± 0 (1)
A _s × A _a	404	387	387 ± 0 (1)
A _a × A _s	1,015	649	649 ± 0 (1)
A _s × A _t	904	673	673 ± 0 (1)

*N—no. of replicates

†N_p = Philippines strain, *S. niloticus*

N_j = Israel strain, *S. niloticus*

N_s = Singapore strain, *S. niloticus*

N_j = Japan strain, *S. niloticus*

A_a = Auburn University strain, *S. aureus*

A_t = Taiwan strain, *S. aureus*

A_s = Singapore strain, *S. aureus*

- Project Title* : Catfish Production Economics, Thailand
- Cooperating Institution* : Kasetsart University Research and Development Institute (KURDI), Bangkok
- Duration* : Eighteen months, August 1979-December 1980
- Key Personnel* KURDI : Drs. Sarun Wattanutchariya, Ruangrai Tokrisna, Theodore Panayotcu and Mr. Somporn Isvilanonda
- ICLARM : Dr. Ian R. Smith

Rationale and Objectives

In recent years, the growing demand for fishery products, coupled with declining yields from capture fisheries, has stimulated inland fish culture. In Thailand the most commonly cultured fish species are tilapia, carps, snake-head and catfish. Among these, the culture of catfish (*Clarias batrachus*) has been quite popular because of its short culture cycle and high rate of return.

However, during 1974-76 there was a dramatic fall in the number of farms and pond area due to the incidence of disease affecting catfish and the rising price of inputs, especially trash fish which is commonly used as feed. Rising production costs, as well as high mortality rates, have resulted in losses to catfish farmers. This decline affected not only the producers but had also a pronounced effect on the consumer as, by 1977, catfish prices began to rise sharply.

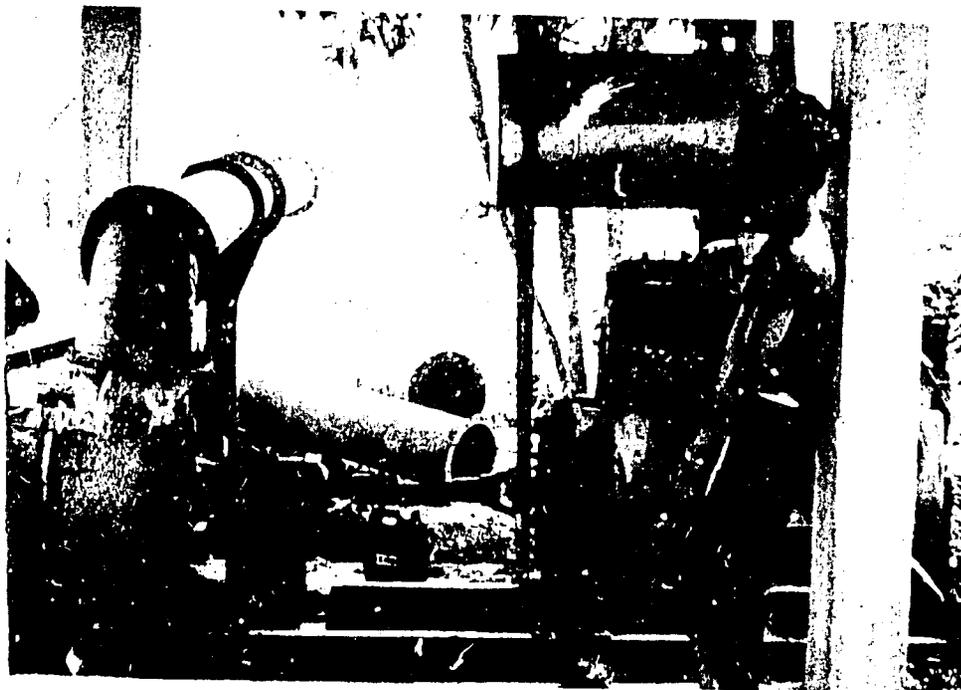
Theoretically, the increase in price caused by the excess demand should have induced a rise in production and a corresponding increase in supply. However, the recovery of the catfish farming industry has not been proceeding at the rate one would have expected, given the high and rising fish prices. Under these circumstances, an economic study of catfish was undertaken by the Department of Agricultural Economics of Kasetsart University, with the support of ICLARM, to investigate the economics of catfish production in the two main catfish culturing areas of Suphan-Buri and Nakhon Nayok.

Results

A field survey was completed in 1980 and analysis is now complete. Findings from the study indicate that the number of catfish farms has been further reduced to below the figures quoted by the Department of Fisheries in



Above: *Clarias batrachus*, one of the commonly cultured Thai catfish. Below: a large pump to facilitate water-exchange.



its latest report. Many catfish farmers switched to the culture of other species or to the cultivation of rice and other crops; some even left the area to take other occupations. The main reasons given in the interviews were high fish mortality due to disease and escalating feed (trash fish) prices. Yet, some of the farms that stayed in business made considerable profit, due to superior managerial ability of the owners, access to low-cost credit, and diversification of farming to spread risk.

A Cobb-Douglas production function was employed to explain variation in output observed from farm to farm. Eighty percent of the variation in output could be explained by the following explanatory variables (inputs): stocking rate, trash fish and broken rice feeding rates, fuel for pumping, medical treatment of fish, size of farm, and experience of the operator. Profits could be increased, however, by reducing the average catfish stocking rates and quantity of trash fish used as feed, and by increasing the use of broken rice, as well as fuel for the purpose of changing pond water.

Project findings will be jointly published by KURDI and ICLARM.

Project Title : Production and Marketing of Milkfish, Taiwan

Cooperating Institution : Research Institute of Agricultural Economics,
National Chung Hsing University, Taichung,
Taiwan

Duration : Twelve months, June 1980-May 1981

Key Personnel Taiwan : Dr. Chaur Shyan Lee
ICLARM : Drs. Ian R. Smith and Kee-Chai Chong

Rationale and Objectives

The fishery sector, including aquaculture, has played a significant role in the agricultural development of Taiwan. The relative importance of the fishery sector can be seen in the fact that its share of total agricultural production increased from 10% in 1950 to 20% in 1978, while the share of crop production declined from 64% to 46% in the same period.

Due to the scarcity of land in Taiwan, farmers have found it necessary to grow crops or raise animals the year round wherever possible, or to change the cultivated land from crops to fish culture in order to maximize profits. The use of land for fish culture has increased significantly during the past



Drs. Lee (left) and Chong (right) interviewing fish farmers, Hsia Chia, Taiwan.

decade—from 40,974 ha in 1969 to 58,245 ha in 1978. Milkfish is the most important fish cultured in Taiwan fishponds, the milkfish production area in 1978 being 15,586 ha, about 27% of the total area.

Basic biological research on milkfish in Taiwan has been extensive, but the few economic studies of production are out-of-date. Moreover, there has been no economic analysis of the fry input sector nor of the marketing of milkfish in Taiwan. The Taiwanese milkfish industry faces chronic shortage of fry, relying for almost half its annual requirements upon fry imported from the Philippines and Indonesia. Increasing demand for milkfish fingerlings as bait fish for tuna long-liners is aggravating supply problems.

Economic problems of a different nature are also surfacing. Milkfish producers in many locations are finding that shrimp and crab rearing are more profitable than milkfish. Because of the importance of milkfish as a protein source in Taiwan, the government is anxious to maintain production. A systematic economic analysis of production and marketing of milkfish is needed to assist government planners in their programs to sustain milkfish production as well as the incomes of producers and other support groups within the sector.

The focus of this study was to analyze empirically the production and marketing aspects of the milkfish industry. The study covered the following major activities:

- Gathering, marketing and distribution of milkfish fry.
- Production of milkfish fingerlings for the baitfish industry.
- Production of market-size milkfish.
- Marketing of market-size milkfish.

Results

Data were gathered through a field survey of approximately 200 fry gatherers and dealers, milkfish producers and market intermediaries, supplemented by secondary data on production, price and consumption patterns available in various monthly and annual official publications. A Constant Elasticity of Substitution (CES) production function was used to estimate input-output relationships for baitfish and market-size production systems, with all inputs classified into labor and capital. An important finding is that the elasticity of substitution between labor and capital indicates rather easy substitutability between the two inputs. Producing fingerlings for the baitfish market was found to be more profitable than producing market-size milkfish, a finding which was supported by evidence of producers' shifting to baitfish production. Rates of return to marketing intermediaries were found to be high for both fry and market-size milkfish. The completed study will provide a useful comparison with the Philippine milkfish industry, where similar studies were conducted between 1978 and 1980. The project culminates with two publications: a Chinese-language report published by the Research Institute of Agricultural Economics in 1981, and an English version to be published by ICLARM in 1982.

Project Title : Conference on the Biology and Culture of Tilapias

Cooperating Institution : The Rockefeller Foundation

Duration : 2-5 September 1980

Key Personnel ICLARM : Dr. Roger S.V. Pullin

Rationale and Objectives

Tilapias have been studied extensively in the field, in culture systems and in the laboratory. Recognizing their growing importance in international aquaculture, the conference was called to bring together tilapia culturists and biologists to exchange views, to collate existing information and to define approaches and priorities for future work.

Results

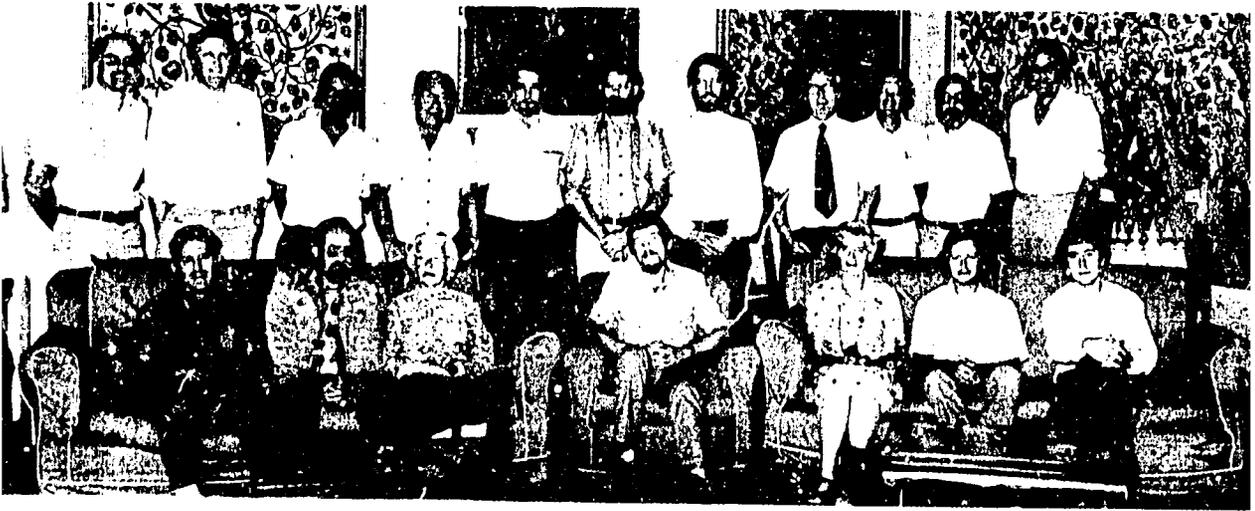
The Conference was held in cooperation with the Rockefeller Foundation at the Study and Conference Center of the Rockefeller Foundation, Bellagio, Italy. It was built around the presentation of 15 major review papers presented by tilapia experts from around the world grouped under the major headings of biology, physiology and culture. Detailed discussions of the material presented and of related research were the main purposes of the meeting.

An important point emerging from the discussions was that fundamental research, such as has been done in systematics, behavior, ecology and physiology, has made great contributions to the development of tilapia culture. From the recommendations and conclusions of the conference, the following important topics are worthy of mention:

- 1) There is a need for standardization of nomenclature for species and strains; all researchers must identify the source and history of their experimental material.
- 2) Conservation of genetic material both in culture collections and natural waters is very important.
- 3) Further work on the environmental, behavioral and physiological factors governing first maturity and subsequent reproductive performance of tilapias is needed to explain the wide variability of observations on captive broodstock.

- 4) The feeding of tilapias, particularly detritivory, merits much greater study; the methodology for determining microbial proteins and detrital composition needs further improvement.
- 5) Pond, cage and intensive culture systems are still evolving and there is ample scope for improvement, including new polyculture systems and the screening of new species and hybrids for culture potential.
- 6) Tilapias are relatively disease-resistant, but diseases will undoubtedly assume more importance in the culture industry and will spread internationally unless proper control measures are taken.

A summary report of the conference was published in 1981 and the full proceedings in early 1982.



Conference participants in the drawing room of the Villa Serbelloni, Bellagio Study and Conference Center. Left to Right, Standing: Prof. R.J. Roberts (Stirling University), Dr. C.E. Nash (Kramer, Chin and Mayo, Inc.), Drs. J. Chervinski and B. Hepher (Dor, Israel), Dr. M. Caulton (Zimbabwe), Dr. D. Moriarty (CSIRO), Dr. D.L.G. Noakes (University of Guelph), Drs. H.F. Henderson and A. Coche (FAO), Dr. B. Jalabert (INRA), Dr. L.L. Lovshin (Auburn University), Dr. R.D. Guerrero, III (Central Luzon State University); Left to Right, Seated: Mr. D. Mires (Ministry of Agriculture, Israel), Dr. R.R. Avtalion (Bar-Ilan University), Dr. E. Trewavas (British Museum), Dr. R.S.V. Pullin (ICLARM), Dr. R.H. Lowe-McConnell (British Museum), Dr. S.H. Bowen (Michigan Technological University), and Dr. J.-Cl. Philippart (University of Liège).

- Project Title* : Economics of the Milkfish Resource System, Philippines
- Cooperating Institution* : United Nations University (UNU), Japan
- Duration* : Twelve months, September 1980-August 1981
- Key Personnel* ICLARM : Drs. Kee-Chai Chong and Ian R. Smith
BAEcon : Ms. Maura Lizarondo

Rationale and Objectives

The United Nations University commissioned ICLARM to conduct a review of the economics of the milkfish resource system of the Philippines.

The authors assembled a unified body of information on milkfish aquaculture in the Philippines to pinpoint where further efficiency of resource use in the milkfish system can be obtained. Each of the subsystems of fry supply, rearing and marketing was examined in turn.

The major deficiencies in the Philippine milkfish resource system were found to occur in the rearing subsystems rather than in the fry supply or marketing subsystems. Reduction in mortality rates during rearing and increased application of supplementary inputs, such as fertilizers, are the two major means by which the existing system can substantially increase the supply of milkfish available to consumers in the Philippines.

The manuscript was approved by the UNU Publication Committee for publication in their Resource Systems Theory and Methodology series.

- Project Title* : Economics of Aquaculture Research Workshop
- Cooperating Institution* : International Development Research Centre (IDRC), Singapore
- Duration* : 2-5 June 1981
- Key Personnel* ICLARM : Drs. Ian R. Smith and Kee-Chai Chong
IDRC : Dr. Brian Davy

Rationale and Objectives

Little information on the economic aspects of aquaculture in the tropics is available. Existing economic studies are often based on very limited samples and tend to be descriptive rather than rigorously analytic. While the biological and technological aspects of aquaculture are important and underpin the success of the aquaculture enterprise, it is necessary to understand the economics of aquaculture if the sector is to remain viable as a business proposition, and to enhance its contribution to the production of protein food.

The limited information on tropical aquacultural economics is indicative of a serious shortage of practitioners in the field. The number of active aquacultural economists in South and Southeast Asia amounts to perhaps no more than a dozen, and few of these are devoted to the subject matter full-time. On the positive side, most have backgrounds in agricultural or resource economics which, because aquaculture is not a capture but rather a husbandry activity, makes their analytical tools applicable in an aquaculture setting. Both IDRC and ICLARM believe that there is a pressing need to bring about a more coordinated approach to aquacultural economics research.

The initial step in this process was a regional workshop held in Singapore, jointly sponsored by IDRC and ICLARM. The major objective of the workshop was to illustrate alternative tools of economic analysis through theoretical papers and selected case studies covering:

- Economic analysis of pilot-scale (experimental) projects.
- Economic analysis of existing aquaculture systems.
- Social welfare economics; social costs and benefits.

Several papers were presented by ICLARM personnel and staff of the relevant projects (see p. 94). Case studies presented by participants included the economics of milkfish farming in the Philippines and Taiwan, catfish farming in Thailand, integrated pig-fish farming in the Philippines, mussel raft culture in Singapore, tilapia cage culture in Sri Lanka and carp poly-culture in India. The proceedings of the workshop will be jointly published by IDRC and ICLARM in 1982.

- Project Title* : Economics of Integrated Farming
- Cooperating Institution* : Central Luzon State University (CLSU), Philippines
- Duration* : Eighteen months, January 1980-June 1982
- Key Personnel* CLSU : Mr. Ruben Sevilleja
 ICLARM : Drs. Ian R. Smith and Kee-Chai Chong

Rationale and Objectives

Several experiments on integrated animal-fish farming systems have been conducted at the Freshwater Aquaculture Center (FAC), Central Luzon State University, Philippines. The cooperative project was initiated with the principal objective of developing technically and economically viable animal-fish systems.

Initial research results have demonstrated the benefits derived from utilizing animal wastes in fish production (see Applied Research on Integrated Animal-Fish Farming project, p. 18). Fish yields are increased and production costs reduced when animal manure is used to fertilize the ponds.

Specific objectives of the economic component of this project are:

- To determine the profitability of integrating fish production with chicken, duck and pig raising.
- To develop enterprise budgets for these systems.
- To compare the management and production efficiency between experimental and actual farm operations.

Partial budgeting is being applied to meet these objectives. Basic data on the expected fish output response to pig and poultry manure loadings are obtained from the CLSU/ICLARM experimental project.

Results

Economic analysis of the pig-fish operation has been completed. The feasibility of integrated fish production with existing pig operations was determined. Three case studies were examined: (1) commercial pig growing operations represented by the CLSU/ICLARM integrated pig-fish experimental project which purchased weanlings; (2) a backyard piggery (< 8 head); and (3) a small commercial pig breeding and growing operation. The net incomes of backyard and small commercial breeding and growing oper-

ations increased by about 317% and 228%, respectively, with fish production as an integrated component of their operations. The commercial growing operation was not profitable.

Economic analysis of the poultry-fish combinations was initiated in November 1981. Final results will be available by mid-1982. It is planned to extend the economic analysis of integrated animal-fish systems to include the optimal combination of activities for farms of given sizes and capital constraints, and the socioeconomic issues of technology transfer to existing and new farm systems.



Sampling the tilapia catch at the CLSU experimental project. Economic factors determine the viability of growing them with duck or pig manure.

- Project Title* : Mass Production of Tilapia Fry
- Cooperating Institution* : The Freshwater Aquaculture Center of Central Luzon State University, Philippines
- Duration* : 2.5 years, beginning July 1980
- Key Personnel* ICLARM : Dr. Ching-Ming Kuo
CLSU : Renato Recometa

Rationale and Objectives

Despite their reputation for uncontrolled breeding at early ages in ponds, tilapia are fish with low fecundity, and the production of large numbers of fry requires spawning of many adults. As tilapia production has expanded and become more intensive, the failure of hatcheries to produce adequate numbers of fry at optimum times has become a major constraint to production. Improved methods for mass production of fry are needed to address this problem.

This project is designed to help meet this need. Both raceway and pond systems are being tested. Experimentation will center on the following: (1) definition of optimum stocking densities of adults, (2) definition of optimum sex-ratios of mating broodstock, (3) definition of optimum size and age ranges of spawners, and (4) increasing the frequency of spawning through feeding, environmental control, egg removal or special treatment of broodstock.

Activities likely to be undertaken as a follow-up to present research include selection for improved reproduction and growth performances, induced synchronization of spawning, and development of refined methods for fry rearing in hatcheries.

All the tilapia species/hybrids with culture potential as determined by market demand and biological characteristics will be thoroughly examined. The research began with *Sarotherodon niloticus*. Other tilapia species and hybrids which show culture potential under various environmental conditions (e.g., red tilapia and *S. aureus*) will be investigated subsequently.

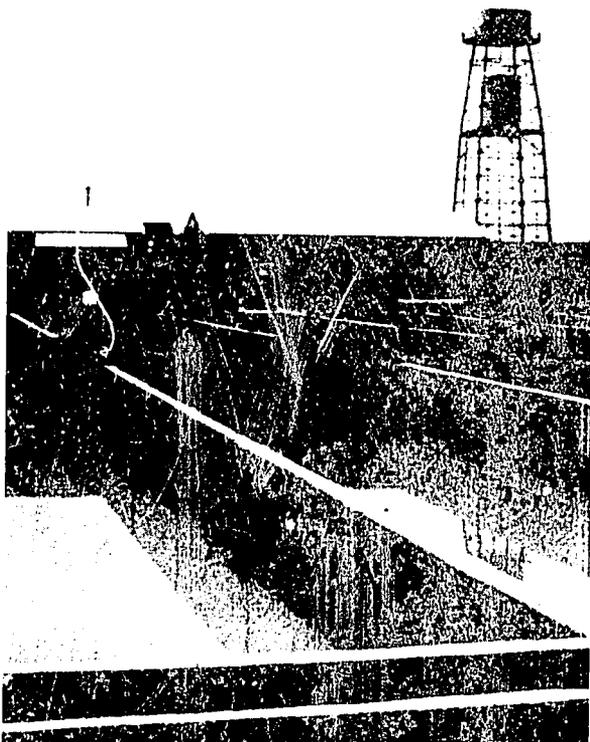
Results

The efficiency of a seed production system has been examined initially with *S. niloticus* under outdoor and indoor conditions at various stocking densities. The sex-ratios of parents examined were 2:1, 1:1 and 1:2. The numbers of fry produced and the spawning frequencies have been closely monitored. Preliminary results indicate that the best fry production can be expected under outdoor conditions with a sex-ratio of 1:1 at a stocking density of five fishes per square meter.

The reproductive performance of tilapia species and strains has also been monitored. The results are summarized in Table 1 (p. 25). The frequency of spawnings varied between species, as well as between individuals of the same species or strain. There was no significant correlation between the number of fry per clutch and the size of brood fish. Considerable variation in clutch sizes from the same individual was also evident.

Efforts have been made to develop an efficient fry collection method. Fry collection systems incorporating collection troughs and net partitions have been tested and are being improved. Studies of fry behavior and responses to environmental stimuli, reproductive performance and behavior of the intra- and interspecific progenies are underway.

Concrete raceways for fry production, CLSU.



- Project Title* : Controlled Reproduction of Commercially Important Fishes
- Cooperating Institutions* : New Jersey Marine Science Consortium; U.S. AID (Cooperative Marine Technology for the Middle East); Egyptian Academy of Scientific Research and Technology; Israel Oceanographic and Limnological Research Ltd.
- Duration* : 2.5 years, beginning August 1980
- Key Personnel*
- | | | |
|--------|---|----------------------|
| ICLARM | : | Dr. Ching-Ming Kuo |
| Egypt | : | Prof. A.R. El Bolock |
| Israel | : | Hillel Gordin |

Rationale and Objectives

Competition among users of freshwater in arid countries will virtually prohibit its future use for aquaculture. In Israel, an arid country that has developed some freshwater aquaculture, water is the limiting factor in production; only very intensive systems have been profitable. The use of seawater for aquaculture in coastal countries is one of the few viable options for fish farming under these circumstances.

Problems associated with controlling reproduction in important marine fish species are still a major obstacle to their culture. The problems include a lack of refined techniques for inducing maturation and triggering spawning on demand in captivity, and for mass rearing of fry.

Egyptian efforts to spawn mullet and develop mullet hatcheries, especially at sites with unusual water quality, and the Israeli research related to improvement in techniques for hormonally induced maturation and spawning of gilthead seabream are the parallel thrusts of this research. The basic problems as related to endocrinology and environmental influences on reproduction are similar.

The principal objective of the project is to increase understanding of the reproductive processes of the gilthead seabream and the grey mullet. Specific studies are directed toward determination of the effects of given doses of LH-RH on gonadal development and on definition of optimal injection schedules and dosages to achieve desired effects on gilthead seabream. With mullet, studies are designed to determine the effects of photoperiod and other environmental parameters on gonadal maturation.



Dr. Y. Zohar (center) examines broodstock seabream. Behind him is a rotatable holding cage for seabream culture.

Results

Two visits made entailed development of detailed protocols and familiarization with the facilities and logistical support available in Egypt and Israel. During the first visit, discussions of the research were held and recommendations were made on the scope of work and modifications of facilities. Seminars were presented to update project staff on recent developments and to encourage detailed discussion before initiation of research activities.

During the second visit, progress was reviewed and adjustments were made in research protocols as required.

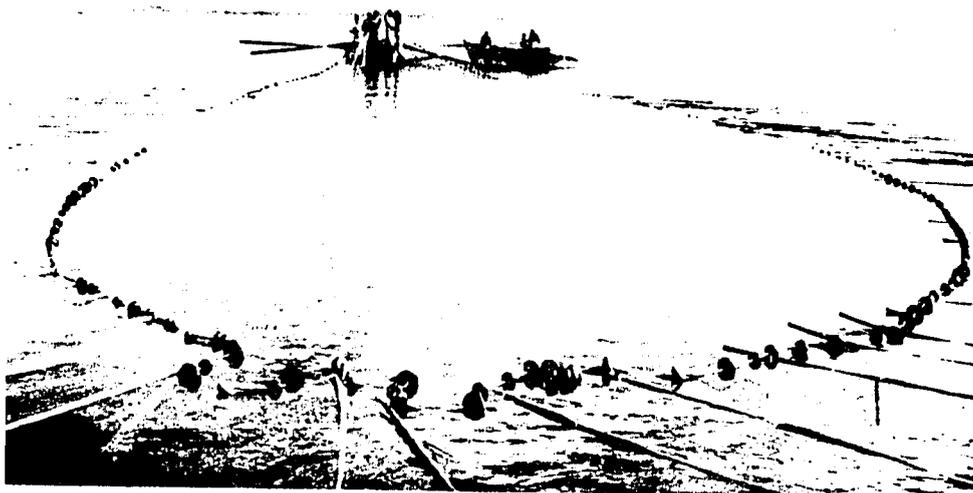
In Israel, development of mature broodstock of gilthead seabream out-of-season has been attempted through manipulation of photoperiodic regimes. The effect of photoperiodic regime on initiation and control of gonadal development was examined using three retarded photoperiods of varying attenuation of the natural photoperiod, 0.5, 1.0 and 1.5 minutes per day. The photoperiod of 0.5 minute per day attenuation was found to be most effective and vitellogenesis was thereby accelerated by 5-6 weeks. Preparation for induced-breeding by LH-RH is underway. The effectiveness of the manopeptide LH-RH analog on gonadal maturation and ovulation in the gilthead seabream will be evaluated in the coming breeding season.

Mature broodstocks of the gilthead seabream have been established in captivity. The spawnings of these mature breeders were initiated by one to three injections of chorionic gonadotropin (HCG). Spawnings were also triggered by preconditioning the breeders to cold temperature.

Major efforts have been directed towards rearing the larvae through the fingerling stage. The best survival obtained this year was 8%. This low survival is partly attributed to inherent characteristics of the species and partly to the limited facilities available to the project.

In Egypt, emphasis has been placed on a review of existing literature on the reproduction and culture of two mullet species in Egypt and Mediterranean countries, *Mugil cephalus* and *M. capito*, and the annual study of their gonadal development in Lake Qarun.

Specimens have been collected and examined monthly. Work has been limited to histological studies, due to lack of supporting facilities. The proposed work of induced breeding of mullet will be initiated when facilities become available for the project.



*Hauling the bouri, a double-walled seine net, in Lake Qarun for *M. cephalus* adults.*

- Project Title* : Evaluation of Mariculture Potential of Tilapia
- Cooperating Institution* : Council for Agriculture Planning and Development (CAPD), Taiwan
- Duration* : Three years, beginning May 1981
- Key Personnel* ICLARM : Dr. Ching-Ming Kuo
CAPD : Dr. J.C. Lee

Rationale and Objectives

Satisfactory survival and reproduction of a few tilapia species in seawater and even in hypersaline conditions have been recorded, but their growth is usually unsatisfactory. A search for tilapia species and hybrids which are fast-growing and preferably capable of reproduction in saline waters is essential, not only for further expansion of tilapia culture in coastal waters, but also to reduce conflicts with agricultural users of land and water.

This project is aimed at evaluating the culture potential of tilapias in brackish and marine waters by determining their growth performance, survival and reproductive capacity. A red tilapia variety (*Sarotherodon* sp.) and blue tilapia (*S. aureus*) were selected initially for their tolerance of salinity and cold temperatures, respectively, and a continuing search for other candidate species and improved hybrids is underway.

Results

The project is being conducted at the Lukang Station, Taiwan Fisheries Research Institute, Taiwan. The growth, survival and reproduction of red tilapia and *S. aureus* have been evaluated in 3 x 3 x 1.5-m cages at three different salinity conditions ranging from freshwater to full seawater in both the warm and cold seasons. The present work is designed to determine the survival and growth performance of these species under various salinities.

Growth has been very promising over the range of salinities examined, but mortality up to 20% occurred during the first few days in seawater. Experiments are underway to reduce this mortality through extension of the acclimation period. In brackishwater, the tilapias performed exceptionally well with a food conversion of 1.2-1.5 to 1.0 (dry to wet weights).

- Project Title* : Aquacultural Trends and Development Prospects: Country Case Studies
- Cooperating Institution* : Studies are individually commissioned
- Duration* : First country case studies began in mid-1981
- Key Personnel* ICLARM : Drs. Ian R. Smith and Richard A. Neal
 Taiwan : Dr. Chaur-Shyan Lee, National Chung Hsing University
 Israel : Dr. Dan Cohen, Aquaculture Production Technology Ltd. and Hebrew University

Rationale and Objectives

Aquaculture's historical and current role in the overall economy of a country and its prospects for future development are determined by factors that are both internal and external to the sector. The dynamics of change in any economy of which aquaculture is a part, suggest that there are three major areas from which forces that influence aquacultural development may emanate. These are: (1) the relative economics of rearing and marketing various aquacultural species; (2) the relative economics of aquaculture and other production sectors that either require the same inputs used by aquaculture and/or compete in the same market place, and (3) the expansion of non-agricultural activities in other sectors that produce positive or negative externalities for aquaculture.

Government policy potentially plays a very important role in all three of these areas. Subsidies for certain sectors or activities will alter the relative economics of production, thus shifting the pattern of development. Taxes, price supports or price controls, marketing assistance, provision of credit and funding for research are means by which government action can spur development in one area or retard it in another. In years to come, governments may give increasing protection and incentives to food producers, including aquaculture, to enhance their ability to compete with other sectors.

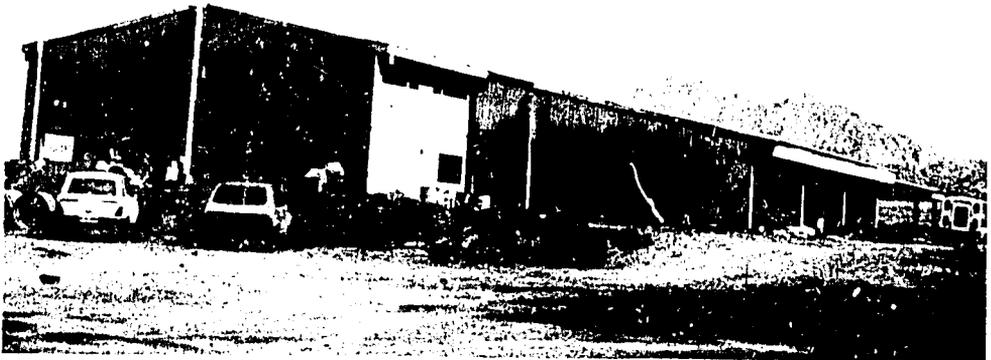
The above points imply that a broad economic and institutional overview of aquaculture's role in each country is likely to yield a more realistic appraisal of the sector's potential than would a view that is narrowly technical or biological.

ICLARM believes that such an appraisal of aquaculture is long overdue, and, as an initial step, is commissioning several case studies in countries

where aquaculture is an important activity and where data are available to permit analysis without resorting to extensive field surveys. The country case studies attempt to isolate those factors—technical, economic, or institutional—that can explain historical trends and which either constrain or enhance future aquacultural development prospects.

Studies of the Taiwanese and Israeli cases have been commissioned. In both cases, developmental constraints are already apparent. Competition for aquacultural inputs has increased from other sectors, such as for water in Israel. Industrial development has created rural labor shortages and pollution problems in Taiwan. Also, international market changes have resulted in species shifts in both countries.

Lessons from experience in these two countries and from other studies to follow, are expected to identify major constraints to aquaculture development and thus to bring a measure of realism and objectivity to bear on aquaculture planning. Clarification of potential future constraints will also help identify: (1) aquaculture systems which are most likely to survive in the long term, and (2) the research inputs required to develop or strengthen those systems.



A new saltwater hatchery for Israel Oceanographic and Limnological Research, Ltd., Israel. It is the site for ICLARM's cooperative project on seabream and mullet reproduction (p. 39).

- Project Title* : Milkfish Production Dualism: A Socioeconomic Perspective
- Cooperating Institutions* : Bureau of Agricultural Economics (BAEcon) and the Bureau of Fisheries and Aquatic Resources (BFAR), Philippines.
- Duration* : Eighteen months, beginning July 1981
- Key Personnel* ICLARM : Dr. Kee-Chai Chong
 BAEcon : Ms. Maura Lizarondo
 BFAR : Mr. Cesar Guerrero

Rationale and Objectives

For reasons to be determined from this study, production from Philippine brackishwater aquaculture has generally lagged behind its potential. This is surprising, since aquaculture in the Philippines, particularly that of milkfish, has a long history and tradition.

As part of a continuing effort to realize this potential, the United Nations Development Programme and the Bureau of Fisheries and Aquatic Resources have set up four Brackishwater Aquaculture Development and Training Centers in the Philippines, one in each of the following provinces distributed by climate types: Bulacan, Quezon, Bohol and Lanao del Norte. One of the basic purposes of these Centers is to demonstrate that higher productivity from existing milkfish ponds is economically feasible and can be accomplished with the use of more inputs.

Despite the success that has been achieved with intensive production methods by experimental stations and leading private entrepreneurs, the majority of private milkfish farmers continue to rely on extensive methods. Their production and profits are much lower as a result, yet they coexist with other producers using more intensive methods. In many cases, extensive and intensive operations are physically adjacent to one another.

The question that must be addressed is why milkfish farmers have not been adopting the available technologies at a faster rate. In addition to socioeconomic factors, there are also other possible constraints to higher yields which are physical in nature, such as the problems of acid sulfate soils, salinity, and the occurrences of typhoons and floods. Is it possible that there are no great economic pressures or apparent incentives for milkfish farmers to obtain higher output because of these environmental factors? An in-depth analysis is needed to determine conclusively whether the con-

straints to higher yields are physical, socioeconomic or institutional in nature. Appropriate measures to correct and improve the existing situation can be formulated and implemented once the nature of the constraints is determined. The importance of this research to extension programs is obvious.

The project, which is funded by UNDP/FAO, has two phases. The first, which began in July 1981 and will last for 12 months, involves a survey of 300-400 producers in provinces in the vicinity of the four Brackishwater Aquaculture Development and Training Centers. The purpose of the first phase is to identify the constraints to increased production from milkfish farms, and it will culminate in a written report to FAO. The second phase, which will take six months, involves the preparation of training materials for BFAR extension officers in the economic and business management aspects of milkfish aquaculture, based in part upon the findings of the first phase. The project is a follow-up to the recently completed BAEcon-FIDC-ICLARM project on milkfish production economics in the Philippines, the results of which will also be useful in preparing training materials (see p. 21).

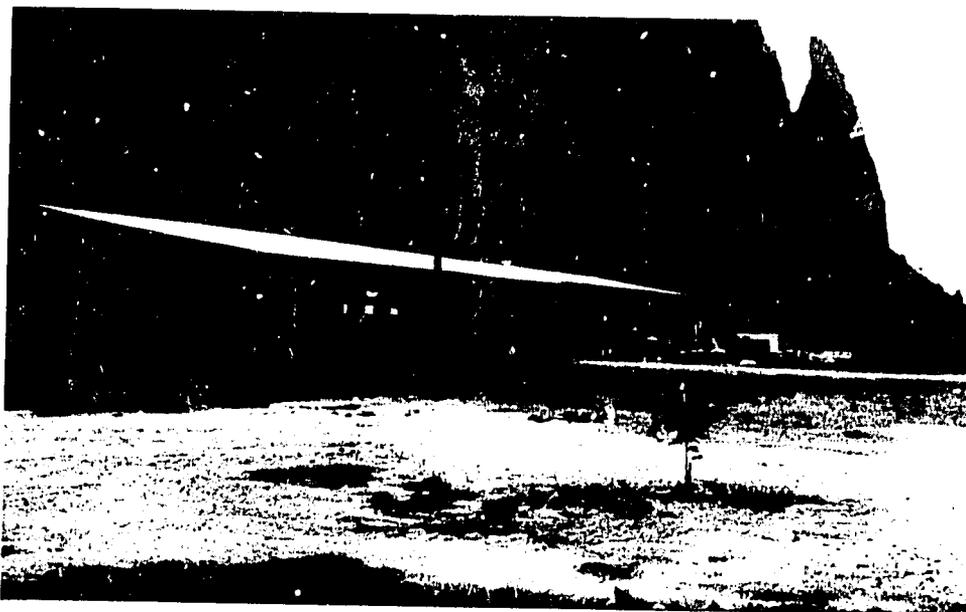


One reason for low productivity from milkfish ponds—incomplete excavation means less surface area, shallower ponds.

- Project Title* : Technical Assistance for Applied Research on Coastal Aquaculture Phase I: Mollusc Culture
- Cooperating Institutions* : Department of Fisheries, Ministry of Agriculture and Cooperatives, Government of Thailand and the German Agency for Technical Cooperation (GTZ)
- Duration* : 18 months with possible extension for 18 months, beginning December 1981
- Key Personnel ICLARM* : Drs. Edward W. McCoy, Ronald F. Ventilla, Richard A. Neal, Roger S.V. Pullin
Thailand : Anant Saraya

Rationale and Objectives

This project is a part of the new aquaculture development program to increase fish supply in Thailand and will specifically address the culture of bivalve molluscs. Government emphasis is on production by small-holder fish farmers and fishermen, and mollusc culture is well-suited for this type of farming. The culture methods in use will be improved by transfer of existing



Prachuap Khirikhan Research Station; the shellfish biology segment is based here.



Harvesting cockle beds in southern Thailand.

technology and adaptive research. The marketing and post-harvest handling of shellfish are also important considerations in insuring that producers benefit from increased production. The project will deal with the shellfish industry as a continuum from production through marketing to the consumer, including analysis of public health aspects such as heavy metal accumulation.

Project objectives during the initial 18-month period are as follows:

- To identify technical, biological and economic constraints hindering successful expansion of mollusc culture in the coastal zone, particularly of the mussel (*Perna viridis*) and cockle (*Anadara granosa*).
- To assist the Department of Fisheries to initiate applied research aimed at eliminating identified constraints.
- To provide technical advice on mollusc culture, product handling and marketing.
- To assist the Department of Fisheries select a lead station for research and development work on mollusc culture which will serve as a site for applied research activities of this project.
- To assist the Department of Fisheries to initiate work on introduction and/or improvement of appropriate technologies for mollusc farming.
- To increase seed production of cockles through development of hatchery technology.
- To demonstrate and spread technical advances to coastal communities through the existing extension service of the Department of Fisheries.

The project team leader and economist, Dr. Edward W. McCoy, was posted to Bangkok in December 1981 to start the project. The project's shellfish biologist, Dr. Ronald F. Ventilla, from the U.K. joins the project in April 1982, and will be based at the Prachuap Khirikhan Brackish Water Fisheries Station.

- Project Title* : Intensive Mariculture of Tilapia
- Cooperating Institution* : Mariculture and Fisheries Department, Kuwait Institute for Scientific Research (KISR)
- Duration* : One year, January 1982-January 1983, with possible extension for additional two years
- Key Personnel ICLARM* : Dr. Kevin Hopkins

Rationale and Objectives

The proven value of certain tilapia species as hardy, efficient culture fishes and the evidence that at least some are widely tolerant of salinities up to and even higher than that of seawater, indicate the need for a serious evaluation of the commercial potential of tilapia in coastal desert areas.

A project has been initiated in Kuwait in cooperation with the Kuwait Institute for Scientific Research to conduct research on this topic with specific reference to commercial production in Kuwait, but also with a broader view of worldwide applications in coastal desert areas. This work will be closely coordinated with related ICLARM research in Taiwan where more basic research on salinity tolerance and related culture problems is being carried out. If a suitable species or hybrid can be identified or developed for use in seawater and if an appropriate production system can be devised, tilapias may become an important source of animal protein for human consumption in such arid regions.

The objectives of this project are:

- To screen and select species and hybrids of tilapias suitable for intensive culture in the coastal zone of Kuwait.
- To develop suitable methods for the mass production of tilapia fry under conditions existing in Kuwait.
- To evaluate intensive growout systems for tilapia including cages and raceways.

The program of work in 1982 will focus on development of mass fry production methods and growout tests in raceways and cages, using locally produced and imported feeds.

Project Title : Tilapia Marketing, Philippines and Taiwan

Cooperating Institutions : To be determined

Duration : Twelve months, beginning March 1982

Key Personnel ICLARM : Dr. Ian R. Smith

Taiwan : Dr. Chaur-Shyan Lee, National Chung Hsing University

Others to be determined

Rationale and Objectives

Tilapias are becoming increasingly important as food fish throughout the world. The culture industry is not without problems, however. One current constraint is adequate supply of seed stock which ICLARM is addressing (p. 37). A second problem, amenable to economic analysis, relates to marketing. Although tilapia farm-gate prices have doubled in the Philippines in the past two years, the extent of the market is not known. Tilapias compete not only with other cultured species such as milkfish and to a certain extent with capture fisheries, but also with other animal protein sources such as pork, beef and chicken. Supplies and prices of these items and consumer demand all affect the ability of local markets to absorb additional quantities of tilapia. Export markets, particularly in the temperate zone, may offer some potential for expansion.

The purpose of this study is to examine the production and marketing of tilapias in the Philippines and Taiwan. Specific objectives are:

- To determine production costs under alternative production systems.
- To describe the structure, conduct and performance of the market.
- To measure consumer preferences and consumer characteristics.
- To estimate the demand for tilapias (price and income elasticities) and the market relationship (cross price elasticities) between tilapias and other sources of animal protein.

The full study, including report preparation, is expected to take approximately 12 months.

TRADITIONAL FISHERIES

Program Overview

Although there is great diversity in tropical fisheries and among the peoples that exploit them, certain general observations can be made regarding the causes of continuing low income and low standard of living in traditional fishing communities. First, it must be recognized that there is an inherent divergence between the objectives of individual fishermen for higher catch and the broader goals of society for resource conservation and management. Due to the common property and open-access nature of the resource, there is no incentive for an individual fisherman to limit his fishing effort, for what he fails to catch will only be caught by someone else. In the case of highly migratory species, the same characterization can be made of national fishing fleets *vis a vis* those of other nations. The result, particularly for coastal fish stocks in South and Southeast Asia, has been extreme competition for the catch among various gear types, overcapitalization of fishing fleets, and overfishing of the available stocks. Underlying biological limits to the resource thus constrain the potential for fishermen as a group to expand their catch and income.

Second, recent increases in the cost of fuel have also reduced fishing incomes, and because of the costs associated with travelling to far-off fishing grounds, additional fishing pressure has been placed on coastal resources.

Third, population growth in most countries in South and Southeast Asia has resulted in increased numbers of fishermen, due in great measure to the lack of alternative income opportunities in many rural areas. All three of these factors have combined to produce a situation where fishing incomes remain low.

To deal with the low income of fishermen, fisheries development programs have historically emphasized the upgrading of vessels and gear, often in association with various credit and/or cooperative schemes.

However, now, in the face of increasing evidence that technical approaches will not solve the overfishing and low-income problems of the sector, attitudes about suitable means to solving these problems are slowly beginning to change. It is becoming recognized that the most promising solutions lie in approaches that limit fishing effort and thus potentially produce higher sustainable yields and incomes from capture fisheries. This shift from development to management leads, however, to some very sensitive areas that

could be ignored as long as technical (development) solutions were applicable. No longer is it possible to expand the pie to benefit all fishermen. It is now necessary to make difficult decisions regarding allocation of a pie of given size among the various competing users. Little previous experience with explicit fisheries allocation programs, especially in the tropics, is available to help guide decision-makers in this new direction.

An expansion in the number of alternative limited entry approaches that might be considered for the fisheries sector is needed, and research can do much to facilitate moves in this direction. Clearly, evaluating alternative approaches and expanding the horizon of policymakers is a long-term process. Because of the nature of the problems facing the sector, interdisciplinary approaches that draw on biology, economics and sociology are necessary. ICLARM's research is based on that premise.

In more specific terms, the Traditional Fisheries Program expects to engage in and encourage interdisciplinary research in the following areas:

- *Evaluation of alternative management objectives, mechanisms and programs for small-scale fisheries*, including issues related to allocation, alternative decision-making mechanisms, and development of information requirements and tools of analysis to project and monitor impact of alternative management measures that limit fishing effort.
- *Evaluation of the income-generating potential of aquaculture for fishing households*, including technical, economic and social feasibility. The focus would be primarily on small-scale aquaculture, such as cage culture, and mollusc and seaweed farming.
- *Evaluation of non-fishing alternatives for fishing households*, including those that supplement rather than replace fishing incomes, and those that require shifts to new occupations, or locations.
- *Broader macro-level studies that evaluate the fisheries sector and its potential for being managed* in the context of increasing populations in both rural and urban areas, increasing demand for protein (including fish), and growth or decline of other sectors in national economies.

For such research to be meaningful, it is important that more explicit contacts be forged between the research community and policymakers. Through the research activities that it supports, ICLARM hopes to encourage such links at the national and international levels.

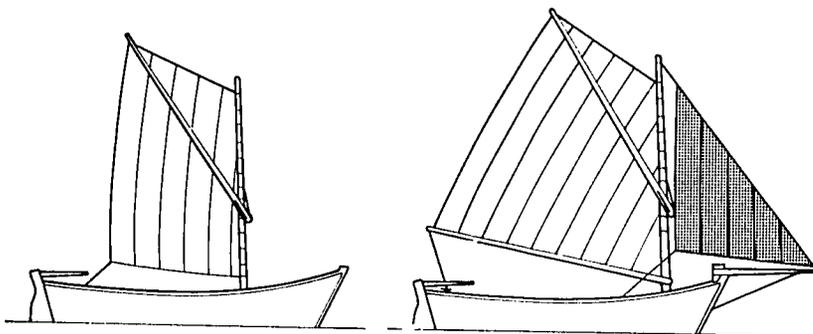
Progress of Work, 1981

ICLARM has continued the country-specific research synthesis projects that began in the Philippines in 1979. The Philippine study was published jointly with the Fishery Industry Development Council in 1980 and a similar Malaysian study will be published in 1982. With partial funding support from the Rockefeller Foundation, ICLARM staff and two Indonesian colleagues are conducting a similar review and synthesis of previous research and development policies on small-scale fisheries of Indonesia from October

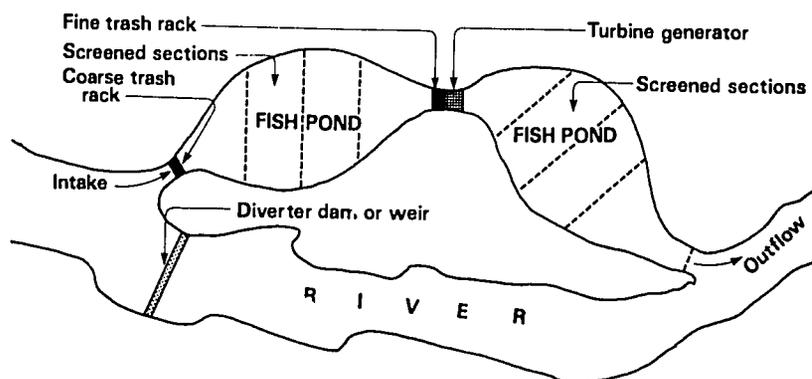
1981 to June 1982 in cooperation with the Directorate General of Fisheries (DGF) and the Marine Fisheries Research Institute (LPPL). Each of these three multidisciplinary studies is designed to recommend research priorities for subsequent projects that could be conducted by various research institutions, possibly in association with ICLARM.

For example, in 1979, using the FIDC/ICLARM study of Philippine municipal fisheries as a framework, ICLARM and the Institute of Fisheries Development and Research (IFDR), University of the Philippines (Visayas), initiated a multidisciplinary study of the fisheries of San Miguel Bay, Philippines. Various reports of the project covering aspects of biology, economics and sociology will be published in 1982. Results of this project which will outline the various options for increasing incomes of the small-scale fishermen will be presented in a seminar for municipal and provincial officials.

Already the project has attracted attention due to the comprehensive nature of the data collected and the analysis applied and to the fact that it is the first such multidisciplinary study in the Philippines, and probably in Southeast Asia. Because it deals explicitly with allocation issues in a coastal fishery, its results are expected to have an impact beyond the San Miguel

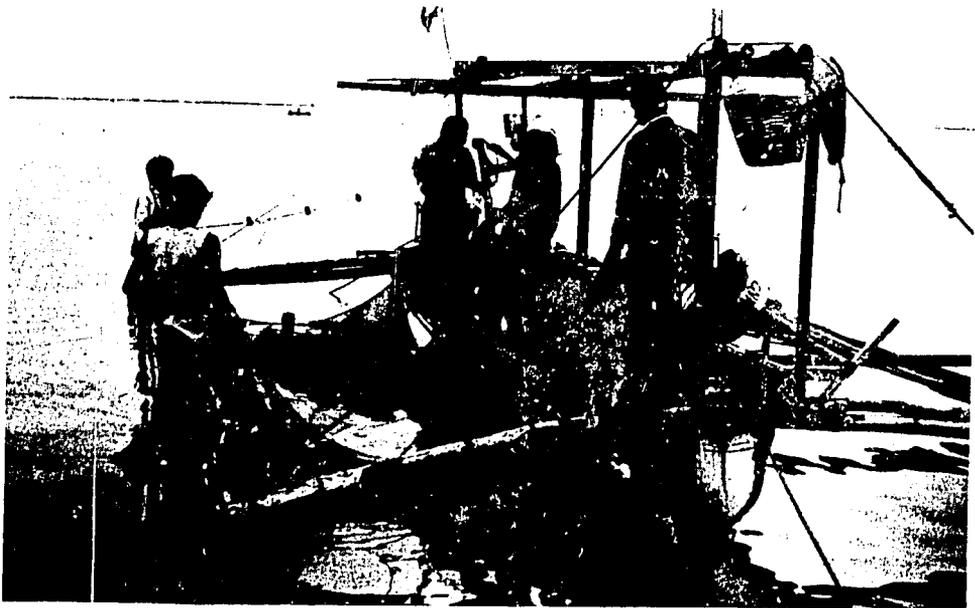


Alternative energy options: for fishing craft, spritsail rig and temporary bowsprit to increase sail area (above) and for aquaculture, a scheme to generate hydro-power (below). From the ADB/ICLARM workshop on these themes, February 1981.



Bay area. Several Philippine research groups are planning projects of a similar nature.

In 1981 ICLARM co-sponsored with the Asian Development Bank (ADB) a workshop on Appropriate Technology for Alternative Energy Sources in Fisheries. Six major resource papers and 15 contributed papers addressed various aspects of renewable energy applications in fisheries and aquaculture. Subsequent expressions of interest for a renewable energy referral center for fisheries have been expressed informally by ADB and by the German Appropriate Technology Exchange (GATE). ICLARM's future involvement in this subject matter will be contingent on the availability of substantial external funding to support additional manpower to implement such an activity.



Small-scale fishermen near Manila, Philippines. Above: often makeshift craft. Below: working conditions are not always ideal.



Program of Work, 1982

The Indonesian small-scale fisheries review that was initiated in 1981 will continue through June, 1982 and ICLARM is exploring possibilities for extending the research activities in Indonesia for follow-up work with Indonesian institutions.

The core of ICLARM's future research on traditional fisheries in the near future is expected to be within the framework of networks of national research institutions. Discussions were initiated in mid-1981 with the International Development and Research Center (IDRC) of Canada regarding financial support for a fisheries social science research network in South and Southeast Asia. ICLARM shares a common philosophy with IDRC in that both seek to encourage and support the development of national 'centers of excellence' where high-quality research and complementary activities such as curriculum development and training can evolve. Very much complementary to ICLARM's work, the Social Sciences Division of IDRC has been supporting a major effort in fisheries research in six countries (Philippines, Thailand, Malaysia, Indonesia, Sri Lanka and Bangladesh) since 1979, involving a large number of institutions and individuals. With the conclusion of this project, IDRC has expressed interest for future fisheries social science research in cooperation with ICLARM, including both capture fisheries and aquaculture components. Preliminary plans call for establishment of a network of up to seven affiliated institutions in South and Southeast Asia with financial support from IDRC and ICLARM to be used for a professorial chair or similar position, with funds available for the conduct of research, workshops and support of graduate student research. Possible themes for research include those discussed in detail in the aquaculture and traditional fisheries program overviews of this Annual Report. After consultation with national institutions that are potential participants in the network, ICLARM will prepare a detailed proposal for IDRC consideration in mid-1982.

The key to the success of ICLARM's traditional fisheries research program has been its sharp focus on key issues and its continuity. Its continued success will lie in its ability to help establish a similar focus and continuity in selected national institutions. This parallel effort is deemed the most effective means of bridging the gap with policymakers in the long term. The number of professionals to be involved in this parallel effort need not be large but must extend beyond the confines of ICLARM's own staff. The task at hand is to identify the network participants in various countries, define a specific program of work in consultation with participating researchers and develop an overall operational infrastructure for the program.

- Project Title* : Skipjack and Traditional Fisheries: A Solomon Islands Case Study
- Cooperating Institution* : Rockefeller Foundation
- Duration* : 2 years, November 1978-November 1980
- Key Personnel ICLARM* : Ms. Sarah K. Meltzoff, Research Fellow (Columbia University, New York)

Rationale and Objectives

Migratory tunas are key resources for capital development in the South Pacific. The newly independent South Pacific states focus on tuna for Pan-Pacific development. The Forum Fisheries Agency emerged in 1979 to handle their regional concern over controlling the swelling tuna fishing industrialization.

During the past decade, skipjack have become an important source of foreign exchange, especially for the Solomon Islands and Papua New Guinea, where baitfish, mandatory for the live-bait pole-and-line fishery, are plentiful. The fleets exploiting these tuna stocks are run by Japanese and American-based multinational firms, and government joint ventures backed by foreign

Japanese tuna fleet, Solomon Islands.



aid and loans from the World Bank and the Asian Development Bank. These companies are supplying the ever-expanding tuna markets in Japan, the U.S.A. and Europe.

Needs for increasing tuna production, and thus baitfish, to meet these demands on one hand, and manpower on the other hand, are having a substantial impact on regional economics, island cultures, and perhaps ecosystems of the South Pacific states.

For two years, from November 1978, a maritime anthropologist, Ms. Sarah Meltzoff, doctoral candidate at Columbia University, worked on a case study of the Solomon Islands skipjack development, with funding support from ICLARM and the Rockefeller Foundation.

In addition to analyzing the history and decision-making regarding Solomon Islands agreements with Japanese companies, the study also assessed the extent to which (1) nationalization of fishing fleets and companies is feared, feasible, or desirable and (2) coastal communities can participate in skipjack fisheries, either in the labor market or in the bait fisheries.

Results

Two-years extensive field work was conducted in various locations ranging from multinational firms' headquarters in Tokyo and California, to national policymakers' offices in Honiara, to skipjack fishing bases and village homes of workers. Field work is now complete and ICLARM expects to receive a manuscript based on the author's dissertation for possible publication in 1982.

Project Title : Malaysian Small-Scale Fisheries: A Research Review

Cooperating Institutions : Faculty Members from Universiti Sains Malaysia, Penang, and Universiti Malaya, Kuala Lumpur

Duration : Two years, August 1979-July 1981

Key Personnel

ICLARM : Dr. Ian R. Smith
 Universiti Sains Malaysia : Drs. Chua Thia Eng and Lim Teck Ghee
 Universiti Malaya : Ms. Jahara Yahaya

Rationale and Objectives

There has probably been more research conducted on Malaysian fisheries than the fisheries of any other country of Southeast Asia. The present needs in traditional fisheries are to: (1) synthesize available information on the resources and socioeconomics of small-scale fishing communities in Malaysia, and (2) explore some of the options for development in these communities against a background of previous government programs. ICLARM commissioned a three-member team of university researchers to carry out such a review.

Prior to initiating its study, the research team identified the following factors as indicative of crisis in the small-scale fishing communities of Malaysia, and decided to examine evidence of each.

- Conflicts between inshore and offshore fishermen
- Declining real incomes
- Underemployment and 'surplus' fishermen
- Malnutrition
- Growing inequalities and disparities in and among rural communities

The review's major sections cover the resources, socioeconomics and institutional aspects of small-scale fisheries in Malaysia. The review also examines selected aquaculture systems as a source of alternative income for small-scale fishing communities. The resulting manuscript will be published in 1982.

- Project Title* : Small-Scale Fisheries of San Miguel Bay, Philippines: A Multidisciplinary Analysis
- Cooperating Institutions* : Institute of Fisheries Development and Research (IFDR) of the University of the Philippines College of Fisheries; United Nations University (UNU); and the Philippine Council for Agriculture and Resources Research (PCARR)
- Duration* : Two years, September 1979-December 1981
- Key Personnel* IFDR : Prof. Antonio Mines
 ICLARM : Drs. Ian R. Smith, Daniel Pauly and J. Conner Bailey

Rationale and Objectives

The underlying rationale for research related to Philippine municipal fisheries and fishing communities is to examine alternatives for improving household incomes. This is particularly important for San Miguel Bay in the Bicol region, because the area has been designated as overfished by the Bureau of Fisheries and Aquatic Resources. It was hoped that an in-depth study of the San Miguel Bay fisheries would facilitate this sector's inclusion in the Bicol integrated area development program, a plan from which fishing communities have been generally excluded.

It is clear that biological, technical, economic and sociological factors all influence the well-being and incomes of municipal fishermen living on the coast of the bay, and that concentration of research on any single aspect would likely overlook important interrelationships among them. Because an interdisciplinary approach has not been used before in municipal fisheries research in the Philippines, an underlying motive for the project was to develop such an approach for application elsewhere.

There are four complementary aspects to this research program: (1) stock assessment; (2) economics of production and marketing; (3) social and demographic characteristics of the fishing communities (sociology); and (4) an assessment of occupational and geographic mobility among fishing households.

The four research activities are coordinated by an IFDR-ICLARM research committee headed by Prof. Antonio Mines, IFDR Director.

Results

Detailed catch and effort data collected during the study are still being analyzed but are expected to yield information needed for a comprehensive understanding of the stocks and the impact of the fishery on these stocks.

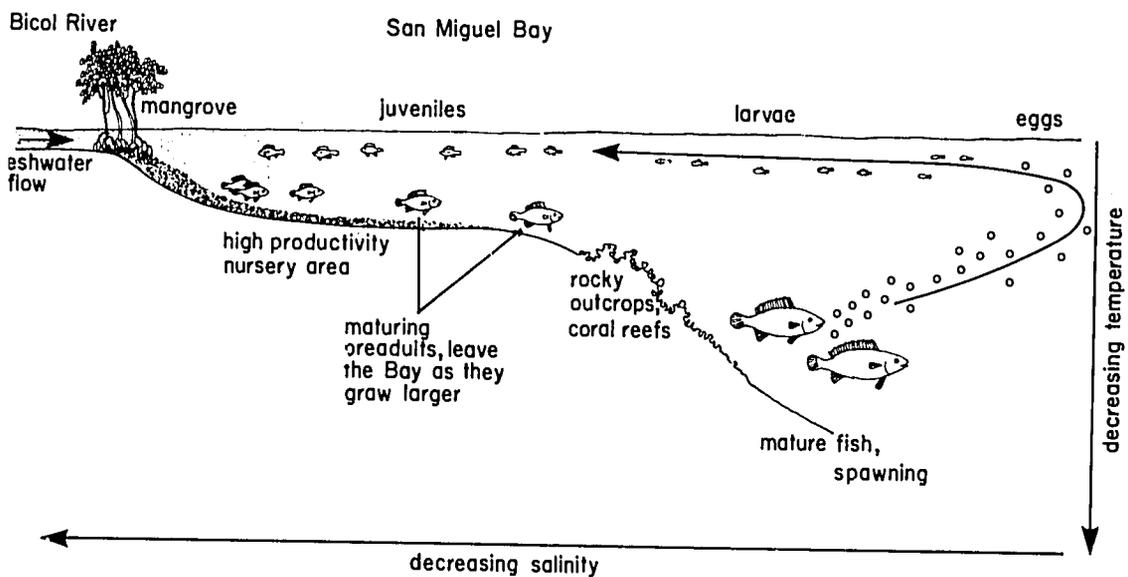
Economic analysis demonstrates a clear dichotomy in the municipal fishery with the most prevalent gear (gill nets) operating at the margin while a small number of trawlers capture half the total catch and almost all the pure profits. In the interest of equity, there is a need to address the questions



San Miguel Bay, 25 km x 35 km. Satellite photo (U.S. Geological Survey).



The project team and its headquarters. Front row (left to right): Elviro Cinco, Noli Arle Navaluna, Antonio Mines (Project Leader), Amelia Esporlas, Luz Yater, Estrella Tulay, Neri Supanga, Elma Villafuerte, Anita Villegas. Back row (left to right): Gregorio Bañacla, Francia Yater, Daniel Pauly.



One important feature of San Miguel Bay: Virtually all species spawn outside the Bay. The Bay fishery is therefore based on the juveniles and preadult fish.

of control of access and allocation of fishing rights within the municipal fishery.

Returns to labor are low, but generally higher than those in other, non-fishing activities. This finding supports the observation that there are very few alternative income-generating activities to fishing, and therefore that levels of fishing effort are likely to remain high despite the low level of income that fishing labor obtains.

The importance of the fisherman's family in terms of income generation and their role in decisions affecting investment in fishing units was demonstrated by analysis of the sociological data. Women and children are active in both processing and marketing of the catch and the income from fishing itself is typically handed over to the wife, who controls the family finances. Thus, women play a key role in the economy of San Miguel Bay fishing communities.

The potential for reducing fishing pressure by attracting fishermen to other income-generating activities in the area is quite limited, because the agricultural sector has surplus labor problems of its own. The only activity that has promise of increasing incomes seems to be in supplementary animal husbandry, particularly backyard pig raising.

Five Technical Reports will be produced, to be published jointly in 1982 by IFDR, UNU and ICLARM. The final report will outline the various options for increasing fishing household incomes.

- Project Title* : Workshop on Appropriate Technology for Alternative Energy Sources in Fisheries
- Cooperating Institution* : Co-sponsored with the Asian Development Bank (ADB)
- Duration* : 16-21 February 1981
- Key Personnel* ICLARM : Dr. Ian R. Smith
 ADB : Dr. Robert C. May
 : Mr. David Thomson (consultant)

Rationale and Objectives

The Indo-Pacific fisheries support over 6 million fishermen who in turn provide work for over 10 million shore-based artisans. These 16 million workers plus their families comprise over 80 million persons. Despite their social and economic importance, the region's fisheries are beset with serious problems. Most of the fishermen are small-scale operators living in communities characterized by geographic and economic isolation and by low standards of living, with few alternative sources of income. Recent increases in the price of fossil fuel have compounded the problems of the fisheries sector, which requires energy to power fishing vessels and run equipment for refrigeration, ice-making, fish preservation and processing.

The application of technologies appropriate to small-scale fisheries, both marine and inland, could do much to reduce the problems of the sector, with benefits both to the nutritional status of local communities and to the socioeconomic condition of fishermen. In recent years, there have been numerous valuable advances in the field of alternative energy sources, many of them suitable for application in fishing communities. A number of organizations have carried out pioneering work in the development of technologies which: (1) reduce the use of irreplaceable fuels by developing renewable energy resources; (2) create employment opportunities for the poor through low-cost, labor-intensive technologies, and (3) respect socio-cultural factors. Recent advances in the development of low-cost windmills, solar dryers and distillers, modern sail-powered vessels, bio-fuels, and integrated agro-fisheries systems, could have a significant and immediate impact on fishing communities. If applied thoughtfully, they could promote self-sufficiency, reduce dependency on fossil fuels, generate employment and increase net incomes.

To date, little of the valuable data compiled and experience gained by various research organizations in these fields has been disseminated in the

developing countries, least of all among the communities of rural fishermen who need it most. The countries concerned, and in particular officials responsible for development, need to be informed of the new technologies.

The ADB-ICLARM Workshop brought together 35 representatives of governments and international agencies in the Asia-Pacific region to review, discuss and critique alternative energy possibilities for fisheries and fishing communities, and the technologies appropriate to their development and improvement. Participants had an opportunity to exchange ideas based on reference to their respective countries and to view applications of the technologies in question.

The core of the Workshop was five discussion sessions of one-half day duration each, devoted to the following topics of relevance to the Workshop theme:

- Wind energy alternatives for on-shore activities
- Solar power alternatives for on-shore activities
- Bio-fuels in fisheries
- Low energy fishing boats and methods and low cost fish processing
- Integrated energy systems for fishing villages.

The Workshop concluded with review and critique sessions on the applicability and relevance of the various alternative energy sources and appropriate technologies discussed and demonstrated during the previous days, and provided recommendations for follow-up activities and their implementation. Proceedings of the Workshop will be published jointly by ADB and ICLARM in 1982.



Participants visit Maya Farms, a large piggy complex powered almost exclusively by biogas. Residue from the digesters is also dried and makes up 10% of the pig feed.

- Project Title* : Indonesian Small-Scale Fisheries: Research Review and Synthesis
- Cooperating Institutions* : Directorate General of Fisheries (DGF) and Marine Fisheries Research Institute (LPPL), Jakarta
- Duration* : Nine months, October 1981-June 1982
- Key Personnel* ICLARM : Dr. Conner Bailey
 DGF : Ir. Firial Marahudin
 LPPL : Mr. A. Dwiponggo

Rationale and Objectives

Much of the literature related to traditional fisheries remains scattered and generally underutilized. ICLARM's strategy, proposed in "A Research Framework for Traditional Fisheries," published in 1979, is to carry out research syntheses on a country by country basis. In cooperation with other fisheries organizations, ICLARM is preparing a series of publications that review research conducted to date on the biological, technical and socioeconomic problems of traditional fisheries and fishermen and alternative development policies and programs that seek to alleviate them. These reviews seek to summarize and generalize from previous research results and development experience in the belief that valuable insights can be gained by taking stock of what is already known.

The first synthesis, on Philippine small-scale fisheries, has been jointly published with the Fishery Industry Development Council (FIDC), Ministry of Natural Resources. A second study is soon to be completed in Malaysia.

The present review was initiated in Indonesia with partial funding support from the Rockefeller Foundation. As elsewhere, considerable biological, technical and socioeconomic research on traditional fisheries has been conducted in Indonesia, but published results are scattered and are of variable quality. Much is published in Bahasa Indonesia.

The review is timely because of the recent Indonesian government ban on trawlers and because of rising fuel prices, which will affect current fishing activity, and thus necessitate rethinking of government plans for motorization of the predominantly sail or paddle-powered traditional fishing fleet. The review is a cooperative effort between ICLARM and the Indonesian Fisheries authorities. A final report will be completed by mid-1982 and published in both English and Bahasa Indonesia.

- Project Title* : Fisheries Social Science Research Network
- Cooperating Institutions* : International Development Research Centre, Canada, and selected national institutions in South and Southeast Asia
- Duration* : 6 years, 1983-1988
- Key Personnel* ICLARM : Dr. Ian R. Smith
 IDRC : Drs. Elwood Pye and David King

Rationale and Objectives

This proposed activity stems from the belief that if the goals of fisheries development and management programs are to raise the standard of living of traditional fishing communities and to increase aquaculture production, the goal of research should be to expand and clarify the alternative choices available to decision-makers, be they government policymakers, project managers, private entrepreneurs or fishermen themselves.

Since mid-1981, ICLARM has been holding discussions with IDRC regarding the possibility of a jointly funded network of institutions in South and Southeast Asia to engage in fisheries and aquaculture economics research.

The underlying objective of this proposed research network is to build national research capacity. Only through sustained long-term involvement of national institutions can research have an impact on fisheries development and management policy. This project seeks to provide continuity and quality to fisheries social science research by addressing priority issues through a small network of affiliated institutions. Major purposes of the network are to strengthen selected national research institutions, facilitate their long-term commitment to fisheries social science research, and forge links between the research community and policymakers.

It is proposed to establish a network of up to seven selected national research institutions, preferably in universities, in South and Southeast Asia during 1983-1985, with coordination and support from ICLARM. Within each institution, a "professorial chair" or similar position would be funded by IDRC and ICLARM. These chairholders will plan and implement the fisheries social science research program of the individual institution. Annual research grants would be provided to each national institution for a period of four years. Afterwards, the IDRC/ICLARM funding would be reduced and the research program of each institution should become self-sustaining with funding from other sources, both external and national.



RESOURCE DEVELOPMENT AND MANAGEMENT

Program Overview

If the doomsday prophets are to be proven wrong, the last two decades of this century will have to see a large-scale shift in the prevailing attitudes toward both renewable and non-renewable resources in general, and living aquatic resources in particular.

There are already indications that this change is taking place, resulting in a change of emphasis from development of resources and very often their over-exploitation, toward an approach where management is seen as contributing to the optimal use of resources, and conservation is understood as keeping options open for the future use of resources.

This transition is clearly perceptible in tropical marine fisheries, where the emerging Law of the Sea has helped those involved in the fishery sector of many developing countries realize that the "new" resources are theirs to manage for the long-term benefit of their people, or to decimate in the pursuit of short-term interests.

Two major requirements for efficient management are:

- The resources must be known, such that sustainable yields and optimal exploitation patterns can be established for the various ecosystems and species involved.
- Government policies concerning the exploitation of these resources must be explicit, compatible with the nature of the resources and firmly enforced.

The first set of issues involves research and training predominantly in the field of tropical fish stock assessment. This field, the importance of which has greatly increased with the transition from fisheries development to fisheries management, is still largely neglected within the larger field of fishery biology and population dynamics. This is unfortunate since requests for assistance towards the establishment or upgrading of institutions in charge of assessing tropical fish stocks are received in increasing numbers by inter-governmental and other agencies involved in technical assistance.

For ICLARM, these developments have led to added emphasis on the development of methodology for tropical stock assessment and the training of young scientists from developing countries in the use of this methodology. A Senior Scientist will shortly be recruited to intensify the research and training components of the program and to broaden its base, both in geographic areas and subjects covered and in linkages with, and support by,

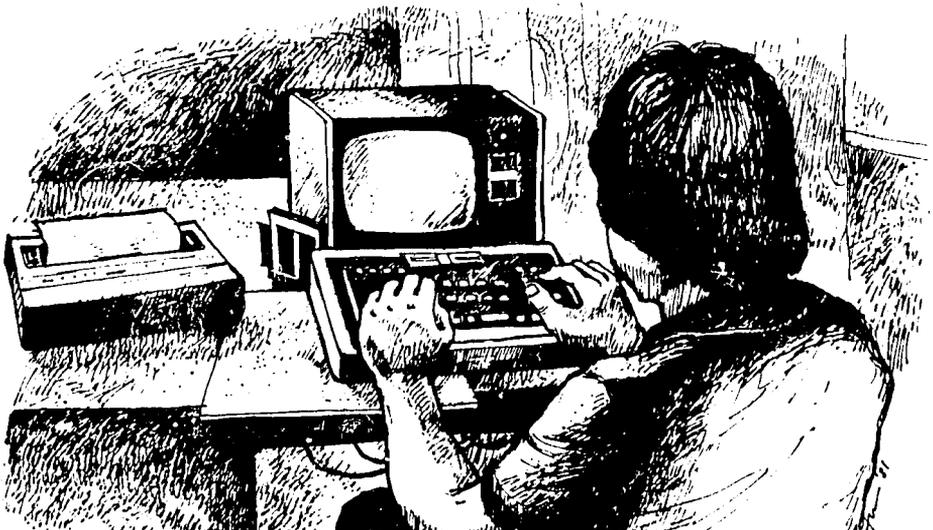
other institutions.

The issues related to government policies have also received less attention at ICLARM because of manpower limitations. This situation will change with the recruitment of the Senior Scientist to the Program early in 1982.

Progress of Work, 1981

The major thrusts of research in tropical stock assessment through 1981 were:

- The further development of methods that use length-frequency data, or catch-at-length data, which are particularly suited for use in the tropics, where reliable fish aging is difficult. This project was a cooperative effort between Mr. J.G. Pope of the MAFF Laboratory in Lowestoft, England, and Dr. D. Pauly, in October 1980, on the development, at Lowestoft, of a new length-structured form of Virtual Population Analysis.
- The development of simple methods by which certain interactions between stocks (e.g., predation) can be quantified, given catch data from a multispecies fishery. These methods, first applied to shrimp and fish stocks of the Gulf of Thailand, have also been used in tilapia aquaculture systems, where a predator is used to prevent unwanted recruitment. Papers on both aspects are in press.
- The identification of reliable methods for use in the assessment of coral reef fishes. This topic was pursued both in terms of in-house research, as an attempt to apply methods developed at ICLARM to reef fish data and through a preliminary "Ad hoc Consultation on Coral Reef Stock Assessment", held at ICLARM on 25-26 May 1981, with selected participants from the 4th International Coral Reef Symposium (May 1981, Manila).



- The development of software both for programmable calculators and microcomputers specifically designed to assist in the assessment of tropical stocks. During 1980 and 1981, a series of program was developed which allow the estimation of stock assessment parameters from minimal data about the stocks concerned. These programs were well received when presented at the 1981 annual meeting of ICES, Woods Hole, U.S.A. Their applicability to a variety of different organisms is demonstrated in several papers in press.
- The identification of further, worthwhile, research problems whose resolution would facilitate the assessment of tropical fish stocks and catch prediction. This topic was pursued through correspondence and at meetings, particularly during the meeting of the "Group of 4 Scientists" at FAO Headquarters in Rome, October 1980. The group consisted of Mr. A. Bakun (Pacific Environmental Group, NMFS, Monterey, California), Mr. J.G. Pope (MAFF Laboratory, Lowestoft, England), Dr. J. Beyer (Danish Institute of Fisheries Research, Charlottenlund), Dr. D. Pauly (ICLARM) and a number of FAO fisheries staff. The group's task consisted of identifying worthwhile research topics for oceanographers that would assist fisheries scientists in developing countries, and that could be implemented in the UNESCO/IOC program of "Ocean Science in Relation to Living Resources." The report of the group was widely circulated by UNESCO/IOC among biological oceanographers.

In addition to the research outlined above, a major activity in 1981 consisted of a conference on the Theory and Management of Tropical Multispecies Stocks, held in January 1981. This conference laid the basis for a planned series of follow-up projects, to be implemented as "country modules". Research topics identified at the Workshop will be integrated with current research in the various cooperating countries.

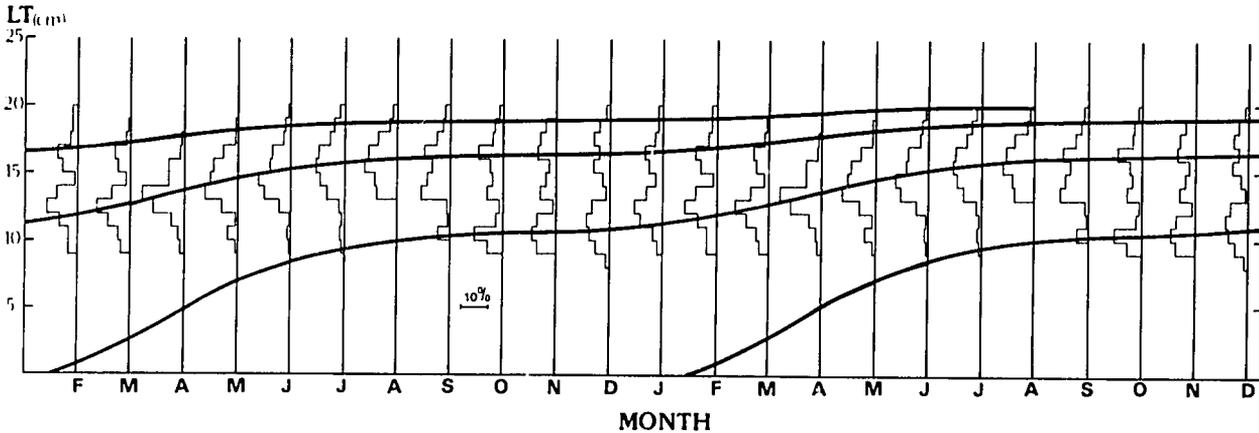
A research network covering five countries in Southeast Asia and the Pacific has been proposed (see p. 78).

Field-based stock assessment research was also carried out in the context of the Small-Scale Fisheries of San Miguel Bay project, Philippines (see also Traditional Fisheries Program). The field data acquisition phase has now been completed and a report will be available in 1982 in which the status of Bay's fisheries is assessed.

The major biological findings are:

- The Bay is extremely productive, and its annual production of fish and invertebrates is several times higher than the figure given in Philippine fishery statistics.
- An increase in total effort will not increase catches from the Bay.
- The Bay's total catch is attributable in almost equal parts to about 100 trawlers (owned by less than 30 households) and about 3,000 small-scale fishermen operating a wide variety of gears.
- Siltation caused by upland erosion is rapidly reducing the Bay's ability to sustain productive fisheries.

The research objectives given above were pursued in cooperation with colleagues from a number of institutions, both in developed and developing countries. As well, there were several requests for various forms of assistance, from lecturing to project formulation from a number of countries (p. 89) and a number of training activities were undertaken (p. 80).



*ELEFAN, a series of microcomputer programs developed in this project, extracts various information from length frequency catch samples. Here, the seasonally oscillating growth of the shrimp *Penaeus kerathurus* from Spain is derived.*

Program of work, 1982

The coming year will see an expansion of the research and training in stock assessment, so far restricted to the Philippines, to institutions in five countries of SE Asia and the Pacific, the aim being to bring about a Network of Management-Oriented Tropical Fisheries Research. Two of the five country modules included in this project, the Philippines and Indonesian modules, are funded and will be implemented in 1982.

Studying the community dynamics of multispecies demersal stocks is a direct outflow, and a recommendation of the recently held ICLARM/CSIRO Workshop on the Theory and Management of Tropical Multispecies Stocks. For such a study, however, both exhaustive data sets and sophisticated software for data analysis are necessary. It is planned to apply the software developed at ICLARM for the detailed analysis of trawl catch-per-effort

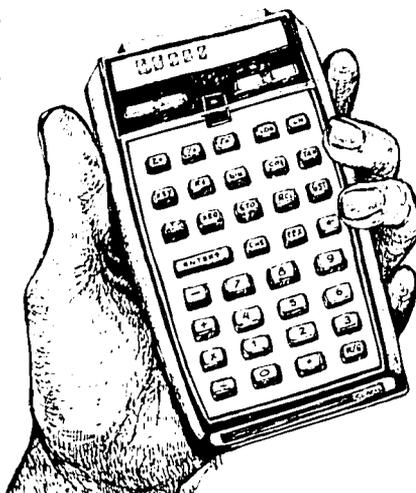
data, to the broad data base on Indonesian demersal stocks gathered by several fisheries development projects. These data have remained virtually unanalyzed.

The Indonesian study should be particularly useful in that it will be possible to investigate the effects on the resources of the recently declared trawling ban in Indonesia and assess the biological impact of the ban as a management measure. The project will complement the project of Dr. Bailey on the small-scale fisheries of Indonesia (see p. 65) to which Dr. Pauly is a consultant.

To strengthen the above network and facilitate research in tropical stock assessment, an informal network of scientists working on tropical stock assessment will be established in 1982 with membership including, but not restricted to, participants in the Management-Oriented Research Network. This informal network, which will involve scientists from both developing and developed countries, is intended to accelerate research on tropical fish population dynamics, by bringing the various practitioners in this area in touch with each other and by identifying means to ensure continuity of research effort.

The improved communication between various workers in this field should help to:

- Identify gaps in knowledge and thus, areas of worthwhile research.
- Locate the relevant literature and other sources of information for the benefit of those without direct access to the international community.
- Reach a critical mass of researchers working on related topics such that development of methodologies and concepts are accelerated and, possibly, standardized.



- Project Title* : Tropical Stock Assessment Research and Training Project, Philippines. (To be continued in 1982 under the "Management-Oriented Tropical Fisheries Research Network.")
- Cooperating Institution* : Predominantly in-house study, with informal linkages with (colleagues in) various research institutions
- Duration* : July 1979-December 1981
- Key Personnel* ICLARM : Dr. Daniel Pauly
Mr. Noel David (Affiliate Scientist, computer sciences)

Rationale and Objectives

Advanced fish stock assessment in the tropics has generally been conducted by expatriate fishery biologists contracted on a fixed-term basis, and very often working toward narrowly-defined objectives. This has resulted in the field becoming extremely fragmented, and generally based on uncritical application of methodology more suited for the assessment of temperate stocks.

The project seeks to alleviate this situation by testing the applicability of methods developed in temperate waters for the study of the population dynamics of tropical fish, and by developing new approaches where suitable methodology does not presently exist.

Results

In 1981, the project was particularly successful in developing a new methodology called Electronic Length Frequency Analysis (or ELEFAN) which is implemented on a series of BASIC Programs for use with micro-computers. It can be used to extract a vast amount of information useful for stock assessment from the length-frequency data routinely gathered in many developing countries.

A program package for use with HP 67/97 programmable calculators was completed, which will be part of a manual on tropical population dynamics in preparation. This manual, which is aimed mainly at working fishery biologists, could also be used for graduate courses in population dynamics and may form the start of an explicit involvement by ICLARM in the development of textbooks for students from and in tropical countries.

Project Title : ICLARM/CSIRO Workshop on the Theory and Management of Tropical Multispecies Stocks

Cooperating Institution : Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Fisheries and Oceanography, Cronulla, Australia

Duration : 12-21 January 1981

Key Personnel ICLARM : Dr. Daniel Pauly
CSIRO : Dr. Garth Murphy

Rationale and Objectives

Most tropical fisheries, especially of demersal stocks, are multispecies fisheries. Yet, most models used for stock assessment purposes apply to single species stocks only, and are not very useful for managing multispecies fisheries.

In recent years, a series of conferences has been held to deal with the problem of interactions affecting temperate fish stocks, but none of these conferences dealt explicitly with the much more complex matter of interactions within tropical multispecies stocks.

Objectives of the workshop were:

- To review the databases available for the study of tropical multispecies stocks.
- To review the methodology presently used and/or available to assess tropical multispecies stocks.
- To propose directions for research in the field and at the theoretical level.

Results

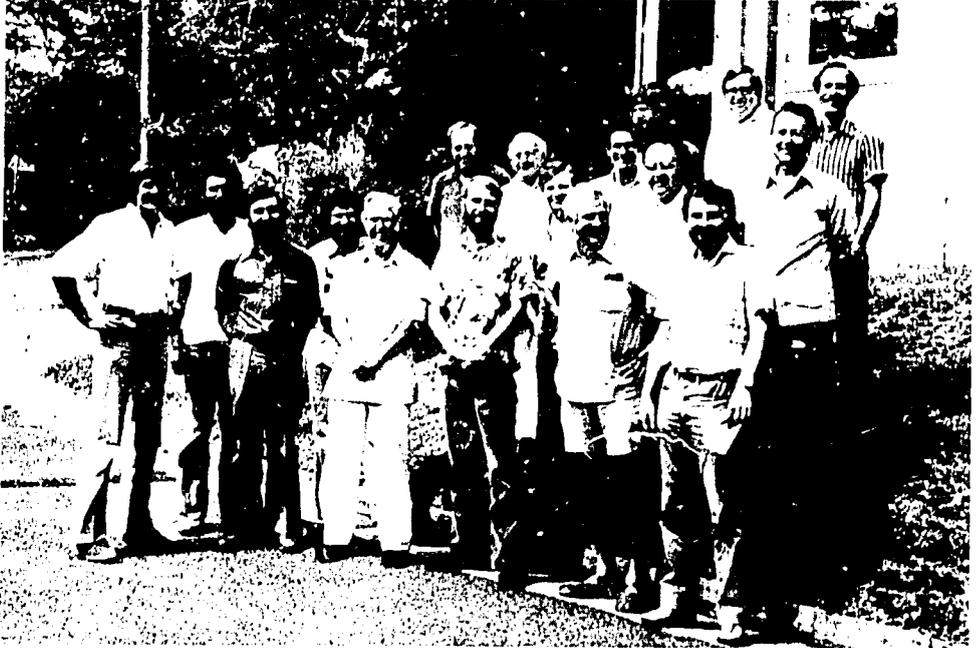
Fifteen invited scientists addressed the various problems of multispecies stock management. The papers presented by the participants are presently being prepared for publication by Drs. Murphy and Pauly, and the workshop proceedings will be published in 1982. The workshop was funded by the Australian Development Assistance Bureau.

The workshop successfully attained its objectives and formulated requirements for follow-up studies, which should be

—management-oriented, i.e., lead toward the formulation of management

options for a given fishery, and
 —geared toward maximum use of data already available, particularly catch-per-effort data from research surveys, and length-frequency data from both surveys and market samplings.

The Management-Oriented Tropical Fisheries Research Network (see p. 75) has been formulated largely on the basis of the recommendation of this workshop.



Above: The participants, L to R: Peter Sale (Sydney Univ.), Daniel Pauly (ICLARM), Keith Sainsbury (CSIRO), Graeme Morris (CSIRO), Peter Larkin (Chairman, Univ. of British Columbia), William Gazey (Univ. of British Columbia), Gerald Marten (East-West Center, Hawaii), John Gulland (FAO, Rome), Rodney Jones (Marine Lab., Aberdeen), Garth Murphy (CSIRO), Maurice James (James Cook Univ., Townsville), D. Gilbert (New Zealand), Richard Neal (ICLARM, observer), Jacek Majkowski (CSIRO), Norm Hall (West-Absent authors: John Marr (U.S.A.), John Munro (Univ. of Papua New Guinea), J. Polovina (NMFS, Hawaii).

- Project Title* : Management-Oriented Tropical Fisheries Research Network
- Cooperating Institutions* : Departments of Fisheries and Universities in Indonesia, Thailand, Malaysia, Philippines and Fiji
- Duration* : Two years for each country
- Key Personnel ICLARM* : Senior Scientist (under recruitment) and Dr. Daniel Pauly
- Others to be determined

Rationale and Objectives

In Southeast Asia and the Pacific Islands, per capita consumption of fish is three to four times higher than the world average of about 10 kg/year. The marine resources, particularly tuna and shrimp, also represent major sources of foreign exchange.

Marine resources, however, are finite and an awareness has developed that increased pressure on these resources has led to widespread manifestations of overfishing, such as decreasing catches and decreasing returns from fishing investments.

In Southeast Asian countries, these effects have brought about, among fishery managers, a marked shift in emphasis away from fishery development (e.g., mechanization of small-scale fishery gears; "soft" loans for fishing ventures) to fishery management (e.g., limiting entry into the fisheries; catch and gear regulations).

The shift of emphasis also brought into focus the urgent need for skilled scientific personnel able to generate management options on the basis of fishery investigations.

The present proposal addresses this problem. It is designed to augment the number of skilled fisheries personnel in the context of a management-oriented fisheries research and training program encompassing five selected countries in Southeast Asia and the South Pacific. This is seen as a key step in the process of strengthening the capabilities of developing countries to manage their own fisheries.

The approach proposed here differs from conventional fisheries development projects in that, rather than generate a large body of new data, the project will concentrate upon in-depth analysis of data presently available

and/or routinely collected by fisheries research vessels of the participating countries.

The project aims at strengthening the capabilities of the participating countries to manage their fisheries. Specifically, the project will:

- Train young fishery scientists from the region in the interpretation of fishery data (especially in extracting a maximum of information from available data) and in formulating implementable management options.
- Help determine, in the countries involved in the project, the basic information requirements for stock assessment and fisheries management.
- Produce well-documented reviews of the various fisheries investigated, original studies on tropical fish population dynamics and a manual in stock assessment methodology suitable for use in the tropics.
- Help establish a dialogue between the fishery managers and the fishery biologists, and between the fisheries departments and the universities of the project's host countries.

By the end of the two-year period, each of the five countries will have a well-trained nucleus of researchers capable of utilizing up-to-date stock assessment techniques and of interpreting results. This core of trained researchers will be the basis for future in-country training of additional workers, for improvement of university curricula and for interaction with administrators setting policies and regulations affecting fisheries.

Two projects are about to commence, the Indonesian and Philippine studies.

Indonesia

Trawl fishery data have been gathered in the last decade off the coasts of Java, Sumatra and Bali, Indonesia, through a number of projects, including Indonesian survey/research projects, two Indonesian-German fisheries development projects, and an international project (JETINDOFISH). These data, obtained at very high cost, have remained largely unanalyzed mainly due to lack of adequate soft- and hardware for data analysis, and of personnel trained in the use of the necessary software. On the other hand, these data have become extremely valuable since they represent benchmark data against which the effects of the recent Indonesian trawling ban could be measured.

The proposed project aims at assisting present efforts by Indonesian scientists to retrieve, computerize and analyze the data in question, as well as to investigate, on the basis of these data, the impacts on the Java Sea stocks of the trawling ban.

Philippines

Fisheries research in the Philippines has to date been fragmented and largely descriptive, with the result that the biology and population dynamics

of the major exploited stocks in the country are not known sufficiently for rational management options to be proposed.

A large amount of data has been collected in the last two decades by various research institutions, notably Bureau of Fisheries and Aquatic Resources and the College of Fisheries of the University of the Philippines. These data, suitably analyzed, could provide a basis for the management of several major stocks and fisheries. Examples include the Manila Bay demersal fishery, on which a vast amount of largely unanalyzed data is available, and the various roundscad fisheries, from which sufficient data may be available to reconstruct time series of management-oriented parameters.

The results of this project will be published in a form that will allow their use as reference and teaching material for courses in fishery biology, both in the Philippines and elsewhere in the tropics.

- Project Title* : Network of Tropical Fisheries Scientists
- Cooperating Institution* : Project based on linkages with scientists working in different institutions and occasional technical workshops
- Duration* : Continuous, beginning 1982
- Key Personnel* ICLARM : Senior Scientist (under recruitment)
Dr. Daniel Pauly

Rationale and Objectives

Scientists working on the population dynamics of tropical fish and shrimp stocks, and on the routine assessment of such stocks are faced with a number of problems, including:

- Lack of continuity of research.
- Limited access to literature on the subject matter.
- Limited communication among research groups, i.e., limited awareness of parallel research efforts or of newly developed methods which could help solve the problems they are tackling.

These problems could be alleviated by establishing an international network of scientists linked-up by a small, informal newsletter through which all involved could be kept informed of ongoing activities, of recent publications, and of relevant meetings. Also, the possibility of arranging meetings of members of the network will be investigated, as well as the possibility of tapping the resources of the group to identify suitable papers for a Reader in tropical fish population dynamics for use as a basic text.

The research network would include, but not be restricted to, scientists participating in the Management-Oriented Fisheries Research Network (see p. 75).

EDUCATION AND TRAINING

Program Overview

Education and training are essential components of all ICLARM programs. Developments in this area are therefore closely linked to activities in other program areas both in terms of subject matter and scope.

However, ICLARM is moving towards an organized program thrust based on guidelines developed in consultation with the Program Advisory Committee. These call for efforts in:

1. Curriculum development relevant to tropical developing countries, planned on the basis of evaluation of:
 - The need for research personnel.
 - Specialized versus general training.
 - The relationships between fishery curricula and problems encountered in the execution of national fishery policies.
2. Specialized training in tropical stock assessment based on existing data, including preparation of simplified training manuals.
3. Training seminars aimed at advising fishery administrators on recent developments in fishery policies, technology and related matters.
4. Training of extension officers and vocational trainees in the context of "training centers."

Since ICLARM could not effectively carry out the last three activities above without first developing its capabilities in the relevant program areas, efforts were first concentrated on developing and demonstrating these capabilities. As this was accomplished for each program area, training and education elements, commensurate with the Center's financial and technical capabilities, were introduced into the various projects.

Progress of Work, 1981

Activities related to Education and Training in the technical program areas have involved a variety of media in many countries.

Aquaculture

Integrated farming methodology developed by the ICLARM-CLSU project was extended through training seminars to the International Institute for

Rural Reconstruction (IIRR), Philippines. The Institute initiated a rural extension program which has already resulted in the establishment of a number of integrated ponds in rural communities. A television documentary film, on the ICLARM-CLSU project and the IIRR rural extension activities, was prepared in cooperation with the National Media Production Center (Channel 4) and aired in September 1981. In addition, and as a result of a different type of "extension"—the exposure of the private sector to the project and its published results—a major agribusiness firm in the Philippines has established a 10-ha pig-fish farm and a second firm is contemplating a similar investment.

Traditional Fisheries

Training was an important element in the success of the San Miguel Bay, Philippines, project. All research assistants were involved in the entire project from data collection and analysis to report writing. In addition, one doctoral and three master's degree students from Germany, Japan, the Philippines and U.S.A. have been affiliated with the project for their theses field work. The University of the Philippines, Visayas, is planning new projects based on experiences gained during the San Miguel Bay study.

Resource Development and Management

The training elements of this program included in-house training of ICLARM interns, by series of lectures given externally and by the supervision of six graduate students working on M.Sc. theses. The interns presently with the project and working under the guidance of Dr. Pauly are Mr. Jose Ingles (M.Sc.), from the University of the Philippines, College of Fisheries, who is working on growth and mortality parameter estimates on Philippine fishes; and Mr. Ranin Regalado, Bureau of Fisheries and Aquatic Resources (BFAR), Philippines, who has completed an analysis of data on the demersal resources of the Philippines that have been gathered by BFAR over a period of several years. Comprehensive reports based on the data obtained by these two interns will be published in 1982.

External lecturing involved a one-semester course, October 1980 to March 1981, in the "Management of Aquatic Resources" given at the University of the Philippines, Department of Zoology; a week of lectures at the FAO/DANIDA Training Course on the Methodology of Fisheries Sciences, Mombasa, Kenya, in May 1980. The lecture notes on simple methods of stock assessment were subsequently published by FAO; a series of lectures at the FAO/SCSP course in Fisheries Stock Assessment and Fishery Statistics, Bangkok, September-October 1981; and lectures in tropical stock assessment given at the Instituto del Mar de Peru during Dr. Pauly's visit there in November-December 1981.

The theses presently supervised by Dr. Pauly are of students enrolled at

the University of the Philippines. The Departments involved in marine research (College of Fisheries, Department of Zoology, Marine Sciences Center) have not hitherto focused on quantitative research on Philippine commercial fish stocks.

The theses cover the following areas:

- Growth and mortality of leiognathid fishes in Manila Bay.
- Studies on stocks and fisheries of *Caesio* species at Sumilon Island (a coral reef island).
- Aging of rabbitfish (*Siganus*) by means of daily otolith rings (the student working on this is recipient of a PCARR/ICLARM Graduate Scholarship).
- Stocks and fisheries of yellowfin tuna in the southern Philippines, including a study of a payao fishery for tuna.
- Selectivity in a hook-and-line fishery for yellowfin tuna in La Union Province.
- Population dynamics of Abo (*Otolithes ruber*) in San Miguel Bay.

There were also two activities in Education and Training not directly related to the technical programs:

Graduate Study Program in Aquatic Resources

This joint activity with the Philippine Council for Agriculture and Resources Research (PCARR), got underway late in 1980 and has supported the research of four graduate students working towards their M.Sc. degree.

ICLARM monitored progress of the research. The project concluded in October 1981. Theses topics were:

- Production of marine fungal proteins as feed in the culture of shrimp postlarvae.
- The growth of rabbitfish in the wild and in captivity: a comparative study.
- The role of institutions and resource environment in agricultural development: a study of access to fishery resource use in San Miguel Bay, Philippines.
- Environmental factors affecting the survival of milkfish fry and fingerlings.

Curriculum Development

Discussions were held with fisheries faculty members of the University of the Philippines, Visayas and Diliman campuses, on several occasions during the year. ICLARM has agreed to assist the UP with curriculum development in the fisheries field. A number of possible areas for collaboration were discussed and textbook development is one which seems best suited for a cooperative undertaking. A basic text on the principles of aquaculture has been proposed as the first in a series of possible contributions. Discussions on this topic are continuing.

Program of Work, 1982

The coming year will see further expansion in this program area encompassing subject matter in aquaculture, social sciences (traditional fisheries) and stock assessment. Most of the increased activity represents expansion on past projects in the three technical program areas, including:

Aquaculture

- *Training in Milkfish Production Economics, Philippines.* The second phase of this project (p. 21) involves preparation of training material for fisheries extension officers.

Resource Development and Management

- *Research and Training in Tropical Stock Assessment.* This regional project will include training of young fishery scientists in the interpretation of fishery data (p. 72).

Traditional Fisheries

- *Research and Education in Fisheries Social Sciences.* One of the goals of the proposed regional Fisheries Social Science Network (p. 66) is to provide a means of improving the quality of such research through workshops, etc.
- *Fisheries Economics Reader.* A reader in fisheries economics is being prepared, containing 12-15 previously published theoretical and applied research papers, focusing on Southeast Asia, particularly Indonesia. The volume will be produced in Bahasa Indonesia, and is part of a program by the Obor Foundation (U.S.A.) to assist production of Indonesian-language books relating to community and national issues. Editing of the book will be a cooperative task between personnel from ICLARM, the Indonesian Directorate General of Fisheries and the Agricultural Development Council.

INFORMATION SERVICE

ICLARM's Information Service consists of two basic elements, a library and publications unit, designed to serve the scientific staff. As predicted in the previous 3-year report, this section has grown from an in-house service to take part in activities leading towards development of efficient, regional information systems in fisheries.

Information Systems

With regard to in-house services, we have been able to simplify identification and retrieval of much relevant literature by (i) obtaining a teletype facility which provides direct links on-line to the western world's scientific databases and (ii) accessing the vast, U.S.A. inter-library computer network via the University of Hawaii's Hamilton Library.

Through the teletype facility, we have begun searching interactively the DIALOG system of over 120 databases, including Aquatic Science and Fisheries Abstracts, Aquaculture, Oceanic Abstracts and Biological Abstracts. As the editor was able to attend training courses on the use of the DIALOG system during visits to information groups overseas prior to the installation of the terminal, the latter was put to immediate use.

As to (ii), literature access, the research library of the University of Hawaii is computer-linked to a large number of similar U.S. scientific libraries. Their combined holdings can be investigated from any single terminal in the network; inter-library loan requests are transmitted instantaneously and rapid feedback facilitates document retrieval. ICLARM has made arrangements to use this network, which has already proven invaluable in retrieval of bibliographic material. Use of this system complements our new accessibility to the computerized databases.

ICLARM's special library fills some of the literature gap that computer databases and western libraries leave and we are making progress in devising optimum means of closing the remaining gap. The information gap has two aspects, the language problem and the broader unconventional literature phenomenon.

Foreign-language publications are a problem of such magnitude that we can tackle only a small portion. The first of ICLARM's translation series has been deposited with Transindex register in Chicago, reportedly the biggest "central" register. We have made arrangements with the editors of a major fishery journal in Taiwan and another in mainland China to facilitate translation of interesting material; contacts have been made in Japan, and

ad hoc translations continue in Thailand.

Unconventional or "grey" literature (neglecting the compounding language problem) is potentially the more readily solved issue. During 1981, we explored the available and proposed information systems in the Southeast Asian region. There is no existing fisheries system and this situation has led to dialogue between ICLARM and various donor, information and fisheries organizations, including the Agricultural Information Bank for Asia (AIBA), Agricultural Research Information System (AGRIS), Aquatic Science and Fisheries Information System (ASFIS), IDRC and SEAFDEC.

AIBA produces the quarterly bibliographic index AGRIASIA, which contains much unconventional literature from the region. There is a substantive network of input centers, many of which also supply citations for fisheries documents, and it seems that a relatively modest effort to reinforce the fisheries input may be adequate to initiate a regional database. Discussions with the various organizations are continuing.

Publications

Since the last report, all five technical publication series have become established, with six *Studies and Reviews*, six *Conference Proceedings*, two *Technical Reports*, two *Bibliographies* and one *Translations* in all. This output, to which must be added the 4-year old quarterly *Newsletter*, makes ICLARM one of the largest scientific publishers in the Philippines.

In addition, a great deal of material emanates from ICLARM staff and requires (sometimes multiple) editing before release to outside publishers. One measure of this material is the number of ICLARM published contributions. At the time of the last report, there were 32 contributions to the literature, spanning six years, 1975-80. This number increased to 60 during 1980-81. In addition to these published contributions were several unpublished conference papers and miscellaneous manuscripts.

Escalating costs of publications and distribution have prompted negotiations with overseas distributors, advertising and appearances in exhibitions. ICLARM participated in the International Book Fair, Manila, November 1981, and further exhibits are planned.

Given ICLARM's finite space and growing number of publications, external storage became necessary early in 1981. A large, airconditioned room has been leased.

Library

Book and monograph holdings are increasing at a steady pace, currently 2,950 volumes. The Editor is overseeing purchase requests to avoid "subject duplication," the present practice of publishers. Prices of specialty (low

volume) books, it should be noted, are increasing, while quality is problematical.

The number of Journal titles received (365) has remained constant. A regional newsclipping service is now used to retrieve relevant newspaper articles.

The decision has been taken to add microfiche reading/printing capability to the library in view of space limitations and the potential saving in mailing charges.

The librarian is involved in preparation of several annotated bibliographies, which require retrieval of a large number of documents. Our new umbrella arrangement with the University of Hawaii has reduced much of the time-consuming searching through union catalogs, etc. The on-line facility, of course, multiplies ICLARM's capacity to prepare bibliographies and background project material.

The library is well used. Professional staff borrowed over 500 technical documents, apart from materials used within the library, over the 12 months to August 1981. In the same period over 100 persons from 25 other local and overseas institutions used the library as well as 64 students from various tertiary institutions and a number of private individuals.

The librarian receives frequent requests for advice on various matters associated with library practice. In 1981, three trainees from a local college have each spent six months in the library learning aspects of librarianship.

Audio-visual

ICLARM has a growing collection of transparencies (slides) and photographs relevant to its operations. Such audio-visual material has been found very useful for in-house activities, such as committee meetings, and information for visitors. In fact, since ICLARM's projects are scattered throughout tropical, developing countries, this approach is the only practical way of familiarizing staff and visitors with project progress.

In 1981, ICLARM's audio-visual capability was upgraded with the acquisition of additional slide projectors and synchronizing unit for matching sound with slide showings. Routine and special sound/slide shows on various ICLARM programs and projects will be produced in the future.

Program of work, 1982

The activities of the Information Service form a continuum. The goal of establishment of a regional fisheries information retrieval system will continue to be pursued. Techniques towards greater efficiency will continue to be explored.

The efficiency of information handling within ICLARM is gradually

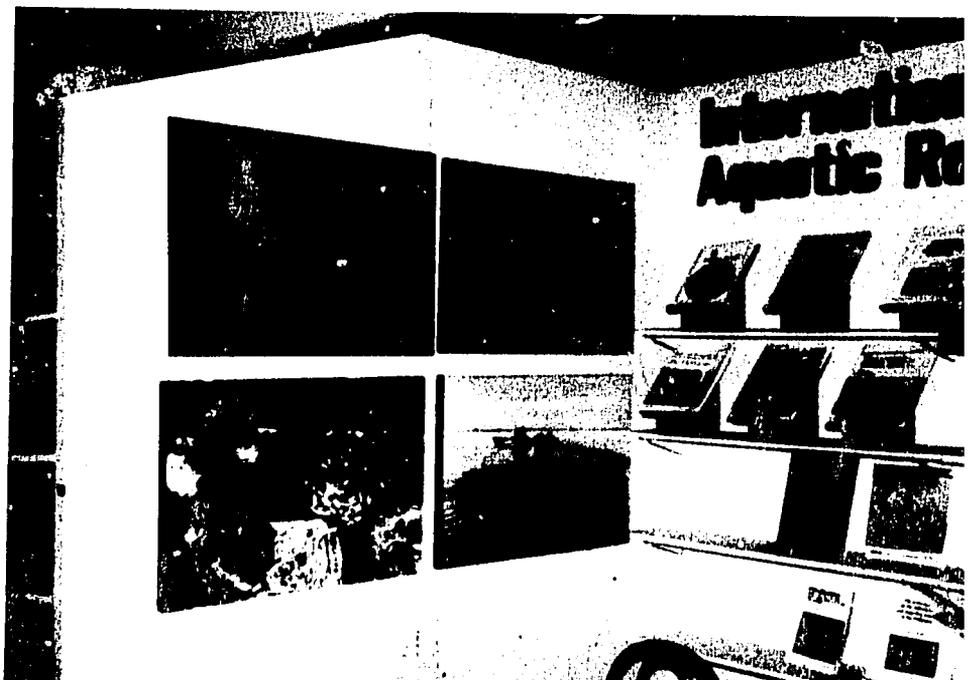
decreasing with increasing demands. These range from publication mailing lists, of which there are several for each production, to project data. The latter are currently processed 60 km away at the University of the Philippines, Los Baños campus.

Given the growing activities in all spheres of ICLARM's operations, there is immediate need to computerize the publication mailing lists, accounting and filing systems, and to process existing project data at a more accessible site. In the longer term, it is also desirable to automate the library holdings and photo/slide holdings.

The Information Service has been investigating alternative means of accommodating these needs. A suitable large computer with several terminals would be ideal, but would cost over \$100,000 plus operator and maintenance. Single-terminal desktop microcomputers were investigated by a computer consultant. These begin at around \$10,000, but ICLARM would require several such machines, which are also much slower and cumbersome. Recent discussions with the Technology Resource Center (TRC), a Philippine government corporation, have led to an agreement with them to transfer existing data to their large UNIVAC computer in Manila and to handle new project data from both our field and in-house projects. In addition, TRC can provide direct linkage to their computer, by means of one or more terminals and a printer in ICLARM's offices. It is hoped to proceed further towards full automation during 1982.



ICLARM exhibited at two International book fairs in Manila in 1981. Attendance at further exhibitions and other promotional activities are planned for 1982. Above: ICLARM personnel arranging the display. L to R. Ben Bayron, Roberto Bugay, Ramon Estarez, Letty Dizon. Below: section of the display.



ADVISORY SERVICES

AS ICLARM has become more widely recognized and the professional staff have become acknowledged authorities in their disciplines, requests for advice and consultation have increased dramatically. These requests, not all of which could be accommodated in view of the limitations of staff time, have come from most parts of the third world.

A summary of services provided over the past 18 months follows.

Aquaculture

The ICLARM aquaculture staff provided advisory technical services to several national and international organizations:

- Dr. C-M. Kuo served as an adviser to the United States Agency for International Development (USAID)-sponsored Cooperative Marine Technology Program for the Middle East at a meeting 27-30 August 1980 in San Diego, California. This was a research planning and organizational meeting for the cooperative research to be conducted in the Middle East.
- Dr. Kuo also served as an adviser to USAID 15-20 December 1980, in Jakarta on the design of facilities and equipment for two new aquaculture research stations in Indonesia.
- Dr. Kuo worked with the Center for Advanced Studies in Mariculture at the Central Marine Fisheries Research Institute, Cochin, India, during the period 11-30 April 1981, on a UNDP/FAO/ICAR project. This work involved training on reproductive physiology, and advice on research projects and facilities.
- Dr. Kuo returned to Indonesia during 11-22 May and 15-19 June 1981 as an adviser to the International Agricultural Development Service (IADS) to complete recommendations on the design, construction, and staffing of the research stations.
- Dr. R.S.V. Pullin served as a consultant to UNESCO/UNDP in Thailand during April and May 1981 on the development of graduate courses in marine physiology at Chulalongkorn University, at the end of which he prepared for UNESCO a report on Improvement of Marine Science Education.

- Dr. R.A. Neal reviewed a fisheries development project for the National Economic Development Authority (NEDA), Philippines, and prepared a set of recommendations for improvement of the project for the Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office in Cebu in May 1981.
- Drs. Pullin and Kuo worked with BFAR and the Cagayan Integrated Agricultural Development Project (Philippines) to assess the potential for mullet production along the northern coast of Luzon. They visited proposed sites for hatcheries and research facilities, and reviewed available information on important mullet species in the area.
- Drs. K.D. Hopkins and Pullin assisted the International Institute for Rural Reconstruction in the Philippines in their demonstration and extension activities on integrated animal-fish farming.
- ICLARM has established a strong cooperative relationship with the Aquatic Biotic Resources Program (BIO-AQUA) of the Instituto Nacional de Investigaciones sobre Recursos Bioticos (INIREB) in Mexico as a result of advisory visits during 1981 by Dr. Conner Bailey and by Drs. Pullin and Hopkins.

Assistance with research planning and transfer of Asian aquaculture technology was provided in relation to both integrated farming and tilapia culture. BIO-AQUA is focusing on rural development through extension of integrated farming and increased use of coastal ecosystems and is experimenting with raised bed horticulture-livestock-fish systems based on an ancient Mayan "chinampa" farming methodology for use of water-logged lowlands. Dr. Pullin prepared a method sheet for INIREB researchers to assess the genetic purity of their tilapia stocks.



Chinampas cut in lake shore, El Castillo, Vera Cruz, Mexico.

Traditional Fisheries

ICLARM was invited to lend its multidisciplinary expertise to the planning of USAID activities in coastal zone management in the Philippines. This culminated in a two-day seminar, during which ICLARM's experiences with the San Miguel Bay project were used as a case study. Essentially, the problems are those of small-scale fishermen. ICLARM was represented by sociologist Dr. Conner Bailey, aquaculturist Dr. Richard Neal, fishery biologist Dr. Daniel Pauly and economist Dr. Ian Smith. ICLARM also prepared a detailed report on the meeting for USAID.

Resource Development and Management

Dr. Pauly has undertaken a number of activities at the request of FAO agencies:

- Provided a series of lectures at the FAO/DANIDA training course on fishery science methodology in Mombasa, Kenya, May 1980. The lecture notes were later published by FAO.
- Advised on worthwhile oceanographic research topics useful for fisheries scientists in developing countries, as a member of the "Group of 4", a gathering of scientists at FAO headquarters, Rome, October 1980. The report was widely circulated by UNESCO/IOC among biological oceanographers.
- Gave a series of lectures at the joint FAO Regional Training Course on Stock Assessment and Fishery Statistics, Thailand, September 1981.

In addition, two projects in Latin America were visited by Dr. Pauly in November and December 1981 as a result of requests by the respective institutions:

- A three-week consultancy, funded by GTZ, at the Instituto del Mar del Perú, including advice and a series of lectures on stock assessment methodology. The request was from a joint Germany-Peru fisheries project.
- A three-day visit to the ODA (England) Fisheries Development Project in Ecuador to assist in interpretation of project data.

Daniel Pauly lecturing at stock assessment training course, Bangkok, September 1981.



CONFERENCES, SYMPOSIA, COURSES AND WORKSHOPS ATTENDED

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|---------------------|---|
| 3-7 March 1980 | Vith World Congress of the International Association of Agricultural Librarians and Documentalists, Manila, Philippines
J.L. Maclean, E. Barile, H. de Castro |
| 19-23 April 1980 | *Conference on Food Producing Systems for Arid and Semi-Arid Lands, Kuwait Institute for Scientific Research, Kuwait
C-M. Kuo, R.S.V. Pullin |
| 19 May-4 June 1980 | *FAO/DANIDA Training Course on the Methodology of Fisheries Sciences, Mombasa, Kenya
D. Pauly |
| 21-23 May 1980 | 19th Session, Indo-Pacific Fishery Commission, Kyoto, Japan
I.R. Smith, C. Bailey |
| 5-8 August 1980 | Program Committee, SEAFDEC (Manila)
R.A. Neal |
| 7-12 August 1980 | 5th World Congress for Rural Sociology, Mexico City
C. Bailey |
| 18-23 August 1980 | International Federation of Library Associations and Institutions (IFLA), 46th General Conference, Manila, Philippines
E. Barile, H. de Castro |
| 19-23 August 1980 | *1980 Annual Meeting of the Rural Sociological Society, Cornell University, New York, U.S.A.
C. Bailey |
| 2-5 September 1980 | ICLARM Conference on the Biology and Culture of Tilapia, Bellagio, Italy
R.S.V. Pullin (co-Chairman) |
| 8-12 September 1980 | First Coordination Meeting on the UNU Water-Land Interactive Systems Project, United Nations University, Kagoshima, Japan
R.S.V. Pullin, I.R. Smith, K-C. Chong |

- 15-17 September 1980 ***International Symposium on Biogas, Microalgae and Live-stock Wastes, Taipei, Taiwan**
K.D. Hopkins
- 6-10 October 1980 ***International Council for the Exploration of the Sea, 68th Statutory Meeting (Copenhagen)**
D. Pauly
- 14-17 October 1980 **Meeting of the "Group of 4 Scientists" sponsored by FAO and UNESCO/IOC (Rome)**
D. Pauly
- 27-28 October 1980 **National Convention of the Philippine Fishery Industry (Manila)**
K-C. Chong
- 27-30 October 1980 **IDRC Small-Scale Fisheries Workshop, Colombo, Sri Lanka**
I.R. Smith
- 11-15 November 1980 **Council Meeting, SEAFDEC (Bangkok)**
R.A. Neal
- 7-8 January 1981 ***Fisheries Society of the British Isles Symposium on Sexuality in Fish (Birmingham, U.K.)**
R.S.V. Pullin
- 12-21 January 1981 ***ICLARM/CSIRO Workshop on the Theory and Management of Tropical Multispecies Stocks (Cronulla, Australia)**
D. Pauly, R.A. Neal
- 27-29 January 1981 **IPFC Committee for Development and Management of Fisheries of the South China Sea (Manila)**
R.A. Neal
- 16-21 February 1981 **ADB/ICLARM Workshop on Appropriate Technology for Alternative Energy Sources in Fisheries, Manila**
I.R. Smith, A.O. del Mundo
- 6-10 March 1981 **World Mariculture Society (Seattle)**
R.A. Neal
- 18-22 May 1981 **Aquatic Sciences and Fisheries Abstracts (ASFA) Editorial Meeting, Lisbon, Portugal**
J.L. Maclean
- 18-22 May 1981 ***4th International Coral Reef Symposium (Manila)**
D. Pauly

- 2-5 June 1981 ***IDRC/ICLARM Economics of Aquaculture Research Workshop, Singapore**
I.R. Smith, K-C. Chong
- 22 June 1981 **UNDP/FAO-NACA/SEAFDEC/UPV Training Programme for Aquaculturists in Asia and the Pacific Region, Iloilo, Philippines**
R.S.V. Pullin
- 21 August 1981 **Potentials of Integrated Aqua-Agriculture (Manila)**
R.S.V. Pullin
- 24-28 August 1981 ***American Sociological Association, Toronto, Canada**
C. Bailey
- 1-9 October 1981 ***Regional Training Course on Fishery Stock Assessment and Fishery Statistics, sponsored by the Asian Development Bank, FAO/South China Sea Program, FAO-SIDA and Government of Thailand (Samutprakarn, Thailand)**
D. Pauly
- 5-8 October 1981 ***International Council for the Exploration of the Sea, 69th Statutory Meeting (Woods Hole, U.S.A.)**
D. Pauly
- 20 October 1981 **Factors Affecting Fish Production in Shallow, Tropical Lakes, with Particular Reference to Lake George, Uganda. Seminar at ICLARM, Manila**
C-M. Kuo, R.A. Neal, D. Pauly, R.S.V. Pullin, Z.H. Shehadeh
- 5-6 November 1981 **Coastal Zone Management Seminar-Workshop, Manila, sponsored by USAID Philippines**
C. Bailey, R.A. Neal, D. Pauly, I.R. Smith
- 18-24 November 1981 ***FAO/NOAA Workshop on the Scientific Basis for the Management of Penaeid Shrimps (Key West, Florida)**
D. Pauly

- 3-5 December 1981 **First Advisory Committee Meeting of the FAO Network of Aquaculture Centers in Asia, Iloilo, Philippines**
R.S.V. Pullin
- 7-11 December 1981 **9th International Symposium on Comparative Endocrinology, Hong Kong**
C-M. Kuo
- 13-15 December 1981 **Round Table Discussion on the Reproductive Endocrinology of Warm-Water Fishes, Tigbauan, Iloilo, Philippines**
C-M. Kuo
- 16-17 December 1981 ***The International Conference on Endocrinological Application to Animal Culture, Taipei, Taiwan**
C-M. Kuo

*Paper presented. See Papers Presented at Conferences and Seminars.

PAPERS PRESENTED AT CONFERENCES AND SEMINARS

- *Bailey, C. 1980. Social and economic aspects of small-scale fisheries development: a case study from Malaysia. Paper presented at the 19th Session Indo-Pacific Fishery Commission, Kyoto, Japan, 21-23 May 1980.
- Bailey, C. 1980. Social consequences of economic organization: a comparison of three rural Malay communities. Paper presented at the Annual Meeting of the Rural Sociological Society, Cornell University, New York, 19-23 August 1980.
- Bailey, C. 1981. Natural resource management: a basis for viable organizations of small-scale fishermen. Paper presented to the American Sociological Association, Toronto, Canada, 24-28 August 1981.
- *Chong, K-C. and M.S. Lizarondo. 1981. Input-output relationships of Philippine milk-fish aquaculture. Paper presented at the IDRC/ICLARM Economics of Aquaculture Research Workshop, Singapore, 2-5 June 1981.
- *Gaschütz, G., D. Pauly and N. David. 1980. A versatile BASIC program for fitting weight and seasonally oscillating length growth data. Paper presented at the 68th Statutory Meeting, International Council for the Exploration of the Sea, Copenhagen, 6-10 October 1980.
- *Hopkins, K.D. et al. 1980. Optimum manure loading rates in tropical freshwater ponds receiving untreated piggery wastes. Paper presented at the International Symposium on Biogas, Microalgae and Livestock Wastes, Taipei, Taiwan, 15-17 September 1980.
- Kuo, C-M. 1981. The use of hormones in controlled breeding of fishes. Paper presented at the International Conference on Endocrinological Application to Animal Culture, Taipei, 16-17 December 1981.
- *Pauly, D. 1980. A selection of simple methods for the assessment of tropical fish stocks. Lectures given at the FAO/DANIDA Training Course on the Methodology of Fisheries Sciences, Mombasa, Kenya, 19 May-4 June 1980.
- *Pauly, D. 1981. The nature, investigation and management of tropical multispecies fisheries. Lectures given at the Joint FAO Regional Training Course on Fishery Stock Assessment and Fishery Statistics, Samutprakarn, Thailand, 1 September-9 October 1981.

- *Pauly, D. 1981. Stock assessment packages for programmable calculators and micro-computers: two examples, with a discussion of their potential usefulness in developing countries. Paper presented at the 69th Statutory Meeting, International Council for the Exploration of the Sea, Woods Hole, U.S.A., 5-14 October 1981.
- *Pauly, D. 1981. Studying single-species dynamics in a multispecies context. Paper presented at the ICLARM/CSIRO Workshop on the Theory and Management of Tropical Multispecies Stocks, held in Cronulla, Australia, 12-23 January 1981.
- *Pauly, D. and J. Ingles. 1981. Aspects of the growth and mortality of exploited coral reef fishes. Paper presented at the Fourth International Coral Reef Symposium, Manila, 18-22 May 1981.
- *Pauly, D., J. Ingles and R.A. Neal. 1981. Application to shrimp stocks of objective methods for the estimation of growth, mortality and recruitment-related parameters from length-frequency data (ELEFAN I and II). NOAA/FAO Workshop on the Scientific Basis for the Management of Penaeid Shrimps, Key West, Florida, 18-24 November 1981.
- *Pauly, D. and N. David. 1980. A BASIC program for the objective extraction of the growth parameters from length-frequency data. Paper presented at the 68th Statutory Meeting, International Council for the Exploration of the Sea, Copenhagen, 6-10 October 1980.
- Pullin, R.S.V. 1981. The current status of induced spawning techniques in finfish culture. Paper presented at a symposium on Induced Spawning—The Answer to Seed Supply? ; seminar at the UNDP/FAO-NACA/SEAFDEC/UPV Training Programme for Aquaculturists in Asia and the Pacific Region, Iloilo, Philippines, 22 June 1981.
- Pullin, R.S.V. 1981. Low temperature storage of fish gametes and embryos. Paper presented at the Fisheries Society of the British Isles Symposium on Sexuality in Fish, Birmingham, U.K., 7-8 January 1981.
- *Pullin, R.S.V. and C-M. Kuo. 1980. Developments in the breeding of cultured fishes. Paper presented at the Conference on Food Producing Systems for Arid and Semi-Arid Lands, Kuwait Institute for Scientific Research, Kuwait, 19-23 April 1980.
- *Smith, I.R. 1981. Micro-economics of existing aquaculture production systems: basic concepts and definitions. Paper presented at the IDRC/ICLARM Economics of Aquaculture Research Workshop, Singapore, 2-5 June 1981.
- *Smith, I.R. and R. Pestaño-Smith. 1980. Seaweed farming as alternative income for small-scale fishermen. a case study. Paper presented at the 19th Session Indo-Pacific Fishery Commission, Kyoto, Japan, 21-23 May 1980.

Papers by Project Staff

- *Lee, C-S. 1981. Milkfish system economics of Taiwan. Paper presented at the IDRC/ ICLARM Economics of Aquaculture Research Workshop, Singapore, 2-5 June 1981.
- *Sevilleja, R.C. 1981. Economic analysis of integrated pig-fish farming operations in the Philippines. Paper presented at the IDRC/ICLARM Economics of Aquaculture Research Workshop, Singapore, 2-5 June 1981.
- *Wattanutchariya, S. and T. Panayotou. 1981. The economics of aquaculture: the case of catfish in Thailand. Paper presented at the IDRC/ICLARM Economics of Aquaculture Research Workshop, Singapore, 2-5 June 1981.

*Paper subsequently published (see Publications) or to be published.

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- Bailey, C. 1980. Social and economic aspects of small-scale fisheries development: a case study from Malaysia. Proc. Indo-Pacific Fish. Comm. 19(III): 702-714.
- Bardach, J.E., J.J. Magnuson, R.C. May and J.M. Reinhart, Editors. 1980. Fish behavior and its use in the capture and culture of fishes. ICLARM Conference Proceedings 5. 512 p.
- Chonchuenchob, P., K. Chalayondeja and K. Muttarasin. 1980. Hanging culture of the green mussel (*Mytilus smaragdinus* Chemnitz) in Thailand. ICLARM Translations 1. 12 p.
- Cruz, E.M. and Z.H. Shehadeh. 1980. Preliminary results of integrated pig-fish and duck-fish production tests, p. 225-238. In R.S.V. Pullin and Z.H. Shehadeh (eds.) Integrated agriculture-aquaculture farming systems. ICLARM Conference Proceedings 4. 258 p.
- Edwards, P. 1980. Food potential of aquatic macrophytes. ICLARM Studies and Reviews 5. 51 p.
- Gaschütz, G., D. Pauly and N. David. 1980. A versatile program for fitting weight and seasonally oscillating length growth data. I.C.E.S. CM 1980/D:6. Statistics Committee. 14 p.
- Hopkins, K.D. and E.M. Cruz. 1980. High yields but still questions: three years of animal-fish farming. ICLARM Newsletter 3(4): 12-13.
- Hopkins, K.D., E.M. Cruz, M.L. Hopkins and K-C. Chong. 1981. Optimum manure loading rates in tropical freshwater fish ponds receiving untreated piggery wastes, p. 15-29. In The ICLARM-CLSU integrated animal-fish farming project: poultry-fish and pig-fish trials. ICLARM Technical Reports 2. 29 p.
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- Maclean, J.L., Editor. 1980. ICLARM Report 1977-1980. 168 p.

- Meltzoff, S.K. 1980. Anthropologist conducts study of skipjack tuna fisheries in Solomon Islands. ICLARM Newsletter 3(2): 13.
- Nash, C.E. and Z.H. Shehadeh, Editors. 1980. Review of breeding and propagation techniques for grey mullet, *Mugil cephalus* L. ICLARM Studies and Reviews 3. 87 p.
- Neal, R.A. 1980. Recent support for aquaculture by USAID. ICLARM Newsletter 3(4): 10.
- Pauly, D. 1980. A new methodology for rapidly acquiring basic information on tropical fish stocks: growth, mortality and stock-recruitment relationships, p. 154-174. *In* S.B. Saila and P.M. Roedel (eds.) Stock assessment for tropical small-scale fisheries. Proceedings of an International Workshop, University of Rhode Island, Kingston, R.I., 19-21 September 1979. International Center for Marine Resource Development, University of Rhode Island, Kingston.
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- Pauly, D. 1981. The relationship between gill surface and growth performance in fishes: a generalization of von Bertalanffy's theory of growth. *Meeresforsch.* 28(4): 251-282.
- Pauly, D. 1981. Stock assessment packages for programmable calculators and microcomputers: two examples, with a discussion of their potential usefulness in developing countries. International Council for the Exploration of the Sea, CM 1981/D:2 Statistics Committee. 19 p.
- Pauly, D. 1981. Tropical stock assessment packages for programmable calculators and microcomputers. ICLARM Newsletter 4(3): 10-13.
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- Pauly, D., N. David and J. Ingles. 1980. ELEFAN I: Users' instruction and program listing. Mimeo. pag. var.
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- Pullin, R.S.V. 1981. Fish pens of Laguna de Bay, Philippines. ICLARM Newsletter 4(4): 11-13.
- Pullin, R.S.V. 1981. Summary Report of the ICLARM Conference on the Biology and Culture of Tilapias, Bellagio, Italy, 2-5 September 1980. ICLARM Conference Proceedings 6. 13 p.
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- Lee, C-S. 1981. Production and marketing of milkfish in Taiwan. National Chung Hsing University, Taichung, Taiwan. (In Chinese). (English version to be published by ICLARM in 1982).
- Lee, C-S. 1981. An economic analysis of milkfish production in Taiwan. J. Agric. Econ. (Taiwan) 29: 1-30. (In Chinese with English abstract).



The end result of linkages and cooperative projects is alleviation of the results of this problem: many fishermen, few fish. Photo by K-C. Chong.

LINKAGES, AGREEMENTS

Axiomatic to the formulation and successful implementation of ICLARM's programs is the initiation and maintenance of institutional linkages through memoranda of agreement and understanding and the subsequent undertaking of cooperative projects with organizations operating with similar or related program thrusts.

During the report period, ICLARM maintained formal agreements with eight institutions. A further 24 donor and research organizations also cooperated with ICLARM in various activities. The formal agreements include:

- **Council for Agricultural Planning and Development, Government of Taiwan**

Commencing on May 1981 is a 3-year cooperative program of research in aquacultural problems of national and regional importance. The first project is on the culture potential of tilapias in saltwater.

- **Research Institute of Agricultural Economics, National Chung Hsing University (Taiwan)**

An agreement signed June 1980 to undertake joint projects related to fisheries and aquaculture development and management. Under the continuing agreement is the June 1980-May 1981 study of the production and marketing of milkfish in Taiwan.

- **Central Luzon State University (Philippines)**

A three-year agreement for research on integrated farming concluded in 1981.

In 1979 began the 5-year Cooperative Program of Research and Training in Aquaculture and Inland Fisheries. Three projects were undertaken during the Report period under this agreement.

- **Southeast Asian Regional Center for Graduate Study and Research in Agriculture (Philippines)**

Agreement was reached in February 1978 for continuing collaboration on areas of mutual concern: 1) development and conduct of training

courses, 2) pursuit of research, 3) promotion of transfer of technologies in fisheries and related fields, and 4) any other project or activity which is of mutual interest to ICLARM and SEARCA.

- **Department of Technical and Economic Cooperation, Government of Thailand**

The Center provides technical assistance to the Thai Department of Fisheries for applied research in coastal aquaculture. The program, in support of the Thai Government's national aquaculture development plan, deals specifically with shellfish farming.

- **Kasetsart University Research and Development Institute (Thailand)**

Under the continuing agreement signed September 1979 to collaborate and assist each other in pursuit of research projects related to fisheries and aquaculture development and management, is the study on catfish production economics in Thailand. The analysis of data was completed in 1981.

- **Ministry of Natural Resources (MNR), Government of the Philippines**

The memorandum of agreement signed in October 1979 for continuing collaboration and mutual assistance in projects or activities of mutual interest permitted joint projects to be undertaken during the report period with the Bureau of Fisheries and Aquatic Resources and the Fishery Industry Development Council within that Ministry.

- **Philippine Council for Agriculture and Resources Research, Government of the Philippines, who administered a 2-year graduate scholarship scheme in living aquatic resources management, which ended in October 1981.**

The following donor and research organizations also provided support for or cooperation with various projects:

Aquaculture Production Technology Ltd., Israel

Asian Development Bank

Australian Development Assistance Bureau

Bureau of Fisheries and Aquatic Resources, Philippines

Bureau of Agricultural Economics, Philippines

Commonwealth Scientific and Industrial Research Organization, Australia

Directorate General of Fisheries, Indonesia
Egyptian Academy of Scientific Research and Technology
Food and Agriculture Organization
Fishery Industry Development Council, Philippines
German Agency for Technical Cooperation
Institute of Fisheries Development and Research, University of the
Philippines
International Agricultural Development Service
International Development Research Centre, Canada
Israel Oceanographic and Limnological Research Ltd.
Kuwait Institute for Scientific Research
Marine Fisheries Research Institute, Indonesia
New Jersey Marine Science Consortium
Rockefeller Foundation, U.S.A.
Thailand Department of Fisheries
United Nations Development Programme
United Nations Educational, Scientific and Cultural Organization
United Nations University, Japan
United States Agency for International Development

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Kevin D. Hopkins, Ph.D.	Senior Research Fellow*
Edward W. McCoy, Ph.D.	Team Leader, Thailand Project*
Ronald F. Ventilla, Ph.D.	Marine Biologist, Thailand Project*
Mrs. Erlinda Miralles, B.S.	Secretary, Aquaculture/Resource Development and Management

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David Moriarty	CSIRO, Fisheries and Oceanography Australia	Planning for detritus workshop	November 1981
John L. Munro	Department of Primary Industry, Papua New Guinea	Program advice, Resource Development and Management	October 1981
Philip Roedel	San Francisco, U.S.A.	Special advisor, overseas	Continuous
David Thomson	Edinburgh, U.K.	Alternative energy in fisheries (workshop)	January- March 1981

PROGRAM ADVISORY COMMITTEE

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**Elected 1981 to serve 1982.

STATEMENT OF SOURCES AND APPLICATION OF FUNDS
(US \$)

SOURCES OF FUNDS:	1980	1981
Grant—1. Unrestricted:		
Rockefeller Foundation	750,000	812,000
USAID	250,000	250,000
Australian Development Assistance Bureau	—	22,000
—2. Restricted:		
Australian Development Assistance Bureau	57,845	—
Central Luzon State University*	48,761	35,362
United Nations University	20,000	20,000
New Jersey Marine Science Foundation	10,000	6,000
Rockefeller Foundation	22,795	32,947
GTZ-Thailand Project	—	55,234
United Nations Development Programme	—	15,292
Philippine Council for Agriculture and Resources Research	—	2,850
Others:		
Consultancy Fees	5,552	15,224
Publication Income	1,496	6,539
Miscellaneous	26,107	21,444
	<u>1,192,556</u>	<u>1,294,892</u>
 APPLICATION OF FUNDS:		
Administration	299,346	334,821
Information Service	161,138	201,221
Capital Investment	53,823	37,466
Programs		
Program Advisory Committee	28,034	18,170
Program Development	13,608	51,542
Aquaculture	356,110	420,024
Traditional Fisheries	108,796	131,145
Resource Development and Management	84,208	105,208
Education and Training	4,907	5,000
	<u>1,109,470</u>	<u>1,304,657</u>
 FUND BALANCE, END OF YEAR	 <u>83,086</u>	 <u>(9,765)</u>

*Includes income from sale of project fish.