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INTRODUCTION

As ICLARM passed its sixth birthday as an international non-profit institution this year, staff and the many individuals who provide assistance of various kinds were able to view with pride the research accomplishments of the past six years. The Center is functioning as an international research center should, and it has established a track record of sound, applicable research. It has taken international leadership roles in socioeconomic research on small-scale fisheries, on tropical stock assessment, on stock improvement and integrated farming, and in information services and the level of interaction on these topics with other international and national institutions is very encouraging. We are pleased to note the need for ICLARM has been clearly established and its role among development organizations appears to be appropriately focused.

In spite of these successes ICLARM has been made keenly aware this year of the worldwide recession and its impact on research funding. The Center has found itself scrambling along with other researchers to even maintain present funding levels. Donors are faced with increasingly difficult decisions as inflation erodes the impact of static or even decreasing financial resources, and decisions must be made concerning the relative value of research in different sectors and on topics within each sector. The questions asked by donors faced with these hard decisions are questions that are relevant to all fisheries research institutions in developing countries. A general discussion of the questions including a brief summary of our answers should be of interest. The questions fall into three general categories dealing with (1) The Fisheries Sector, (2) ICLARM Program Impact and (3) Communication of Results.

The Fisheries Sector

Questions regarding the broad fisheries sector and its importance are typically: (1) Why work on fisheries? (2) How important is fish in the developing world? and (3) Isn't fish a luxury food, too expensive for the poor?

The 75 million tonne total harvest of fishery products is relatively small compared to other food commodities but its size belies its importance as a contribution to human protein needs. Fish contribute 6% of the world's protein or 24% of the world's animal protein. Because the animal proteins contain essential amino acids lacking in cereal grains the nutritional impact of fish in diets of the poor is often far more significant than it would appear at first glance. In several Asian and African countries 50% or more of total animal protein consumption is in the form of fish. Further, much of it is inexpensive dried or salted fish within economic reach of poorer consumers. Because of this, poorer consumers are often more dependent on fish for their animal protein than their richer neighbors who eat more meat, poultry, eggs and milk products. In short, the fragments of dried fish added to many inexpensive foods in the developing world are an extremely important part of the diet from a nutritional standpoint for a great many people.

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To complicate this picture the rapid increases in the harvest of fish observed during the 1950s and 60s (20 million tonnes to 70 million tonnes between 1950 and 1970) have slowed to a crawl since 1970. Preliminary estimates from FAO are that 75 million tonnes were landed in 1982. Predictions of total production for the year 2000 are diminishing rapidly (i.e. to 104 to 92 million tonnes since 1976) and the present rate of increase about 1.2% per year coupled with problems of overexploitation and increasing fuel costs make even the 92 million tonne estimate appear shaky.

When we shift from consideration of the world situation to the situation in developing countries where population growth averages 2.4% per year and where some countries are already overexploiting existing resources, the seriousness of the problem begins to come into focus. Some countries that are heavily dependent upon fish have decreasing harvests (e.g., Thailand and Pakistan) or catches that are not increasing significantly (Bangladesh and India). In the Philippines per capita fish consumption decreased 47% from 1970 to 1980. The gap between supply and demand is generally widening and prices seem to be moving upward in a predictable but rather striking fashion. Many of us believe a nutritional crisis of serious proportions is emerging.

ICLARM Program Impact

Donors often ask, if capture fishing is facing all these obstacles to increased production (e.g., poor management, increasing costs, environmental degradation), and catches are therefore increasing only slowly, why worry about research? What benefits can be expected? And with reference to the poor small-scale fishermen caught in an almost insoluble tangle of problems, what can be done to help them? Further, what is the potential of aquaculture, would we be better off placing emphasis on production of chickens, for example?

As serious study of the population dynamics of heavily exploited tropical stocks began, ICLARM scientists realized that they are very poorly understood in comparison with temperate fish stocks. A part of the reason nations have often been unable to continue increasing yields toward predicted levels is the inadequate knowledge of what levels of sustainable harvest the tropical stocks will support. Therefore stock assessment becomes the first required step in working toward effective management and increasing sustainable harvests. ICLARM's leadership in developing simplied analytical methods applicable to tropical stocks and manageable on desk-top computers has been important here.

With respect to the benefits to be expected, the stocks of many species have been so heavily overfished that maintenance of present catch levels is a problem. Dangerous shifts in species composition are occurring on many fishing grounds as more valuable stocks diminish and fishermen shift to smaller species that are lower on the food chain. Irreversible changes may

be taking place reminiscent of those occurring in the California sardine fishery or the Peruvian anchoveta fishery in which heavily fished stocks have been greatly reduced resulting in lasting ecological changes. The stock assessment research is needed, first to enable management measures suitable for maintaining present yields, and secondly, to slowly increase sustained harvests and reduce harvesting costs as management practices are refined.

The dilemma of the millions of small-scale fishermen dividing too few fish among too many fishermen is not likely to be resolved entirely within the fisheries sector. As this dilemma is comprised of a complex set of social, economic and legal problems, the solutions will be complex involving agricultural and industrial sectors as well as fishing and aquaculture. When the situation is viewed as a socioeconomic rural development problem, it can be seen that too often efforts to correct it have been mistakenly limited to the fishery sector. The solutions are not simple and are location specific in nature, but when approached as a part of the total rural development problem solutions are possible. ICLARM's research here has been interdisciplinary with emphasis on understanding the situation from sociological, economic, legal, biological and institutional viewpoints. Approaches to potential solutions are also framed in this broad interdisciplinary context and include consideration of basic changes relating to rural development generally and fisheries/community interactions specifically. In the latter category fall access rights, local vs. regional management, ownership of resources, education, limited entry, enforcement of regulations, community organization and a variety of considerations pertaining to wise resource utilization.

Aquaculture should be viewed as a form of animal husbandry with potential and problems characteristic of that industry. It is perfectly valid to compare aquaculture with chicken, egg or goat production as alternative means for production of animal protein. The potential for production of fish through aquaculture is possible to evaluate only as we would another form of animal husbandry, by rigorous economic analysis including examination of required inputs, costs, demand and prices. The exciting aspect of aquaculture is that it offers opportunities for economical utilization of previously underutilized resources (e.g., freshwater, seawater, swampland, labor and organic wastes) and in some cases better opportunities for utilization of presently utilized resources (e.g., feed grains, freshwater, labor and land). To the extent that aquaculture can utilize resources, recycle wastes, employ people and produce food more efficiently than other forms of animal husbandry it will continue to expand. According to FAO the present rate of increase in food production through aquaculture (1975-80) is 7.3% per annum worldwide. ICLARM projects have often involved economic analysis of aquaculture practices and have focused on improvement of production efficiency through stock improvement and integrated aquaculture-agriculture.

Communication of Results

As donor representatives travel they see duplication of research, poor communication and completely inadequate access to reference materials in most

developing-country institutions. This leads to questions regarding how to coordinate and communicate better and how to get research results to the developing-country users.

The designers of ICLARM were well aware of the problems of communication in the developing world and therefore designed an institution to work among the international and national fisheries research and development organizations rather than separately. Cooperative research conducted in developing-country institutions is ICLARM's primary mode of operation. Further, the Center was designed to supplement the work of existing development and extension organizations by conducting complementary research to address specific needs. This requires a high level of communication and interaction.

The mechanisms for communication have been built into ICLARM in an effective and functional way. Conferences and workshops are important mechanisms for communication of information on research and these are used extensively for planning and for dissemination of results. Publication of workshop or conference proceedings is a valuable product of these meetings and together with ICLARM's other technical publication series (Studies and Reviews, Technical Reports, Bibliographies and Translations) constitute a second major vehicle for communication. The ICLARM Newsletter has proven to be another vehicle of major importance being used by developing-country scientists both as a source and a mechanism for reporting results quickly and informally. The Newsletter is used by our library staff to publicize recent publications of interest to developing countries. Other services provided by the library include computer searches of major databases, special library searches, copying and distribution of articles on request and assistance to visiting scientists. Person-to-person interaction between ICLARM staff members and other scientists ranges from exchanges of mail to special extended training at ICLARM headquarters. To an increasing extent Networks are becoming a major part of ICLARM's activities. They provide special mechanisms for communication, exchange of visits, comparison of results, and research collaboration. One, our Network of Tropical Fisheries Scientists, is supported by its own special newsletter.

Outstanding Needs

The magnitude of the fisheries problems in relation to resources available to address these needs is still staggering. It appears as though the rapid increases in fish harvests realized during the 1950s and 1960s created a false impression of the vastness of fish resources. It also not only discouraged research, but also led development organizations along the path of fishing technology improvement too far and too long at least in Asia. Many still view the sea as an inexhaustible source of protein that only requires better technology to harvest and utilize. The trends of the 1970s have shown this not to be the case.

AQUACULTURE PROGRAM

Background

During 1983, ICLARM's Aquaculture Program has continued to address constraints which hinder the expansion of warmwater aquaculture in developing countries. The program is focused on species feeding low in the aquatic food-web; particularly the tilapias, carps, mullets, milkfish and bivalve molluscs. These groups, particularly the finfish, contain species which are highly adaptable to a wide range of culture conditions, from simple backyard and coastal ponds to intensive cage, tank and raceway systems.

Tilapia in particular, on which the program has placed major emphasis, has been dubbed a potential 'aquatic chicken.' Tilapias are essentially omnivorous, opportunistic feeders and are remarkably tolerant to wide ranges of temperature and salinity and to low water quality. They have very few disease problems. Moreover tilapias can be sold whole at large or small harvest weights, according to market preference, or used for the preparation of value-added foods such as fillets, as they have excellent dressing weight characteristics and flesh quality.

The milkfish and the mullets are essentially microphagous, taking in plankton, detritus and micro-organisms from the pond bottom. They are also tolerant of wide ranges of salinity. The carps (common, Chinese and Indian major), while largely restricted to freshwater culture, can tolerate wide ranges of temperature and show very high growth rates with some species capable of exceeding 5 kg/yr in the tropics. Bivalve molluscs (cockles, mussels, oysters and clams) are 'self-feeding' and are very cheap to grow; the main constraints to production being marketing and market demand, post-harvest handling, and public health problems.

The tropical developing countries have distinct environmental advantages over the rest of the world for cost-effective production of these species. Expansion of tropical aquaculture can supply high protein foods for both domestic consumption and export. There are encouraging indications that certain of the species mentioned here are gaining increasing international acceptance as food commodities, particularly the tilapias and bivalve molluscs. However, large-scale aquaculture development projects often fail to achieve their targets. Government agencies, development banks and private entrepreneurs are learning by hard experience the constraints to successful, efficient aquaculture and the necessity for a professional, scientific approach, akin to other forms of animal husbandry.

Constraints can be summarized as the lack of an adequate biological research base on the genetics, reproduction, nutrition and pathology of warmwater species; the need for improved culture systems, particularly waste-fed aquaculture and integration of aquaculture with agriculture; and the poorly developed analysis of aquaculture economics and socioeconomics (particularly market structure and demand), by comparison with agriculture. Implicit in all these constraints is a lack of trained manpower. It is essential that these biological, economic and socioinstitutional constraints are thoroughly investigated and removed.

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Chief among the biological constraints is the need for stock improvement of cultured species. The so-called 'Green Revolution' in crop science was built on the development of high-yielding, adverse environment-tolerant and disease-resistant plant varieties. Aquaculture must investigate this approach to develop high performance, domesticated fish, as many of the stocks cultured at present are wild or not far removed from wild types.

No single agency is capable of tackling all these constraints, but ICLARM's mode of operation through cooperative projects and networks is a highly cost-effective way of making progress. The Aquaculture Program is designed to address key specific research problems for some of the most important commodities, while developing broad themes for sustained work. These themes are outlined below. They are not viewed as separate entities and are highly interactive and multidisciplinary. For example the biologists and economists involved in projects draw frequently on each others' expertise and data.

Progress of Work

The past year has seen significant progress in projects continued from 1982 and initiation of some important new projects. Progress is reported under program theme headings and a summary table of completed, active, and upcoming projects follows.

Commodities/Economics

Tilapias

Research projects on tilapias have been undertaken in Kuwait, the Philippines and Taiwan. In Kuwait, ICLARM's cooperative project with the Kuwait Institute for Scientific Research has continued to generate important data for tilapia culture in saltwater in arid lands. *Oreochromis spilurus*, imported from Kenya, appears to have good potential for growth and reproduction under these harsh conditions and the successful test marketing of tilapias started in 1982 has been continued.

Among the highlights of the 1983 Program activities were studies on the economics of tilapia culture and tilapia marketing which culminated in a 4-day workshop cosponsored by ICLARM and the Philippine Council for Agriculture and Resources Research and Development (PCARRD). These studies involved ICLARM researchers and counterparts from a large number of Philippine universities and development agencies. The workshop was a tremendous success and has highlighted the importance of tilapia culture as a food producing system. It was stated at the workshop that tilapia culture is the key to self-sufficiency in fish supply for the Philippines. While it is still difficult to arrive at an accurate total for countrywide tilapia production, this is probably around 50,000 tons/yr.

As an adjunct of the Philippine Tilapia Economics project, ICLARM hired Ms. Emma Escover as Junior Research Fellow in mid-1983 to conduct economic analyses of tilapia hatcheries to determine the most appropriate approach to development of this sector of the industry. Her studies cover both land-based and water-based hatcheries of the private sector and government managed hatcheries.

Significant progress was also made in the cooperative biological research projects on tilapia with the Institute for Fisheries Research and Development/College of Fisheries of the University of the Philippines in the Visayas (IFDR/UPVCF). The aquatic fern Azolla was assessed as a protein-source for Nile tilapia fingerlings and was found to be nutritionally-deficient: a negative result, but extremely important since some culturists in Southeast Asia have been tending to feed Azolla to their fish uncritically, assuming that consumption by the fish must confer nutritional benefits. This result will prevent further wastage of time and money. Artificial incubation systems for tilapia eggs and larvae have been further improved in another project with UPVCF completed in 1983.

A cooperative project with the Marine Sciences Center of the University of the Philippines (UPMSC) on the genetic characteristics of Philippine food fishes has concentrated initially on tilapias and has shown, by use of electrophoretic markers, that some experimental and commercial stocks of Nile tilapia (Oreochromis niloticus) in the Philippines are seriously contaminated through interbreeding with wild O. mossambicus.

The tilapias have also been the major focus in the program's publications and conference presentations and remain the main species used in ICLARM's integrated farming activities. Throughout 1983, major reviews on tilapia nutrition and tilapia as a worldwide commodity for future publication have been in preparation. For the last of these questionnaires have been sent to tilapia correspondents in 74 countries and 56 replies have been received.

The worldwide interest in tilapias can be judged from the reprinting of ICLARM's major publication on this group - "The Biology and Culture of Tilapias" (Conference Proceedings No. 7) and the reprinting and updating of "Applied Genetics of Tilapias" (ICLARM Studies and Reviews No. 6, 1981, now available the Second Edition, 1983). "The Biology and Culture of Tilapias" topped the scientific books category in the awards for the best Philippine books of 1982, for which a plaque was presented to ICLARM by Philippine Prime Minister Cesar Virata. ICLARM's bibliography on the main species of cultured tilapias (ICLARM Bibliographies No. 2) has also been in great demand.

In Taiwan, ICLARM has continued a multidisciplinary cooperative project with the Council for Agricultural Planning and Development on the development of technology for saltwater culture of tilapias. Cooperating institutions include the National Sun Yat Sen University, Kaohsiung; the Taiwan Fisheries Research Institutes at Lukang and Tainan; the Institute of Zoology, Academia Sinica, Taipei; the National Taiwan College of Marine Science and Technology, Keelung and the National Pingtung Agricultural Professional School, Pingtung.

The following topics have been studied: reproductive performance of tilapias in freshwater; reproductive performance of tilapias in various salinities; salinity tolerance of freshwater-spawned fry of various ages; survivorship of freshwater-spawned eggs incubated at elevated salinities and salinity tolerance of resultant progeny; salinity tolerance of fry spawned at varying salinities; protein and energy requirements of juvenile tilapias in freshwater and the growth, survival and reproduction of tilapias during cage culture at various salinities.

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Important results during 1983 have included decreasing the average interval between spawnings from 40 to 20 days in Nile tilapia; successful spawning of tilapias in seawater and acquisition of hatching and rearing data over a wide range of salinities, from which spawning and incubation of eggs in saline water have emerged as powerful techniques for predisposing fry for saltwater rearing; comparisons of saline tolerance between different tilapias (in which an O. mossambicus x O. niloticus hybrid was the most versatile performer) and preliminary assessments of optional protein content and protein energy ratios for tilapia feeds.

Tilapia economics studies in Taiwan have included an economic analysis of secondary production and price data. This analysis was designed to identify economic issues for followup field research using farm level and market data.

Carps

During 1983 the first major involvement of ICLARM staff in carp culture research and development occurred. Dr. R.S.V. Pullin assisted the Asian Development Bank (ADB) with research planning for improvement to hatchery/nursery technology for common carp, Chinese carps and Indian major carps with visits to ADB and government projects in Bangladesh, Burma, Indonesia (Sumatra), Nepal, Pakistan and Sri Lanka. Dr. Pullin is co-authoring a carp hatchery/nursery manual with ADB-consultant Dr. V.G. Jhingran and is assisting ADB in organizing a 1984 workshop to collate new findings and technology improvements in carp rearing.

Milkfish

During 1983, ICLARM completed a study of constraints to increased milkfish yields in the Philippines. This study was contracted to ICLARM by FAO and was conducted with the Bureau of Fisheries and Aquatic Resources (BFAR) and the Bureau of Agricultural Economics (BAEcon). A host of technical, biological, economic, sociological and institutional factors were examined. The study confirmed the earlier work of ICLARM that farmers are responsive to relative prices in their production decisions and concluded that the major constraints are institutional in nature. These included high (and hidden) costs of credit, limited contact with extension workers and poorly developed extension materials. Specific action steps were recommended in each case.

A later study, the results of which were presented at the SEAFDEC-IDRC International Milkfish Aquaculture Conference in October, documented the major market constraints that inhibit expansion of milkfish production in Taiwan, Indonesia and the Philippines. Shifting consumer preference, high export prices for shrimp and higher profits from other species such as tilapia and crustaceans have combined with market saturation, in Taiwan and the Philippines especially, to reduce milkfish prices and milkfish's share of aquaculture production and markets. Brackishwater producers throughout Southeast Asia appear to be shifting away from milkfish as a result. Consequently, while constraints to higher yields for individual farmers may be institutional in nature, the industry as a whole faces market limitations brought about by supply exceeding effective demand.

Mullets and other finfish

Drs. C.M. Kuo and W.O. Watanabe have maintained ICLARM's interests in mullets and in a number of other commercial brackishwater and marine finfish species through ongoing projects, advisory services and training activities in Egypt, Israel and Taiwan. As in previous years, the main thrusts of this work have been on development of controlled reproduction techniques through a better understanding of reproductive physiology and improvement of larval and postlarval survival. Interest in mullet culture remains strong in the Middle East, while in Taiwan interest in the culture of higher priced species such as groupers (Epinephelus spp.) is increasing as prices obtainable for tilapias and milkfish have fallen.

Bivalve molluscs

The cooperative project between ICLARM and the Brackishwater Fisheries Division, Department of Fisheries, Ministry of Agriculture and Cooperatives, of the Government of Thailand, entitled Applied Research on Coastal Aquaculture, funded through the German Agency for Technical Cooperation completed its first 18-month phase in June 1983 and was extended for a further 18 months. The project has involved multidisciplinary studies on the economics and biology of culture and harvesting of Thai commercial bivalve molluscs, principally the green mussel (Perna viridis), the cockle (Anadara granosa), oyster species (Crassostrea spp.) and the short-necked clam (Paphia undulata). Special studies and reviews completed in 1983 included marketing, product standardization and production cost studies, assessment of the public health aspects of bivalve consumption in Thailand, with analyses of bacterial contaminants and trace metals in samples from the major culture areas and a comprehensive literature review; a series of post-harvest handling investigations on seasonal changes in flesh quality and factors affecting shelf-life and a review of Thai literature of commercial bivalves, including new translations of papers and abstracts. An economic analysis of shellfish marketing was initiated in mid-1983 as part of this project in collaboration with the Faculty of Economics and Business Administration, Kasetsart University, Bangkok. This activity is part of Kasetsart's contribution to the ICLARM Fisheries Social Science Research Network, described elsewhere in this report.

In addition to these activities, the ICLARM project staff Drs. E.W. McCoy, R.P. Ventilla and Mr. J. Michael Vakily and their Thai counterparts participated in a variety of advisory and training activities. The project also held an in-country workshop for Thai researchers and culturists from institutions and agencies countrywide.

Waste-fed agriculture/integrated farming

The most important events of 1983 were the dissemination of the results of ICLARM's previous cooperative animal-fish research project with Central Luzon State University (ICLARM Technical Report No. 5) and the appointment of a Rockefeller Foundation postdoctoral fellow to work on water quality aspects in a wide variety of waste-fed aquaculture (compost-fed ponds, manured ponds and sewage-fed systems) in a cooperative project between ICLARM and the Asian Institute of Technology (AIT), Bangkok. The research fellow is Dr. John A. Colman, a water chemist, who has joined the AIT biologists under Dr. Peter Edwards to form a powerful AIT-ICLARM team investigating water column and pond bottom chemistry and biology.

Plans have also progressed towards holding an international conference on "Detrital Systems for Aquaculture" and materials in preparation for future publication include a review of sewage and waste-water use in aquaculture and a comprehensive bibliography on integrated farming. A review paper on the culture of herbivorous tilapias was presented at an international conference in Malaysia (see below) and is highly relevant to feeding waste vegetation to fish on integrated farms.

Stock improvement

The stock improvement theme has been the most difficult aspect of the aquaculture program in which to expand 'hands-on' project work. This is because fish stock improvement, like most genetics-related studies, requires special facilities and sustained project support. 1983 has been used largely to prepare the case for substantial future research support in this area. At the International Symposium on Tilapia in Aquaculture, Nazareth, May 1983, Dr. R.S.V. Pullin presented a strong case for tilapia stock improvement and convened a discussion workshop of the geneticists and fish breeders present.

A major proposal for an International Network for Stock Improvement in Warmwater Aquaculture has been prepared for presentation to donors early in 1984. A feature of the proposed Network will be the development of new facilities - Stock Improvement Centers. The proposed Network would strengthen the research support proposals of its members. Dr. L.J. Lester, University of Houston at Clear Lake City, has assisted ICLARM with Network and stock improvement project planning throughout 1983.

In addition to this groundwork for a major program thrust in stock improvement, ICLARM's genetics project with the Marine Sciences Center, University of the Philippines has made substantial progressin characterizing cultured Philippine tilapia stocks. ICLARM has also maintained close liaison with the Freshwater Aquaculture Center of Central Luzon State University (FAC/CLSU) and the adjacent hatchery of the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) in their evaluation of culture performance of tilapia stocks from previous ICLARM - FAC/CLSU projects. These evaluations have shown some disquieting deteriorations of culture performance, probably attributable to interbreeding between wild and cultured fish.

Economics

Economics activities are described above in the respective commodity sections. In addition to these activities and those described elsewhere under the Fisheries Social Science Research Network, the Taiwan aquaculture trends and development prospects manuscript was completed by Dr. Chaur-Shyan Lee. The manuscript is now being edited and will be published in 1984.

Advisory Services

Dr. R.S.V. Pullin worked extensively in 1983 as an advisor to the Asian Development Bank on a project entitled "Technical Assistance on Research and Training in Aquaculture". The Project aims to improve hatchery/nursery methods for carp culture throughout Asia (see above). Dr. C-M. Kuo has continued his work with the New Jersey Marine Science Consortium/United

States Agency for International Development (Cooperative Marine Technology for the Middle East)/Egyptian Academy of Scientific Research and Technology/ Israel Oceanographic and Limnological Research Ltd., Mariculture Laboratory program on controlled reproduction of commercially important marine fishes, concentrating on mullets and gilthead seabream (Sparus aurata).

Dr. Ian Smith served as advisor to the Bay of Bengal Programme's (BOBP) shrimp-pen culture project in Killai Backwaters, Madras, India. With ICLARM assistance, a BOBP Consultant Mr. Rathindra Roy, is examining the socio-economic feasibility of this project as a household activity of the cast-net fishermen and gatherers who have traditionally exploited the backwaters.

Aquaculture program staff have also been very active in handling enquiries from all over the developing world in relation to aquaculture research and development. In particular, many of the culturists and scientists contacted while gathering information for the international review on tilapias as a food commodity have requested information on the choice of tilapia species and strains for culture and the best methods for hatchery operations and growout. Advisory services to the Cagayan Integrated Agriculture Development Project, Philippines on the exploitation and culture potential of stocks of the migratory mullet, known as ludong (Oestraeus plicatilis) in Northern Luzon, have continued at a low level, pending the establishment of working facilities by the various cooperating institutions. Plans to extend further advisory services on marine hatchery research and development to the Ministry of Agriculture and Fisheries Development, Sabah, Malaysia are awaiting construction of the facilities designed in 1982.

Training

Drs. Kee-Chai Chong and R.S.V. Pullin assisted with the cause for senior aquaculturists from Asia and the Pacific, organized by the UNDP/ FAO Network of Aquaculture Centers in Asia (NACA). The course leads to a Masters in Aquaculture degree through affiliation with the University of the Philippines in the Visayas, Iloilo City, and the trainees spend time at NACA centers in the People's Republic of China, India, the Philippines and Thailand. Dr. Chong taught the 2-week aquaculture economics component of the course at the Philippine Lead Center (PLC) for NACA, which is located at SEAFDEC, Tigbauan, Iloilo. Dr. Pullin delivered a series of lectures on broad aspects of warmwater aquaculture research and development, choice of cultured species and stock improvement at the PLC and also met the NACA trainees during their stop at the National Inland Fisheries Institute, Bangkok. Dr. Pullin's lectures will be published by FAO for use on future NACA courses.

Dr. C-M. Kuo was appointed visiting professor to both the Department of Zoology, National Taiwan University, Taipei and the Institute of Marine Biology, National Sun Yat Sen University, Kaohsiung, Taiwan. He offered lectures on special topics of fish physiology: reproductive physiology, to both institutions in the spring semester. This service was performed as an ICLARM contribution to the cooperative project currently underway. In addition, Drs. C-M. Kuo and W.O. Watanabe have been involved in training and program development at the Taiwan Fisheries Research Institute at Tainan and in supervising visiting students from the Agricultural University, Wageningen, Netherlands and National Sun Yat Sen University in advanced studies in aquaculture.

Dr. E.W. McCoy assisted the Faculty of Agricultural Economics and Business Administration of Kasetsart University, Bangkok, Thailand with in-depth training of graduate students. Staff and students were involved in marketing and production cost studies on green mussel culture. Dr. McCoy also gave a short course on marketing to staff and graduate students and classes on marketing economics to aquaculture economics students. Dr. R.F. Ventilla assisted the Department of Marine Science, Chulalongkorn University with information on bivalve mollusc biology and culture.

In September, ICLARM provided training awards to the 10 private tilapia hatchery cooperators who have been participating in ICLARM's record-keeping project in Laguna and Rizal Provinces, Philippines. The 3-day training session in hatchery management was conducted at the Bureau of Fisheries and Aquatic Resources (BFAR)-USAID hatchery on the campus of Central Luzon State University. The training was highly successful. Finally, Dr. Chong conducted a series of short courses over 12 weeks on aquaculture economics and farm management for BFAR extension workers.

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World Mariculture Society, 14th Annual Meeting, in cooperation with the Fish Culture Section of the American Fisheries Society, Washington, D.C., 9-13 January 1983. (K.D. Hopkins)

K.D. Hopkins, P. Inocencio and E.M. Cruz. Water quality in integrated livestock - fish ponds.

In-country Workshop on the Current State of the Art of Bivalve Molluscs Culture in Thailand, National Inland Fisheries Institute, Kasetsart University Campus, Bangkok, 19-21 January 1983.

R.F. Ventilla. A note on recent shellfish genetics research.

R.F. Ventilla. Alternative mollusc species for culture in Thailand. A preliminary list and some biological data on abalones (Haliotis sp.) in Thailand.

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R.F. Ventilla. Some biological data and background of common scallop (Amusium pleuronectus) in Thailand.
R.F. Ventilla. A preliminary list, some biological data, and background of pearl oyster culture (Pinctada maxima, P. margaritifera) in Thailand.
R.F. Ventilla. Natural spat collection or hatcheries?

The International Symposium on Tilapia in Aquaculture, Nazareth, Israel, 8-13 May 1983. (R.A. Neal and R.S.V. Pullin)
R.S.V. Pullin. Choice of tilapia species for culture.

Annual Meeting of the Taiwan Fisheries Society, Keelung, Taiwan, 30-31 May 1983. (C-M. Kuo)
C-M. Kuo. Application of sex control in aquaculture (invited resource speaker).
C-M. Kuo. Induced breeding of grey mullet, Mugil cephalus L. with deoxycorticosterone.

International Conference on Development and Management of Living Aquatic Resources, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia, 2-5 August 1983. (R.S.V. Pullin)
R.S.V. Pullin. Culture of herbivorous tilapias.

Workshop on Tilapia Economics in the Philippines, University of the Philippines at Los Banos, Laguna, Philippines, 10-13 August 1983. (E.M. Escover, R.S.V. Pullin, I.R. Smith)
L. Yater and I.R. Smith. Economics of private tilapia hatcheries in Laguna and Rizal provinces.
E.M. Escover and R.L. Claveria. Economics of cage culture in Bicol freshwater lakes.
E.M. Escover, O.T. Salon and C.P. Lim. Tilapia marketing in Bicol.

Research Seminar, Oregon State University, Department of Fisheries and Wildlife, Corvallis, Oregon, U.S.A., 16 August 1983. (K.D. Hopkins)
K.D. Hopkins. Integrated farming and tilapia culture in Kuwait.

Second International Milkfish Aquaculture Conference, Iloilo City, Philippines, 4-8 October 1983. (K-C. Chong, C-M. Kuo, I.R. Smith and W.O. Watanabe)
C-M. Kuo, W.O. Watanabe and Y-Y. Ting. Deep-water culture of milkfish in Taiwan (poster).
C-L. Lin, Y-Y. Ting and C-M. Kuo. Description and treatment of vibriosis (red spot disease) in milkfish, Chanos chanos (poster).
I.R. Smith and K-C. Chong. Southeast Asian milkfish culture: economic status and future prospects (invited paper).

ROC-USA Colloqium on Marine Sciences, Taipei, 19-24 October 1983. (C-M. Kuo)

Program Plans for 1984

The 1984 program will again emphasize the main themes already established: stock improvement, waste-fed aquaculture/integrated farming and economics. The program will also continue to focus on species chosen for their suitability for low-cost aquaculture, particularly the tilapias, carps, bivalve molluscs and mullets.

The concept of an International Network for Stock Improvement in Warm-water Aquaculture will be promoted with proposals for a planning workshop and initial Network activities. The project with UPMSC on the Genetics of Food Fishes will be extended for a further year and the project will be visited by leading geneticists to assess progress. Network establishment will be further assisted by Dr. L.J. Lester, who plans to work with ICLARM and CLSU in the Philippines on determination of realized heritabilities for growth rates in tilapias. The development of tilapias for mariculture will be extended throughout 1984 in the ongoing projects in Kuwait and Taiwan and research/advisory services to controlled marine fish reproduction studies in Egypt, Israel and Taiwan will be continued.

In waste-fed aquaculture/integrated farming, research cooperation with AIT will be strengthened to enable detailed investigations of the detrital food web and water quality factors. Efforts will also be continued at AIT and by liaison with other tropical aquaculture institutions to investigate the potentials of aquatic macrophytes and waste vegetation for fish nutrition, particularly for the microphagous and herbivorous tilapias.

ICLARM has also identified an area of integrated farming in which a new research initiative is called for - the integration of ruminant livestock husbandry with fish culture. Ruminant livestock-fish integration has been hitherto largely restricted to the use of cattle manure to fertilize fish ponds, and has ignored the ruminant livestock of greatest importance in many tropical developing countries, particularly small ruminants (sheep and goats) and the water buffalo. The small ruminants are particularly important in Muslim countries. While these animals produce relatively "nutrient-poor" manures compared to pigs and poultry, their wastes do represent a potential input for aquaculture which has not been adequately investigated. A proposal is being prepared to address this in 1984.

The proposed conference on "Detrital Systems for Aquaculture" will likely be delayed into 1985 to allow for preparation of major review contributions. However, the ICLARM bibliography on integrated farming will be completed in 1984 and commissioned reviews on sewage-fish culture and tilapia nutrition (concentrating on detritivory) will be completed.

In aquaculture economics, ICLARM is exploring possibilities of a staff assignment in South Asia in affiliation with the Bay of Bengal Programme in Madras, India. If funding is located, the individual in this position would work in affiliation with the ICLARM Fisheries Social Science Research Network and national research institutions and universities in Bangladesh, India, and Sri Lanka. Likely topics for research include aquaculture project feasibility and impact studies and assessment of market potential for culture species, especially those such as tilapia which are not yet popular with South Asian consumers.

Ms. Emma Escover will continue her economic analysis of tilapia hatcheries in the Philippines until she returns to her faculty position at Ateneo de Naga College in mid-1984.

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Project Title : Azolla in Tilapia Nutrition

Cooperating Institution : The College of Fisheries of the University of the Philippines in the Visayas (UPVCF), through its research arm, the Institute of Fisheries Development and Research (IFDR)

Duration : May 1982 - December 1983

Key Personnel ICLARM : Dr. Roger S.V. Pullin
UPVCF/IFDR : Dr. Gaudiosa J. Almazan, Mrs. Teresita A. Manalo, Mr. Ramon R. Agbayani, Ms. Aurora F. Angeles, Ms. Ma. Theresa B. Trono

Objectives

- To determine the nutritional value of the aquatic nitrogen-fixing fern Azolla pinnata as a protein source for Nile tilapia (Oreochromis niloticus).

Results

A 28-day nutritional assay was developed for Nile tilapia (Oreochromis niloticus) fingerlings using 20 fish/15-gallon aquarium and a control diet of 40% marine fish meal; 40% rice bran; 10% corn starch; 9% corn meal and 1% Afsillin (micronutrient premix; E.R. Squibb, Manila). Feeding at 5% body weight/day gave a mean specific daily growth rate (G) of 2.4% and a mean feed conversion ratio (FCR) of 1.66 at ambient temperature (24-30°C).

The aquatic nitrogen-fixing fern, Azolla pinnata (Bangkok strain) was grown in soil/water cultures in plastic pools. Fish fed on fresh Azolla alone at 10% and 20% body weight/day and excess lost 24-28% body weight over 28 days, although the Azolla was readily consumed.

Sun-dried Azolla was fed as a powder, in pellet form and as a feed ingredient (Table 1). The results are summarized in Table 2. Growth responses and food conversion ratios were significantly worsened by increasing the level of dried Azolla incorporation.

This study has revealed the inadequacy of Azolla-based diets for O. niloticus fingerlings. For fresh Azolla, the high water content (average 94%) may be a factor, but body weight was not maintained even when excess fresh Azolla was provided. Moreover reduction of the water content to about 11% did not improve its nutritional value since very poor responses to dried all-Azolla diets were also obtained whether presented as a powder or as pellets. However, feeding excess dried Azolla did turn a negative growth rate into a slight positive response.

What are the nutritional deficiencies of Azolla? Although low in fiber content, Azolla seems to have sufficient fiber for tilapia dietary requirements: about 8% dietary fiber is recommended for tilapia species. However, the protein content of high-Azolla diets was probably sub-optimal. Other authors have recommended 20-30% protein or higher levels. Moreover, high-Azolla diets have low crude fat content. Dietary lipid is a major energy

source for fish and its importance in tilapia nutrition in relation to protein level is well known. It is conceivable that in high-*Azolla* diets, a substantial portion of the protein supplied by the plant was used for energy rather than growth. A dietary lipid level of 6-10% has been suggested for maximum utilization of protein for growth, with fish of the size used in this study. Fat content of the high-*Azolla* diets was below this level. At the lower *Azolla* inclusion levels (10% and 25%) a more favorable protein-lipid balance was probably achieved.

It is also possible that high-*Azolla* diets are deficient in one or more specific nutrients: for example, lysine and methionine among the essential amino acids. Analyses are being performed on fresh and dried *Azolla* to investigate this. Essential dietary lipids may also be limiting and the high ash content of *Azolla* may have deleterious effects. There also remains the possibility that digestion inhibitors such as antitrypsins are present in fresh and dried *Azolla*.

It is difficult therefore to recommend incorporation of dried *Azolla* in *O. niloticus* fingerling diets at any level. However supplementation may make this possible once its nutritional deficiencies have been determined. These negative results with *Azolla* are important as it has been assumed hitherto that feeding fresh *Azolla* to *O. niloticus* and other microphagous tilapias in fish ponds and integrated rice-fish culture is beneficial. It remains to be seen whether the macrophyte-feeding tilapias, *Tilapia rendalli* and *T. zillii* grow well on *Azolla*-based diets.

Table 1. Composition (g/100g) and proximate analyses of test diets offered to *Oreochromis niloticus* fingerlings: DA = dried *Azolla*; DAP = dried *Azolla* powder; CP = control pellet mix.

Diet No. (DA: CP % ratio)	1 (100:0)	2 (100:0)	3 (100:0)	4 (100:0)	5 (90:10)	6 (75:25)	7 (50:50)	8 (25:75)	9 (10:90)	10 (0:100)
Dried *Azolla* powder	100	100	95	95	90	75	50	25	10	-
Fish meal	-	-	-	-	4	10	20	30	36	40
Rice bran	-	-	-	-	4	10	20	30	36	40
Corn meal	-	-	-	-	1	2.5	5	7.5	9	10
Corn starch	-	-	5	5	0.9	2.25	4.5	6.75	8.1	9
Afsillin*	-	-	1	1	1	1	1	1	1	1
Moisture (%)	11.21	11.21	10.14	10.14	9.89	10.74	13.82	14.58	14.26	11.92
Ash (%)	33.46	33.46	27.91	27.91	27.81	27.46	19.91	14.89	12.98	10.14
Crude fat (%)	3.30	3.30	3.38	3.38	2.89	3.22	5.41	7.31	7.45	12.41
Crude protein (%)	15.38	15.38	14.34	14.34	13.71	15.71	20.78	21.58	25.32	33.87
Crude fiber (%)	7.16	7.16	7.63	7.63	7.52	6.98	4.54	4.26	3.24	4.57
Nitrogen-free extract (%)	29.49	29.49	36.60	36.60	38.18	35.89	35.54	37.38	36.75	27.09

*(micronutrient premix: E.R. Squibb and Sons, Manila), pegged at 1% in mixed diets.

Table 2. Results of feeding various test diets containing dried *Azolla* to *Oreochromis niloticus* fingerlings in duplicate 15-gallon aquaria (20 fish/aquarium) for 28 days: CP = control pellet mix; DA = dried *Azolla*; DAP = dried *Azolla* powder; FCR = feed conversion ratio; G = specific daily growth rate (%): means and standard errors (+).

Diet No./Feeding rate (% body weight/day)	Initial weight (g)	Final weight (g)	G (%)	FCR
1. DAP/5%	1.38(0.03)	1.26(0.04)	-0.34(0.05)	-
2. DAP/excess	1.18(0.23)	1.45(0.04)	0.83(0.75)	117(106)*
3. DA pellets/5%	1.37(0.09)	1.23(0.08)	-0.40(0.01)	-
4. DA pellets/10%	1.52(0.12)	1.36(0.01)	-0.39(0.26)	-
5. 90% DA:10% CP/5%	1.06(0.01)	1.29(0.18)	0.65(0.71)	-
6. 75% DA:25% CP/5%	1.40(0.08)	1.40(0.04)	0.00(0.10)	-
7. 50% DA:50% CP/5%	1.32(0.11)	2.04(0.06)	1.58(0.41)	3.31(0.80)
8. 25% DA:75% CP/5%	1.32(0.28)	2.32(0.49)	2.01(0.00)	2.34(0.13)
9. 10% DA:90% CP/5%	1.34(0.16)	2.85(0.13)	2.71(0.59)	1.77(0.27)
10. CP/5%	1.45(0.13)	3.39(0.36)	3.03(0.06)	1.48(0.05)

* Very high due to excess feeding.

Project Title		: Tilapia Incubation Systems
Cooperating Institution		: The College of Fisheries of the University of the Philippines in the Visayas (UPVCF), through its research arm, the Institute of Fisheries Development and Research (IFDR)
Duration		: May 1982 - December 1983
Key Personnel	ICLARM	: Dr. Roger S.V. Pullin
	UPVCF/IFDR	: Dr. Gaudiosa J. Almazan, Mr. Ramon R. Agbayani, Mrs. Teresita A. Manalo, Ms. Ma. Theresa B. Trono, Ms. Aurora F. Angeles

Objectives

- To investigate the factors affecting survival of tilapia eggs and larvae in a variety of artificial incubation systems using water flow, aeration and mechanical movement.
- To design tilapia egg and larval incubators to give maximum survival under tropical developing country conditions.
- To investigate the use of disinfectants on tilapia eggs, as used for disease control in salmonid egg shipment.

Results

The artificial incubation of tilapia eggs is now an established practice in a number of commercial hatcheries in Taiwan and Israel. This project has made progress towards an incubator design for situations in which electric power supplies are unavailable or unreliable and on development of a system for continuous supply of tilapia fry from eggs collected at various stages of development from mouthbrooding female Nile tilapia (Oreochromis niloticus).

A variety of incubators have been tested using water upflow in jars and funnels, with or without supplementary aeration. Hatching success rates were generally unsatisfactory, averaging 27% (water flow only) to 39% (water flow + aeration) with very high larval mortalities thereafter. These were attributed to excessive movement from poorly controlled water and air-flow, and frequent power failures. A system similar in principle to salmonid egg incubation in which eggs and larvae were maintained in a shallow trough with water flow-through and no aeration gave superior results (average hatching success, 50% and larval survival to free swimming, 35%) and similar results were obtained using aerated basins (average hatching success, 57% and larval survival to free swimming, 35%).

An interesting new development was the construction of a cylindrical incubator (Fig. 1) rotated by a small waterwheel, and therefore independent of power supply. This device was conceived as a "rolled up version" of the shaker table, which is a well-known type of fish egg incubator (the mechanical movement of eggs ensures adequate oxygen supply and discourages attack by fungi and other pathogens). The incubator has provision for three "life

support" systems - aeration, water flow and mechanical movement, on the assumption that any one of these can ensure survival if the others fail. Initial trials have given hatching successes of up to 84% but larval survival to the free swimming stage has been very poor (0-14%). This has confirmed the 1982 project results that mechanical damage to larvae can be a serious problem in incubation systems.

The general conclusion from this work is that an optimum incubation system should utilize mechanical movement for eggs and static devices for larvae. This necessitates design of a large-scale system for continuous input of eggs (collected at various stages of development) and continuous output of fry, incorporating an automatic method of separating hatched larvae from unhatched eggs. Attempts to achieve such separation by mechanical methods (sieves in the rotating incubator) and a behavioral response (the swim-up reaction of larvae to reduced oxygen, obtained by a nitrogen "pulse" down the aeration line) have so far proved unsuccessful. Data on the use of iodophore disinfectants to treat tilapia eggs are still being analyzed.

Project Title		: Research and Workshop on the Economics of the Philippine Tilapia Industry
Cooperating Institutions		: Philippine Council for Agriculture and Resources Research and Development (PCARRD) and several other research groups and individuals
Duration		: 1 year, ending with a workshop in August 1983
Key Personnel	ICLARM	: Dr. Ian Smith, Dr. Roger S.V. Pullin, Ms. Luz Yater, Ms. Emma Escover
	PCARRD	: Dr. Elvira Tan
		: Researchers from various Philippine institutions

Objectives

The Philippine tilapia industry has clear potential for providing income to small-scale producers and protein to consumers. However, an economic analysis was needed to document its current structure, the response of producers to potential profits and the response of markets to recent increases in production. Possible constraints to further expansion of the industry need to be identified, whether they be in the form of input (feed and seed) supply limitations and costs, overcrowding of available production areas, distribution bottlenecks or limited market absorptive capacity. An in-depth analysis of selected production and marketing systems based on data provided by private input suppliers, producers and middlemen was necessary due to the shortage of reliable secondary data on tilapia. This analysis was especially important to guide government agencies such as the Ministry of Human Settlements which, through its *Kilusang Kabuhayan at Kaunlaran* [National Livelihood Program] (KKK), is encouraging private investment by small-scale producers in tilapia production, particularly in cage-culture systems.

Results

PCARRD and ICLARM provided small grants to about one dozen researchers throughout the Philippines, each of whom conducted research on a selected topic related to the tilapia industry. Studies included those on hatcheries, cage and pond culture, rice-fish culture, backyard fishponds, marketing and community case studies. The results of these research projects were presented and discussed at a very successful PCARRD-ICLARM workshop in August 1983. The published proceedings are expected to provide the first comprehensive analysis and overview of the Philippine tilapia industry.

The economic analyses presented at the workshop provided an extremely encouraging picture of this dynamic industry. Fueled by increased consumer acceptance of tilapia, all participants in the industry, including small-scale hatchery operators, grow-out farm and cage operators and marketing intermediaries earn high profits. Nevertheless, several serious problems face the industry. Paramount among these are deterioration of broodstock and consequently poor quality fingerlings in several locations. Lack of appropriate feed for cage culture is a further constraint. Also overcrowding

of some small lakes with cages has occurred. High consumer demand prevails primarily on the northern island of Luzon in the Philippines and production is thus somewhat limited in the southern part of the country. The workshop participants unanimously endorsed the establishment of a national broodstock management center which would seek to maintain and genetically improve tilapia broodstock in the country.

A summary report of the workshop will be published by the end of 1983 to be followed later in 1984 by the edited proceedings. Several aspects of tilapia economics work are continuing under the initiative of individual researchers, including those of ICLARM (see p. 57).

Table 1. Tilapia introductions in the Philippines (1950-1982).

Species	Year	Origin	Agency responsible
Oreochromis mossambicus	1950	Thailand	Bureau of Fisheries and Aquatic Resources
O. hornorum x *O. mossambicus*	1971	Singapore	Private Sector
O. niloticus (Uganda)	1972	Israel	Laguna Lake Development Authority
O. niloticus (Egypt)	1972	Thailand	Bureau of Fisheries and Aquatic Resources
Tilapia zillii	1973(?)	Taiwan(?)	?
O. aureus	1977	USA	Central Luzon State University
O. niloticus (Ghana)	1977	Israel	Central Luzon State University
O. niloticus (Ghana)	1977	Singapore	Bureau of Fisheries and Aquatic Resources
O. aureus (Israel)	1977	Singapore	Bureau of Fisheries and Aquatic Resources
O. aureus (Israel)	1978	Singapore	Southeast Asian Fisheries Development Center
O. niloticus (Ghana)	1978	Singapore	Southeast Asian Fisheries Development Center
Red tilapia (hybrid)	1979	Taiwan	Southeast Asian Fisheries Development Center
Red tilapia	1981	Taiwan	Private Sector
O. aureus (Israel)	1982	Israel	Private Sector
O. niloticus (Ghana)	1982	Israel	Private Sector
Red tilapia	1982	Taiwan	Private Sector

Source: Guerrero, R.D. III. Tilapia farming in the Philippines: practices, problems and prospects. Paper presented at Tilapia Economics Workshop co-sponsored by PCARRD and ICLARM. 10-13 August 1983. Los Baños, Laguna, Philippines.

Table 2. Relative physical and economic efficiency of privately-owned tilapia hatcheries in Laguna and Pizal Provinces, Philippines (1982, by farm size).

	Farm size				
	<1,250 m^2	1,250-4,999 m^2	5,000-9,999 m^2	10,000 m^2 or more	All farms
Average area (m^2)	658	2,112	9,300	26,450	3,900
Average pond size (m^2)	165	235	465	2,645	557
Total annual fingerling production per farm	81,700	141,800	919,200	3,841,200	488,200
Production per 100 m^2	12,416	6,714	9,884	14,522	12,518
Gross revenue per 100 m^2 (₱)[1]	1,306	636	1,165	1,774	1,474
Fixed costs per 100 m^2	75	60	47	80	72
Variable costs per 100 m^2	730	545	692	789	732
• feed expenditure per 100 m^2	369	172	307	297	284
• fertilizer expenditure per 100 m^2	48	27	174	14	37
Net revenue per 100 m^2 (₱)[1]	501	31	426	905	670
Average production cost per fingerling (₱)					
• fixed cost	.006	.009	.005	.005	.006
• variable cost	.06	.08	.07	.05	.06
• total cost	.065	.09	.075	.06	.064
Net revenue per fingerling (₱)[1]	.04	.005	.04	.06	.05

[1] Does not include income from commissions. In 1982, ₱8.50 = US $1.00. Source of above data: Yater, L. and I.R. Smith. Economics of private tilapia hatcheries in Laguna and Pizal Provinces. Paper presented at PCARRD-ICLARM Tilapia Economics Workshop, 10-13 August 1983. Los Baños, Laguna, Philippines.

Project Title		: Milkfish Production Dualism in the Philippines: A Socioeconomic Perspective
Cooperating Institutions		: Bureau of Agricultural Economics (BAEcon), Ministry of Agriculture, Philippines; Bureau of Fisheries and Aquatic Resources (BFAR), Ministry of Natural Resources, Philippines; Food and Agriculture Organization (FAO) of the United Nations
Duration		: 21 months, 15 July 1981-15 April 1983
Key Personnel	ICLARM	: Dr. Kee-Chai Chong, Dr. Ian R. Smith
	BAEcon	: Ms. Maura Lizarondo
	BFAR	: Mr. Cesar Guerrero

Objectives

As part of its continuing effort to improve yields per unit area from Philippine milkfish farms, the Bureau of Fisheries and Aquatic Resources and UNDP/FAO established four Brackishwater Aquaculture Demonstration and Training Centers in the four different climate zones of the country. One of the basic purposes of these Centers is to demonstrate that it is economically feasible to increase yields by intensifying the use of supplementary inputs, particularly fertilizers.

The majority of the country's milkfish farmers continue to rely on extensive methods. The purpose of this ICLARM/BAEcon/BFAR study, which was supported by a grant from FAO, was to examine why milkfish farmers have not been adopting the available technologies at a more rapid rate. The study hypothesized that a mixture of physical, socioeconomic, technical and institutional factors constrain the majority of producers (but not all) and that as a result a dualistic structure exists in the industry. The analytical model specified for the study was placed in the broad context of various theories of agricultural stagnation and growth.

The project had two phases. The first was to prepare a report for FAO on the results of an extensive survey of producers in selected provinces in the Philippines conducted in late 1981 and early 1982. The second phase was to conduct a series of seminars for BFAR extension personnel, based upon the results of this project's and earlier surveys of producers.

Results

The final report for the first phase of this project was submitted to FAO in mid-1983. The report confirmed information previously published that Philippine milkfish ponds are generally underutilized. Perennial low milkfish yields from under-utilized brackishwater ponds were thought to be primarily the result of the difference between fertilizer application rates followed by most milkfish farmers and those higher rates which would duplicate the results achieved on experimental farms and also on a small number of private farms.

The study focused on farmers' perceptions of constraints. Data were collected from 447 milkfish farmers in seven provinces. Additional data from a previous survey involving 324 farmers from seven provinces were also included. Using multiple regression techniques, 8 of 56 explanatory variables explained 73% of the variation in fertilizer expenditure. The four explanatory variables which were statistically significant at the 1% level were: ratio of milkfish price to organic fertilizer price, ratio of milkfish price to inorganic fertilizer price, interest in working on other milkfish farms and belief in the effect of fertilizers on the taste of milkfish. The other four variables, significant at the 5% level were: salinity of pond soil sample, interest in seeking consultation, family size and farmers' estimates of a "fair" collateral requirement for loans.

Based on these results it was concluded that milkfish farmers are responsive to relative prices of inputs and output and adjust their fertilizer expenditure accordingly. However, high costs of credit and of organic fertilizers in some locations coupled with declining real prices of milkfish inhibit many farmers from increasing fertilizer use.

One major reason why milkfish farmers were not applying more fertilizers was because they claimed not to have the necessary financial means to obtain them. A dual-pricing fertilizer subsidy scheme to encourage more intensive use of fertilizers merits an evaluation by the government to determine its practicality. Increased credit for operating capital, in contrast to credit for investment capital, should also be considered. Along with dual pricing for fertilizers and increased credit for production, there is also a clear need for the government to strengthen and increase the mobility of its information dissemination and extension service. Level of contact between farmers and extension workers was low and few, if any, farmers had published materials which would explain the advantages of intensified fertilizer use.

While the milkfish industry as a whole appeared to be undergoing transformation to higher average yields and not stagnating, the report concluded that strengthened institutional support (e.g., credit, extension and information dissemination) is necessary to accelerate development of the industry.

The second phase of this project involved the preparation of a series of short courses for BFAR extension officers based on the above findings of the first phase and supplemented by additional concepts of farm management and production economics. Between January and March, Dr. Kee-Chai Chong conducted a total of 12 such short courses for over 300 extension agents and supervisory staff.

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Table 1. Summary of constraints to intensification and possible 'action steps' to overcome them.

Category	Constraint	Primary action steps
1. Those related to relative prices of output and inputs	High cost of capital	Production credit. Institutional reform to minimize red tape.
	Fertilizer shortage and high prices (selected provinces)	Encourage poultry farming. Input subsidies and dual pricing subsidies.
	Low cost of mangrove land which encourages extensification	Strictly enforce the mangrove conversion moratorium.
2. Those related to the tech-knowledge of producers	Low contact with extension workers	Increase mobility of extension officers and contact hours with farmers.
	Poor information dissemination	Make available more handouts and improve distribution network for written extension materials. Translate technical materials into local dialects.
	Belief that fertilizers impart bad taste to marketable milkfish	Taste tests in selected provinces and dissemination of results through media outlets.

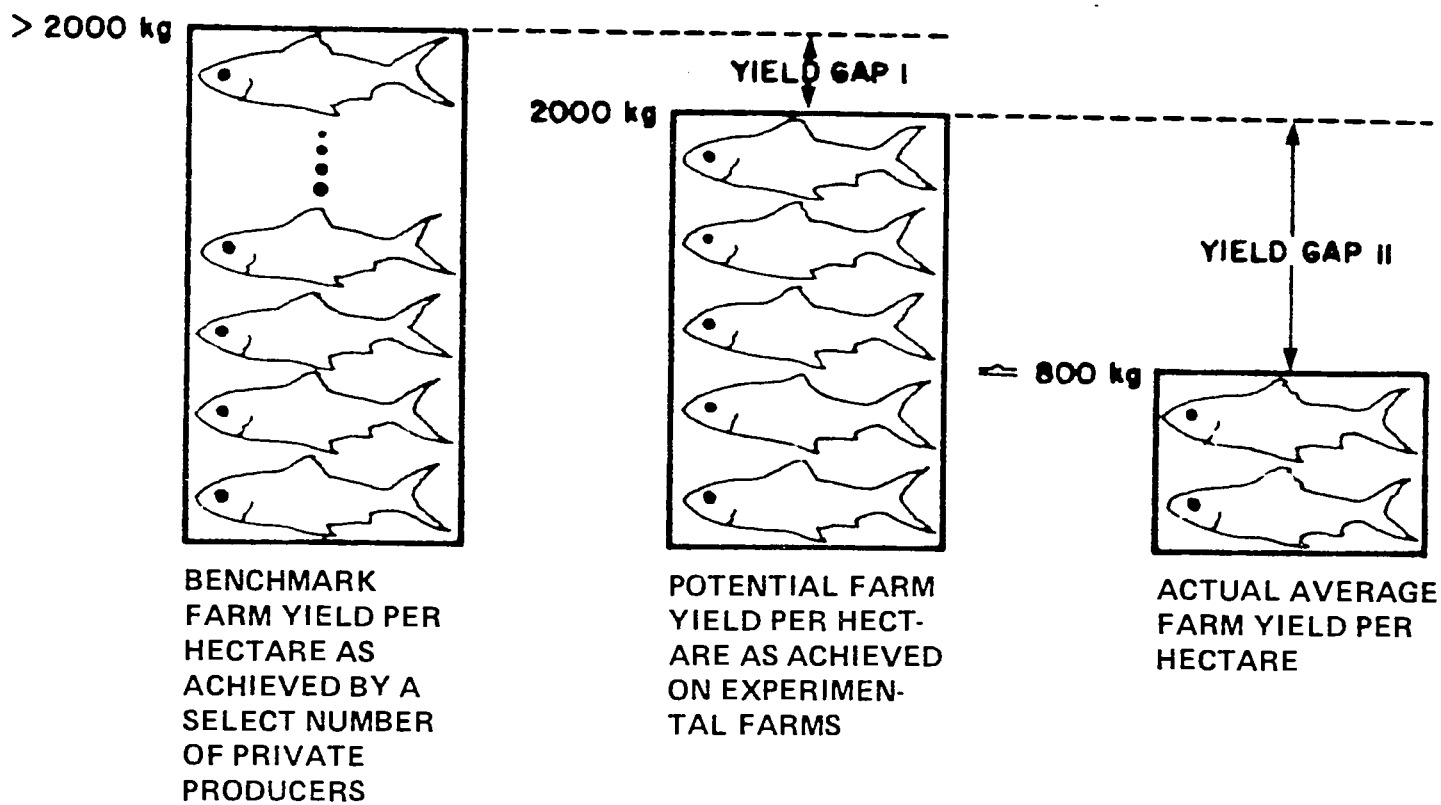

Fig. 1. Milkfish yield gaps in the Philippines.

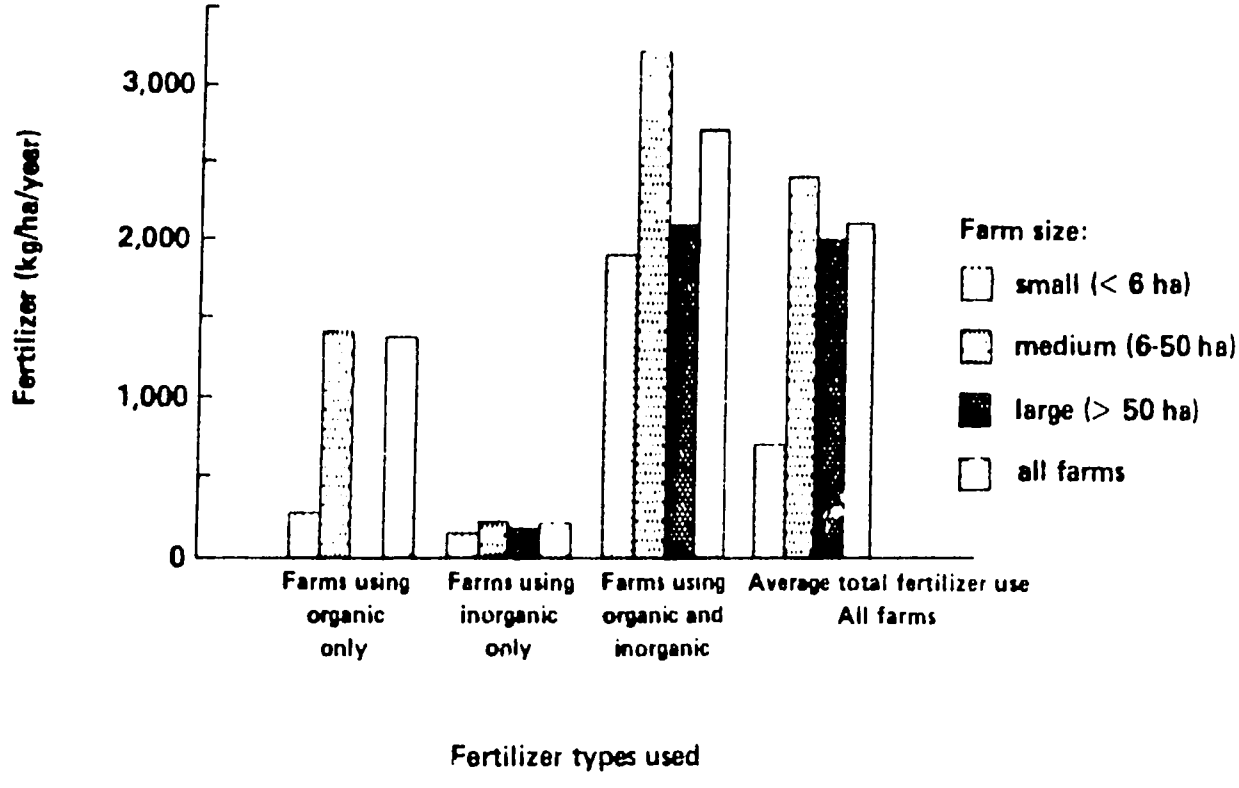

Fig. 2. Types and average quantities of fertilizers used (kg/ha/yr) in milkfish culture by farm size (ha) in the Philippines.

Project Title : Economic Analysis of the Tilapia Industry of Taiwan

Cooperating Institution : National Chung Hsing University, Taichung, Taiwan

Duration : 1 year, beginning July 1982 (first phase)

Key Personnel
Natl. Chung Hsing Univ. : Dr. Lee Chaur-Shyan

Objectives

The general objective of this study, which is part of ICLARM's collaborative research on tilapia with the Council of Agricultural Planning and Development (CAPD) in Taiwan, was to analyze the economics of the Taiwanese tilapia industry based on secondary data. The one-year first phase developed an overview of the industry in terms of (1) regional distribution of current production; (2) classification of different rearing systems by species; (3) numbers and locations of feed and fry suppliers; (4) markets, marketing practices and prices; and (5) major government policies and policy issues. Dr. Lee's report has been completed in Chinese and is currently being translated into English. The report documents the rapid growth of tilapia production in Taiwan during the past few years and the species' popularity with domestic consumers and export markets in Japan.

A second phase may be initiated in 1984, depending upon availability of funds and will consist of an in-depth analysis of selected input supply, rearing systems and marketing sectors of the industry.

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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	Taiwan	: Dr. Lee Chaur-Shyan, National Chung Hsing University
	Israel	: Dr. Dan Cohen, Aquaculture Production Technology Ltd. and Hebrew University

Objectives

There is an important role for research institutions such as ICLARM to play in clarifying the potential for and the impact of aquacultural development in developing countries. The major socioeconomic issues that need attention in this context are those related to technology transfer and constraints to its adoption, market potential, externalities and competition with other sectors, and equity and distribution of benefits from expanded aquaculture production. These can best be addressed at the national level. As an initial step, ICLARM commissioned two case studies in countries where aquaculture is an important activity and where data are available to permit analysis without resorting to extensive field surveys.

Results

Studies in Taiwan and Israel were commissioned in 1981. In both countries, 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. The Taiwanese manuscript is currently in press; the Israeli manuscript is expected by the end of 1983.

The aquaculture sector in Taiwan is undergoing dynamic growth and by 1982, approximately 20% of total fisheries production of almost 1 million tonnes came from aquaculture. Since 1978, much of this increased aquaculture production has been for the export market. In fact as real per capita incomes have risen, domestic fish protein consumption has levelled off in recent years at slightly less than 40 kg annually and per capita meat consumption is now greater than that of fish (Table 1).

In Taiwan, between 1965 and 1982, brackishwater area expanded by 30% to over 20,000 hectares while freshwater area increased by 230% to 17,650 ha. Milkfish production from brackishwater ponds increased until 1969, but declined rapidly by 1982 to 85% of the production level of 18 years earlier. The recent decline was offset partially by use of freshwater ponds for milkfish production. In 1982, 651 ha of fresh deep-water (3-meter) ponds produced 6,104t of milkfish, an average per ha yield of over 9t. In contrast to the recent levelling off of total brackishwater production, freshwater pond production increased by 841% between 1965 and 1979. Coupled with increased production from coastal and reservoir culture, this increase

in production of freshwater species, particularly tilapia, reduced milkfish share of the aquaculture sector in Taiwan from 51% in 1965 to only 14% by 1982. Milkfish production as a percentage of total production from the brackishwater area has declined from 92% in 1965 to 46% in 1982 with the balance now provided primarily by shrimps and crabs. While the aquaculture sector is thus growing rapidly, comparatively speaking the milkfish which historically was the premier cultured species in Taiwan, has now been surpassed by tilapia.

Much of the explanation for this shift can be found in the relative economics of rearing these species; tilapia farming is currently much more profitable than milkfish farming. Furthermore there is some evidence of changing consumer preferences especially among the young generation away from the bony milkfish. Nevertheless, recent developments, which indicate that a responsive aquaculture sector can fill the niche of a stabilized if not declining capture fisheries sector, are extremely encouraging.

Table 1. Changes in per capita income, per capita fish consumption and per capita consumption of other selected protein products in Taiwan, 1955-1980.

Year	Real per capita income (1976 NT$)	Per capita consumption of selected protein products (Kg) Fish	Meat	Eggs	Vegetable/fruits
1955	11,895	18.7	16.3	1.7	72.0
1970	26,582	34.2	25.3	4.1	130.1
1976	39,468	35.3	31.6	5.9	180.5
1977	42,167	35.1	35.3	6.3	179.8
1978	46,295	36.5	36.1	7.6	169.3
1979	48,921	38.1	40.3	7.8	194.1
1980	50,095	38.7	39.6	8.0	199.7

Source: Taiwan Food Balance Sheet and Taiwan Statistical Data Book as reported in Lee, C.S. (In press). Aquaculture trends and development prospects in Taiwan. ICLARM Studies and Reviews.

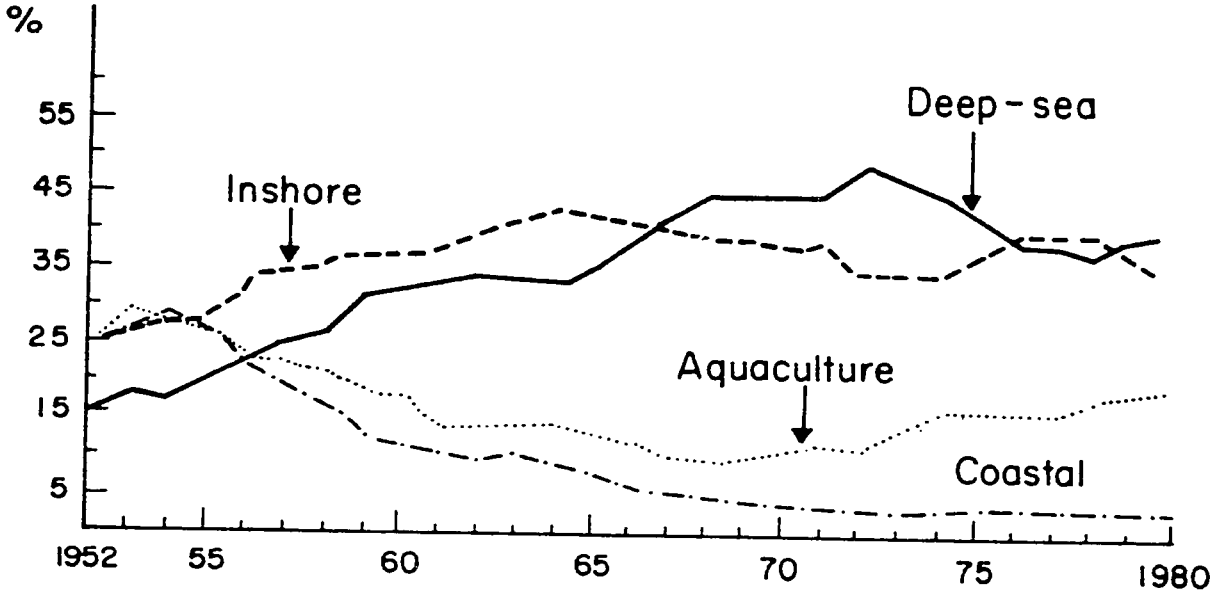

Fig. 1. Percentage composition of fishery production by type of fisheries in Taiwan, 1952-1980. Source: Fisheries Yearbook, Taiwan Area, Taiwan Fisheries Bureau, PDAF, Provincial Government of Taiwan.

Project Title		: Economics of Snakehead Culture in Thailand
Cooperating Institution		: National Inland Fisheries Institute (NIFI), Bangkok, Thailand
Duration		: 16 months, March-June 1983
Key Personnel	ICLARM	: Dr. Edward W. McCoy
	NIFI	: Dr. Maili Boonyaratpalin

Objectives

This research project had two parts. The first was the study of the economics of aquacultural production of snakehead *(Channa striata)*, an important freshwater fish in Thailand. The second was an analysis of the competitive structure of the market for trash fish, the most important food source for cultured fish in Thailand. Growth and changes in the industry were analyzed from secondary data. Production functions and short- and long-run cost functions were estimated from primary data and producer response to varying changes in both demand and cost of inputs was estimated. A descriptive analysis of the trash fish industry was also conducted.

Results

The study was conducted in six provinces of Thailand with data collected through a survey of randomly selected producers. Analysis of variance, multiple regression techniques and simultaneous-equation systems were used in analyzing the data. The project report has been written in Thai and is presently being translated for later publication.

Project Title : Intensive Mariculture of Tilapia

Cooperating Institution : Mariculture and Fisheries Department, Kuwait Institute for Scientific Research

Duration : 3 years beginning January 1982

Key Personnel ICLARM : Dr. Kevin D. Hopkins
KISR : Dr. Tani Al-Ahmad

Objectives

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

Results

Initial yield trials with Oreochromis aureus and O. spilurus in seawater raceways were completed in April 1983 after approximately 240 days of culture. The species showed comparable growth rates until water temperatures dropped below 25°C when O. aureus growth almost stopped (Fig. 1). Additionally, O. aureus were susceptible to a chronic infection caused by a bacterium, tentatively identified as a Vibrio sp. Thus, O. spilurus appears to be a superior candidate for seawater culture under Kuwaiti conditions. Yield trials with large hand-sexed males of both species and sex-reversed males are currently underway.

A brackishwater (3 ppt) fingerling production system consisting of 4 m^2 brood tanks, up-flow incubation bottles made from inverted 750 ml mineral water bottles, and 450-liter conical tanks for sex-reversal was constructed in a shaded greenhouse. During the approximately 120-day fry production season in 1982, 4 O. aureus fry/m^2/day were collected by sweeping the margins of the brood tanks with fine mesh nets. In 1983, eggs were collected weekly from mouthbrooding females and incubated in the "up-flow" bottles. Yields in the first 90 days of the 1983 season were considerably higher than in 1982 (Table 1). O. aureus produced 19 fry/m^2/day, but O. spilurus in brackish-water showed the highest potential followed by a red tilapia from Taiwan. The O. aureus ♀ X O. spilurus ♂ hybrid reproduces at essentially the same rate as O. aureus X O. aureus but the reciprocal hybrid cross, O. spilurus ♀ X O. aureus ♂ has proved unproductive.

An experimental simple recirculating system for tilapia was constructed and tested using brackishwater, again 3 ppt. The system uses artificial aeration to supply all of the oxygen requirements and "new" water is added to dilute metabolic byproducts and other wastes. The basic design consists of a cylindro-conical tank with external airlifts for aeration (Fig. 2). The results of preliminary trials were highly promising with average monthly yields of 2.3 to 3.1 kg/l or 6.2 to 10.3 kg/m^3 (Table 2).

In order to obtain indications of the market acceptability of tilapia in Kuwait, about 500 kg of live O. aureus were sold through a retail fish store in Kuwait City at $6.00 per kg. Fish ranging in size from 150 g to 800 g were readily sold. About 50% of the customers were Egyptians who were already familiar with tilapia while 8 other nationalities, including Kuwaitis, also bought the fish.

Table 1. Production of tilapia fry by egg collection and incubation in "up-flow jars" in brackishwater, 3 ppt.

Species ♀		♂	Stocking rate kg ♀/m^2	Fry/day per m^2	Fry/day per kg ♀
aureus	X	aureus	0.870	19	22
aureus	X	spilurus	1.005	20	20
spilurus	X	aureus	0.475	3	7
spilurus	X	spilurus	0.595	111	187
spilurus	X	spilurus*	0.205	6	27
red	X	red	0.338	40	119

* In seawater

Table 2. Loads, densities and yields of *Oreochromis aureus* attained in 118 days using three water exchange rates.

	Water exchange rates (times per day)		
	3	5	7
Load (kg/l/min)			
Initial	19.3	11.4	7.9
Mean	26.6	20.6	14.6
Final	31.5	22.4	16.6
Density (kg/m^3)			
Initial	38.7	38.0	37.0
Mean	53.7	58.0	57.6
Final	63.0	74.6	77.5
Monthly mean yields			
kg/m^3	6.2	9.3	10.3
kg/l/min	3.1	2.8	2.3

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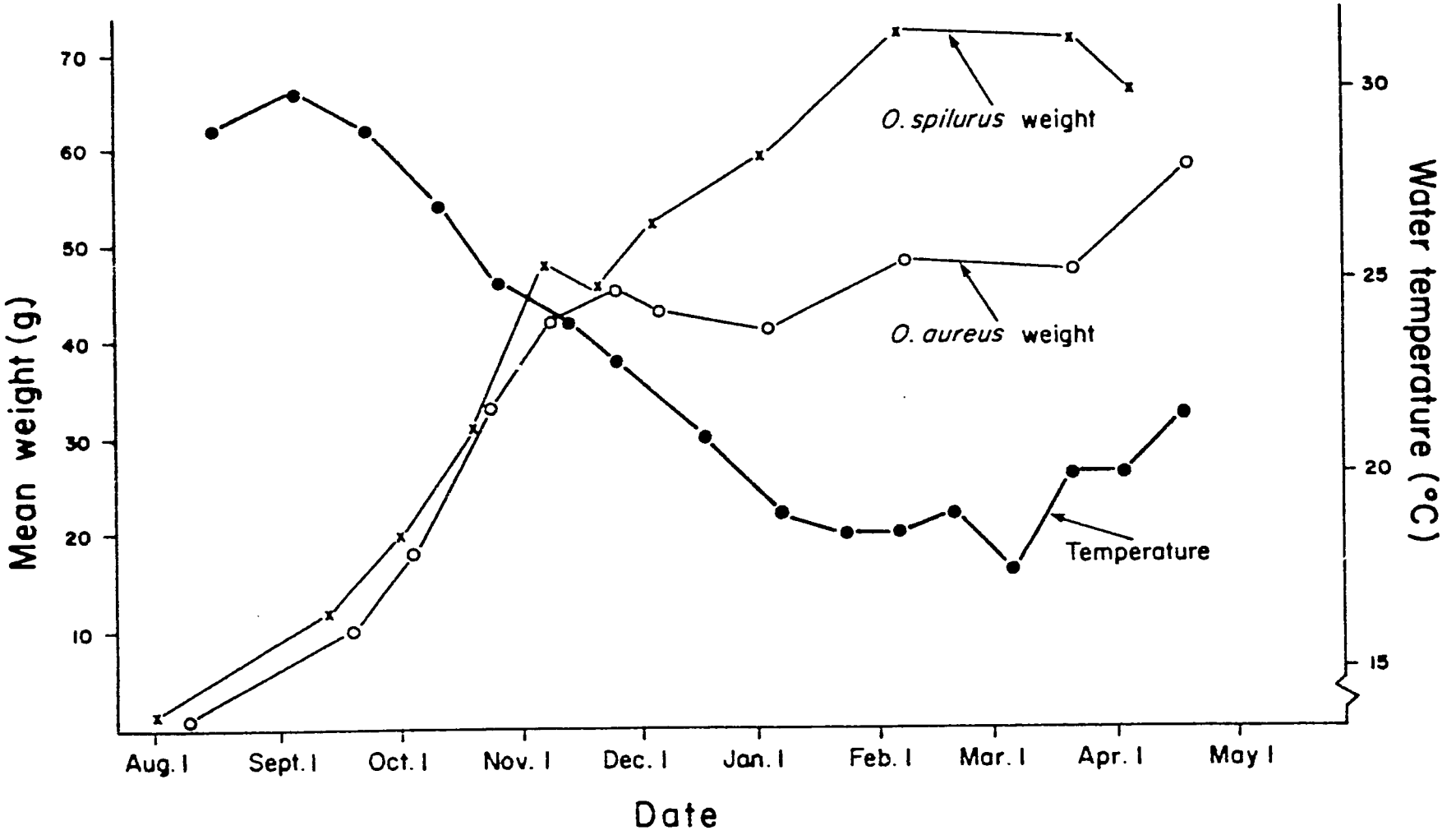

Fig. 1. Mean sample weights of Oreochromis spilurus and O. aureus in seawater raceways in Kuwait, 1982-83.

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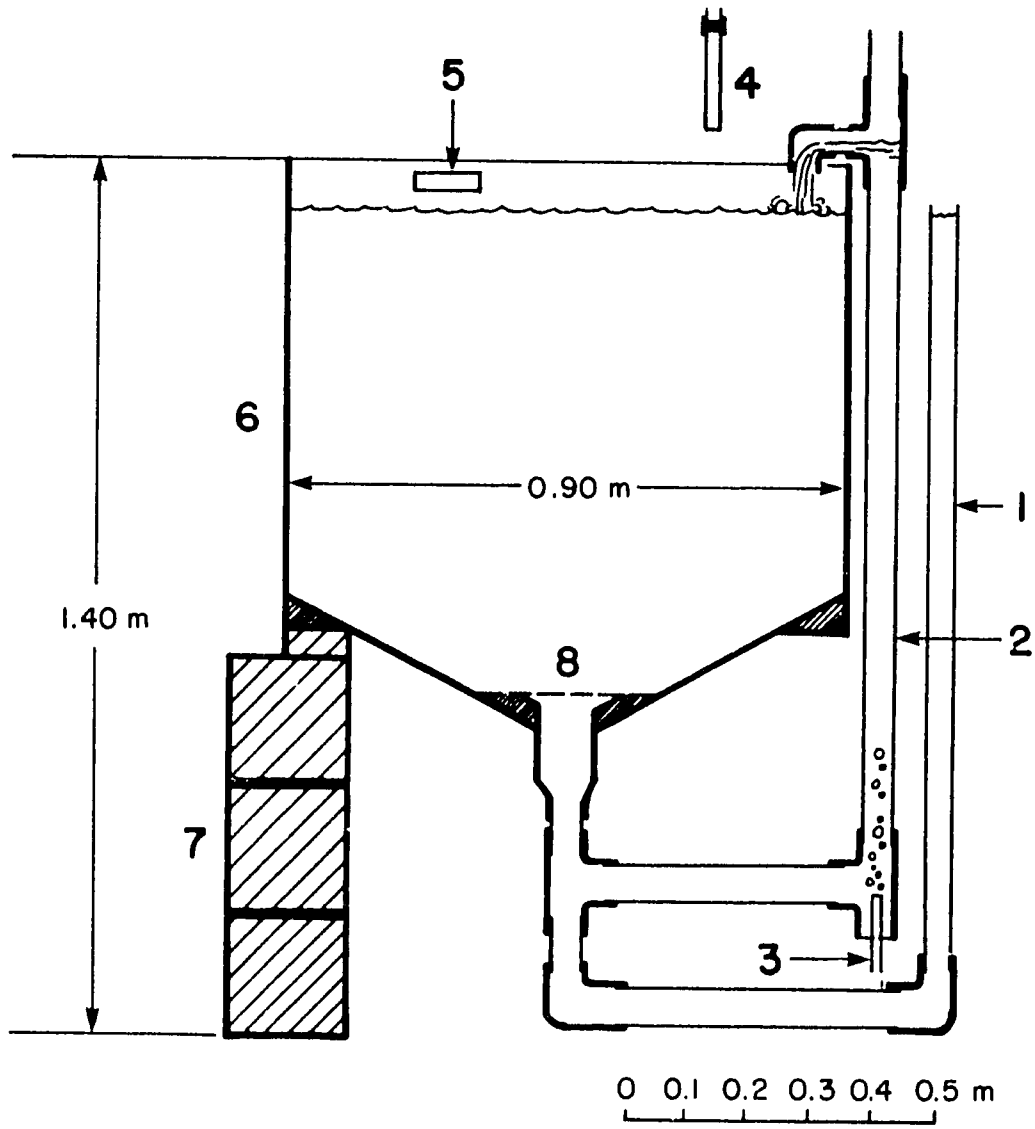

Fig. 2. Schematic diagram for a simple recirculating system for tilapia culture: 1. 50-mm internal diameter (ID) PVC turndown pipe/drain; 2. 500-mm ID PVC airlift; 3. air supply from compressor; 4. 'new' water inlet; 5. overflow; 6. 450-l cylindro-conical fibre glass tank; 7. tank support; 8. base grid.

Project Title	:	Cooperative Tilapia Research Project
Cooperating Institutions	:	Council for Agricultural Planning and Development (CAPD), Taiwan and National Sun Yat Sen University, Kaohsiung
Duration	:	3 years, beginning July 1982
Key Personnel ICLARM	:	Drs. Ching-Ming Kuo and Wade O. Watanabe
CAPD	:	Dr. Jen-Chyuan Lee
Natl. Sun Yat Sen Univ.	:	Ms. Huang Mei Tsun,

Objectives

- Development of saline-tolerant tilapia strains and hybrids suitable for culture in coastal regions and associated technology packages for mass seed production and growout.
- Evaluation of survival, growth and reproductive performance of tilapias with potential for saline water culture in Taiwan.
- Improvement of salinity tolerance of cultured tilapias through genetic methods, such as hybridization and selective breeding, and also through physiological acclimatization.
- Development of efficient feeds for growth and maturation of tilapias cultured in seawater, through studies on their nutritional requirements in varying salinities.

Results

1. Development of procedures in freshwater

Reproductive performance in freshwater was first monitored for Oreochromis niloticus and O. aureus. From 26 March to 7 September, 27 spawnings were obtained from a broodstock of 16 O. niloticus females (mean initial length, weight: 21.4 cm, 176 g) and 21 spawnings from 12 O. aureus females (mean initial length, weight: 21.9 cm, 164 g). For females spawning on consecutive occasions, the mean intervals between spawning were 26 days for O. niloticus and 27 days for O. aureus, from broodstocks in which eggs were removed from some mouthbrooding females and left in others. The mean numbers of eggs spawned per individual were 881 (± S.E. = 125; n = 13) for O. niloticus and 715 (± S.E. = 94; n = 10) for O. aureus.

Thereafter, eggs were normally removed from the mouth of the female 1-2 days post-spawning and incubated artificially in 1.2-l bottles fitted with a perforated round disc bottom, through which was provided a continuous current of filtered recirculated water. Average hatching successes of 84.0% (± S.E. = 4.7%; n = 21) for O. niloticus and 98.0% (± S.E. = 1.93%; n = 3) for O. aureus were obtained during artificial incubation (non-fertile spawnings excluded). For O. niloticus the mean interval between spawnings was reduced from 40 days (range 27-52) with normal mouthbrooding to 20 days (range 14-37) with egg removal and artificial incubation.

2. Reproductive performance of O. niloticus in seawater and hatchery work at various salinities

Fish from a single brood, spawned and reared in freshwater until 248 days old, were acclimatized to seawater (32 ppt) at a rate of 5 ppt per day. Spawning was first observed in the seawater-acclimatized group after 272 days although successful hatching in seawater was never achieved. Seawater-acclimatized individuals of mean initial length 9.9 cm and weight 16.2 g were subsequently distributed to different salinities and their reproductive performance monitored. Eggs were artificially incubated at equivalent salinities (Table 1). The results were similar at 5, 10 and 15 ppt, but spawnings were less frequent at 32 ppt. Hatching successes were similar at 10 and 15 ppt, but significantly greater at 5 ppt, which compared favorably with those obtained in freshwater. However, hatching successes for eggs spawned at 10 and 15 ppt were substantially below those recorded in freshwater. Though total egg production was greatest at 10 ppt, total fry production was similar at both 5 and 10 ppt, due to the improved hatching success at 5 ppt.

3. Evaluation of salinity tolerance of freshwater-spawned tilapia fry

Several indices were evaluated as practical measures of salinity tolerance: (1) Median Lethal Salinity - 96 hours (MLS-96), defined as the salinity at which survival falls to 50%, 96 hours following abrupt transfer; (2) Mean Survival Time (MST), defined as the mean survival time for all individuals in an experimental group over a 96-hour period, following abrupt transfer to full seawater (32 ppt) and (3) Median Survival Time (ST-50), defined as the time at which survival falls to 50% following abrupt transfer to full seawater (32 ppt). Of these, MST was the most reliable index for assessing salinity tolerance.

Salinity tolerance tests were performed on freshwater-spawned O. niloticus and O. aureus fry of known ages from 7 through 120 days. Data were also obtained for O. mossambicus ♀ x O. niloticus ♂ (MXN) hybrid fry from 7-60 days old. At 24.4 - 31.0 C, MST values remained relatively low for fry up to 45 days old in both O. niloticus and O. aureus, and then increased to maximal levels by 120 days old (Fig. 1). MXN hybrid saline tolerance was similar to that of O. aureus and O. niloticus at 7 days, but was substantially elevated by 15-30 days, and increased up to 60 days old. The increase in tolerance with age also occurred at a much faster rate in the MXN hybrid. The MST of 60-day MXN hybrid fry (217 min.) was well above that recorded for either O. aureus (64 min.) or O. niloticus (104 min.). Increase in salinity tolerance appears to be more closely related to length than to age (Fig. 2). Additional data still being analyzed indicate that salinity tolerance is greater at colder temperatures (19-20°C).

4. Incubation of freshwater- and saline water-spawned O. niloticus eggs in saline water and evaluation of the salinity tolerance of resultant fry

Survival of freshwater-spawned O. niloticus eggs incubated at various salinities are shown in Fig. 3. Mortality occurred primarily during early embryonic development and was particularly pronounced in the higher salinities. In full seawater, there was no survival during this period. Survival generally stabilized after hatching, although some mortality continued at

15 ppt. Survival patterns during incubation at 5 and 10 ppt were very similar to those observed in freshwater and MST's for 6-day old hatchings revealed that salinity tolerance was increased with increasing incubation/hatching salinity (Fig. 4).

Fig. 4 also shows that for saline water-spawned eggs, increased spawning salinity improved salinity tolerance. Their relationship was very similar to that observed between MST and incubation salinity. However, at equivalent salinity, early exposure (spawning) produced progeny with comparatively greater salinity tolerance than those spawned in freshwater and incubated at elevated salinity.

The results suggest that a combination of genetic (hybridization) and non-genetic methods (spawning and incubation at elevated salinity) may allow the successful culture of tilapias in seawater. During the coming year, these techniques will continue to be evaluated and refined. In addition, the growth characteristics of saline spawned/hatched progeny in seawater will be studied together with a detailed study of associated osmoregulatory factors including blood and tissue electrolytes, amino acids and tissue Na-K ATP-ases.

The development of feeds for tilapia growout in seawater will also be studied. So far, nutritional assays with red tilapia (Oreochromis hybrids) in freshwater suggest that feed conversion efficiency is optimal with a 35% crude protein and 101 mg/kcal protein/energy ratio feed. These studies will be further pursued in seawater. One possibility to reduce costs is replacing fish meal as the main protein ingredient with soyabean meal.

The project has provided an opportunity for 6-months overseas training for Mr. Anne Van Dam, a Masters student from the Agricultural University, Wageningen, the Netherlands. Mr. Van Dam has worked closely with ICLARM, CAPD and university staff on all aspects of the research.

Table 1. Reproductive performance of Nile tilapia (Oreochromis niloticus) broodstock[a] at various salinities, 30 May - 30 August 1983.

Salinity at spawning (ppt)	No. of spawnings[b]	Mean interval between spawnings (days)	Mean no. of eggs per spawning	Mean hatching success (%)[c]	Total egg production	Total fry production
32	4	42	302	0	1,208	0
15	14	25	174	33.9	2,436	826
10	13	19	284	35.9	3,692	1,325
5	11	17	239	47.6	2,629	1,251

[a] For each salinity a group of 3 females and 3 males was maintained.
[b] Total spawnings observed per group; not necessarily from the same individual.
[c] Non-fertile spawnings included.

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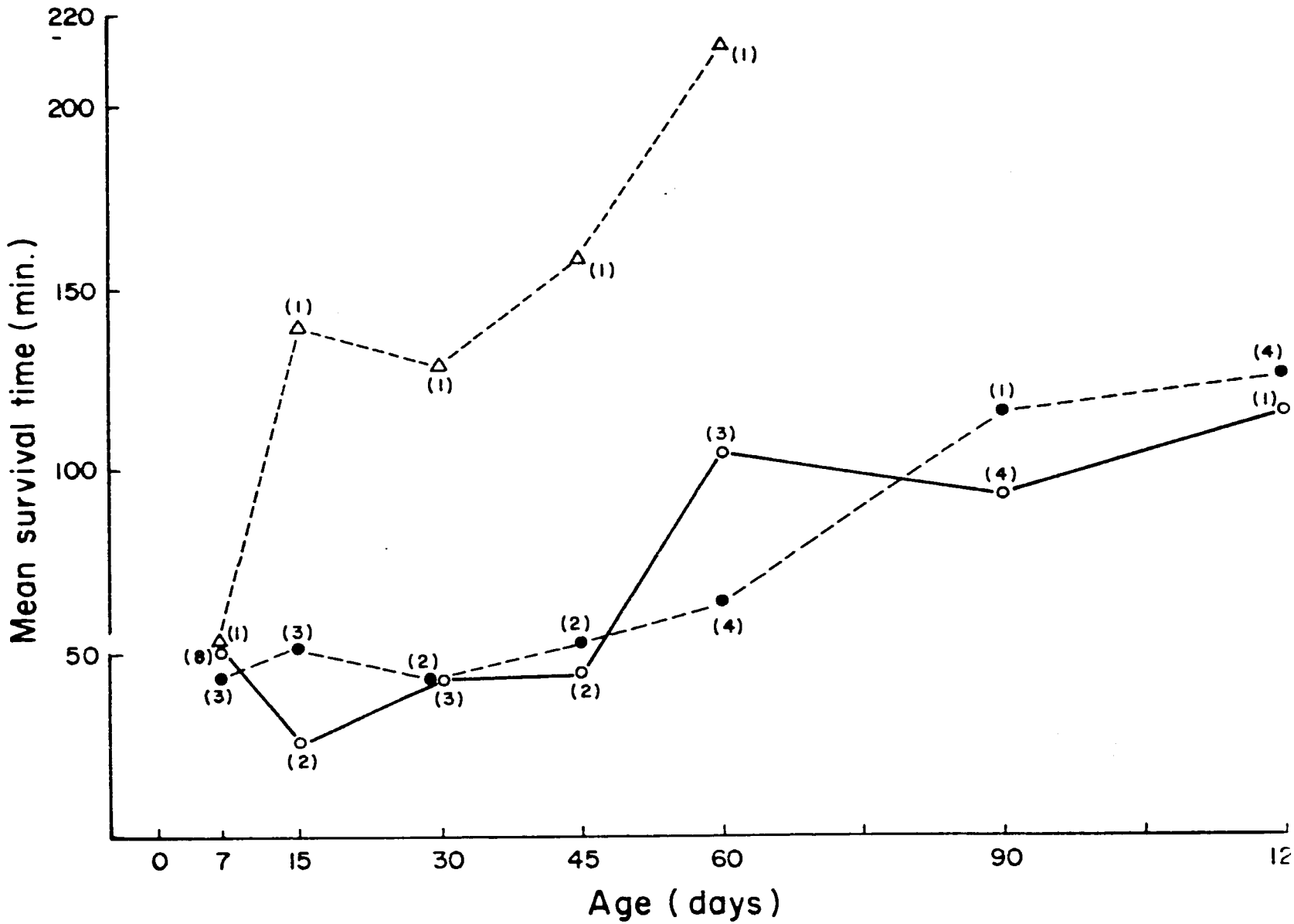

Fig. 1. Variation in salinity tolerance (MST) with age in Creochromis niloticus (○), O. aureus (●) and an O. mossambicus x O. niloticus hybrid (Δ): numbers in parenthesis denote the number of determinations (25 fish/determination).

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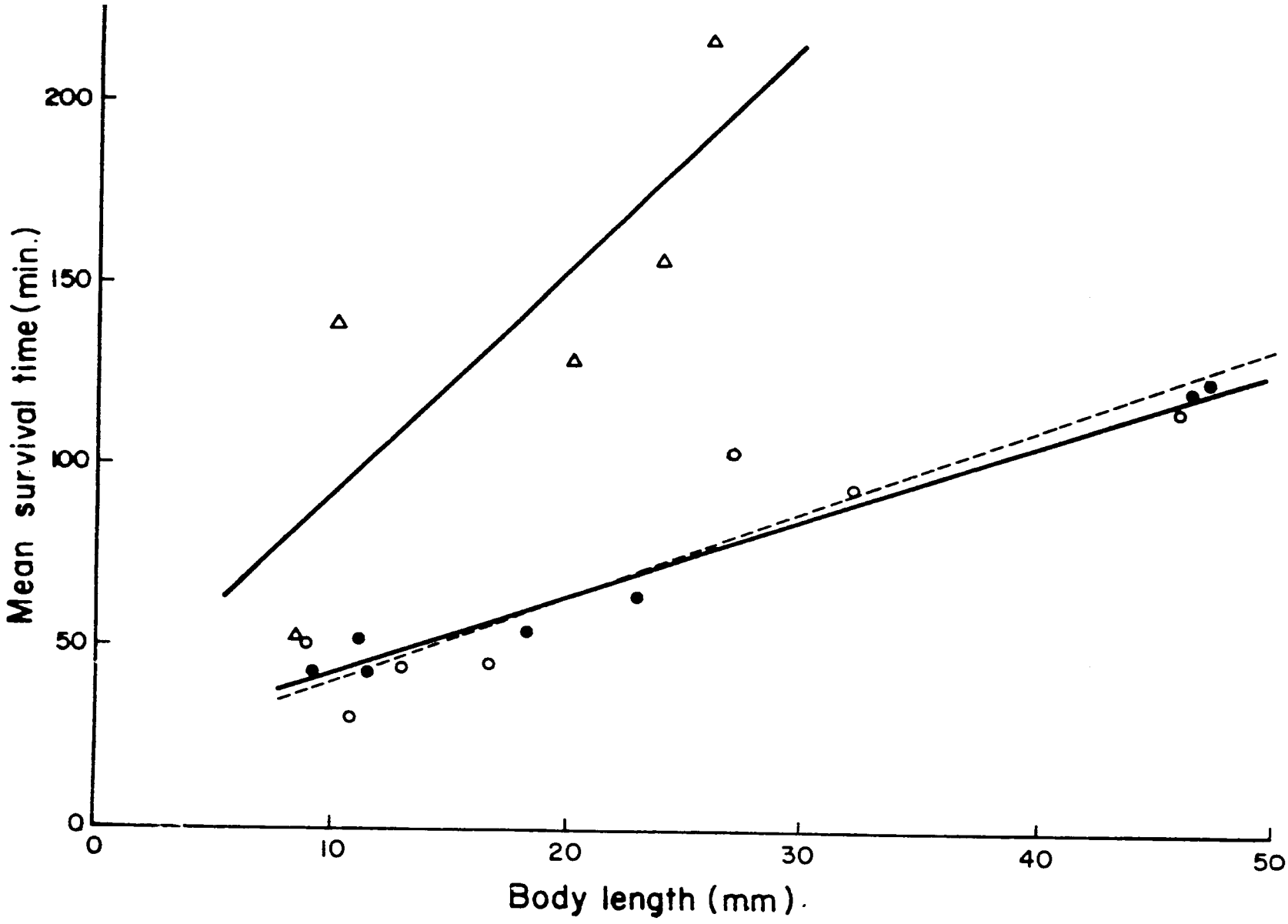

Fig. 2. Relationship between body length and salinity tolerance (MST) in Oreochromis niloticus (○), O. aureus (●), and an O. mossambicus x O. niloticus hybrid (Δ). Each plotted point represents mean values for 1-8 determinations (25 fish/determination) on individuals of uniform age. Regression analysis defined the relationships as follows: O. aureus, $Y = 20.68 + 2.12\ X$; $R^2 = 0.98$; O. niloticus, $Y = 17.32 + 2.32\ x$; $R^2 = 0.85$ and the O. mossambicus x O. niloticus hybrid, $Y = 29.86 + 6.22\ X$; $R^2 = 0.66$.

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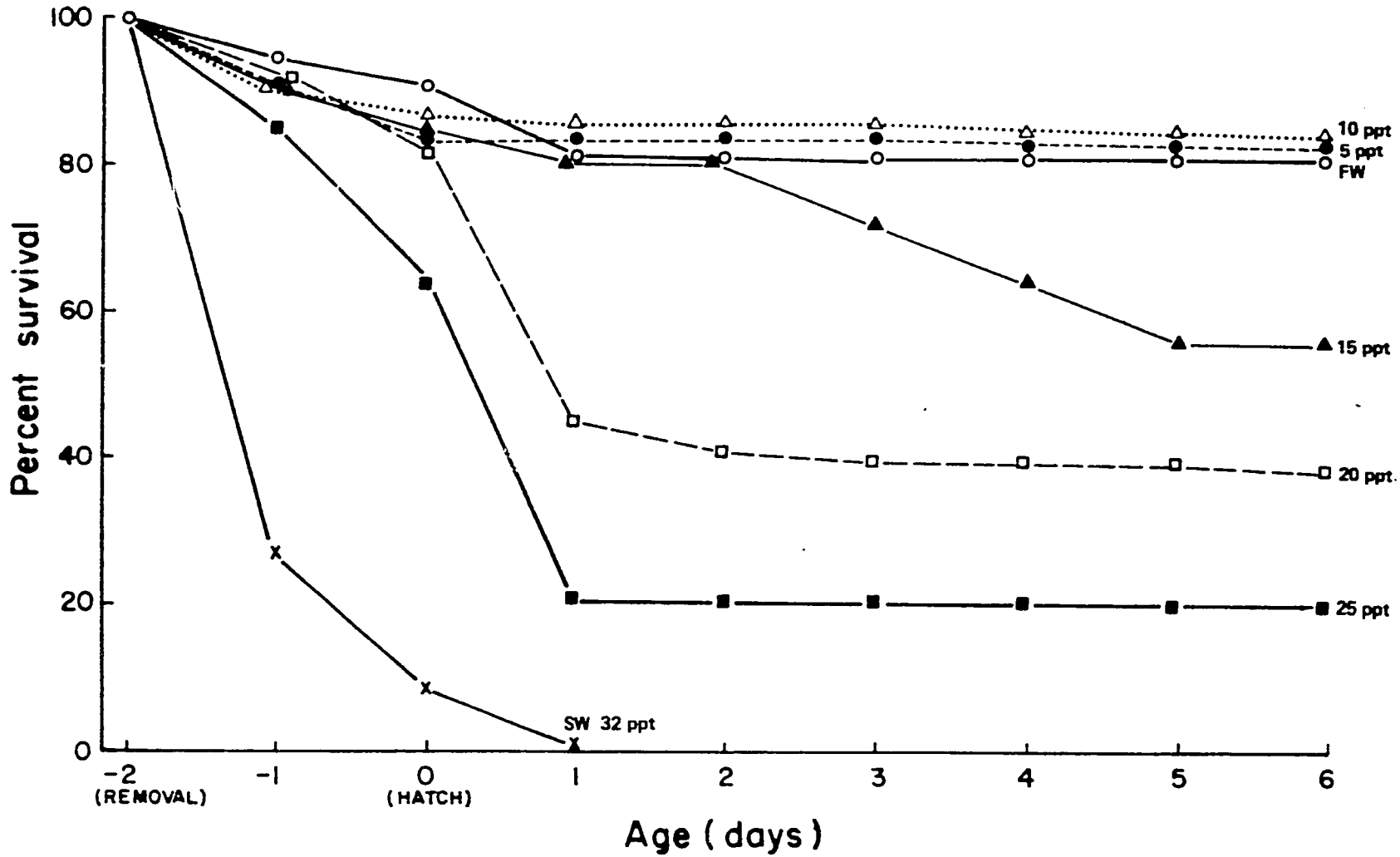

Fig. 3. Survivorship of freshwater spawned Oreochromis niloticus eggs, artificially incubated at various salinities. Each plotted point represents the mean value for four trials.

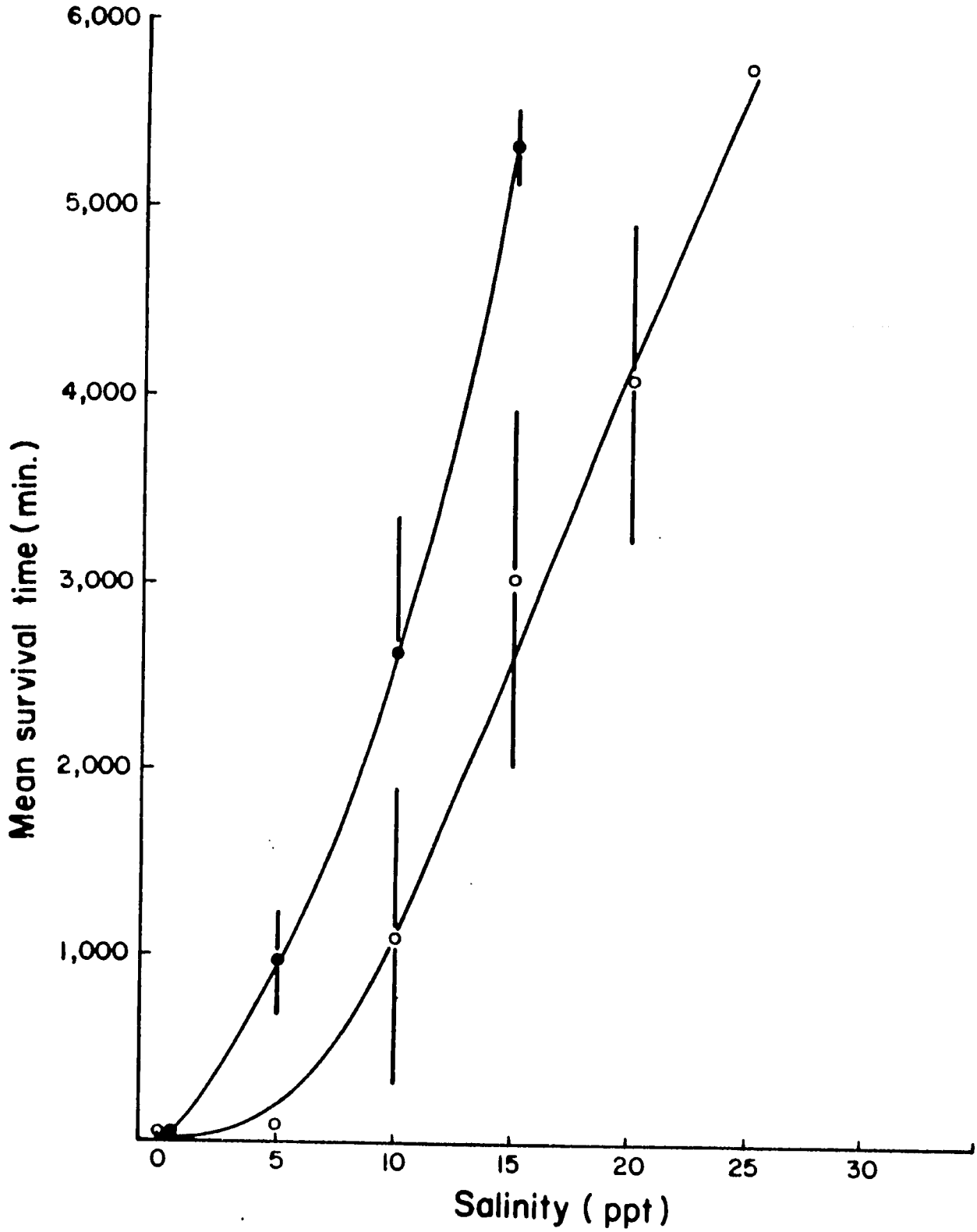

Fig. 4. Salinity tolerance (MST) of Oreochromis niloticus fry as a function of the spawning salinity (● = saline-spawned fry) or as a function of the salinity of artificial egg incubation (o = freshwater-spawned, saline-hatched fry). Plotted points represent mean values for 3-8 determinations (25 fish/determination) and vertical bars represent ± S.E.M. Absence of vertical bars indicates that the S.E.M. lies within the area of the plotted point, except for the MST value at 25 ppt which represents a single observation. Polynomial regression analysis defined the lines as follows: saline-spawned fry, $Y = 51.10 + 1.33.41 X + 7.85X^2 + 0.47X^3$; $R^2 = 1.00$; freshwater-spawned, saline-hatched fry, $Y = 16.25 - 89.33 X + 25.92X^2 - 0.53X^3$, $R^2 = 0.99$.

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Project Title : Genetic Characteristics of Food Fishes (Philippines)

Cooperating Institution : Marine Sciences Center, University of the Philippines (UPMSC), Diliman, Quezon City, Philippines

Duration : 1 year - January - December 1983 (with provision for extension)

Key Personnel ICLARM : Dr. Roger S.V. Pullin
Ms. Josephine B. Capili
UPMSC : Mrs. Julie M. Macaranas
Ms. Ma. Josefa R. Pante

Objectives

- To investigate the genetic characteristics of cultured fish stocks in Philippines with initial emphasis on the tilapias.
- To identify electrophoretic and other genetic markers for diagnostic monitoring of experimental and commercial cultured stocks of Philippine fishes.
- To provide information for the initiation of stock improvement projects in Philippine aquaculture.

Results

Work has been concentrated on assessment of the status of experimental and commercial stocks of Nile tilapia (Oreochromis niloticus), currently the most important cultured tilapia species in the Philippines. In experimental and commercial farms, Nile tilapia stocks are being called 'strains' without any critical evaluation of their breeding characteristics, and contamination of many stocks, through interbreeding with the less desirable species O. mossambicus, has been suspected. O. mossambicus is widespread in Philippine watercourses and water bodies.

O. niloticus were sampled from experimental collections of cultured 'strains' in Central Luzon and from commercial farms in Rizal and Laguna Provinces. Samples of O. mossambicus were obtained from Malabon and Bulacan province. Samples of O. aureus are still to be collected from Philippine and Taiwanese stocks.

Starch gel electrophoresis was used to select diagnostic genetic markers for recognition of mixed stocks. The enzymes investigated were from eye, heart, kidney and liver tissue samples: Table 1 lists the 27 loci investigated. In addition, isoelectric focusing (IEF) of skeletal muscle proteins on polyacrylamide gel (PAG) was used. It is well known that differentiation between O. niloticus, O. mossambicus and their hybrids is difficult using electrophoretic markers as these two species are closely related and their electrophoretic patterns are very similar.

Here, phosphoglucose isomerases (PGI) provided the only clear diagnostic markers. Two loci were detected in tilapia eye and heart tissue samples (Figure 1). PGI - 1 appears as a single band in both species. PGI - 2 also stains as a single band, but O. niloticus displays a slower allele than O. mossambicus. Heterodimers of intermediate mobility are expressed in both species with proportional differences in mobility.

However, IEF of skeletal muscle proteins provided the best diagnostic technique. Figure 2 shows a typical PAG plate comparing samples of O. mossambicus, O. niloticus and mixed stocks. The most useful markers appear to be the low-molecular weight sarcoplasmic calcium-binding proteins called parvalbumins. They are characterized by acidic isoelectric points (pH 4.4 to 5.0 in this study) and are very robust markers, always showing strong, consistent staining patterns. It is probable that other useful markers will appear as investigations using IEF are continued.

Results obtained so far indicate that some experimental and commercial stocks of O. niloticus in the Philippines are contaminated with O. mossambicus. Additional sampling and analysis through 1984 will serve as a first step toward identification and standardization of commercial stocks.

Table 1. Enzymes investigated by starch gel electrophoresis for potential use as diagnostic genetic markers in assessing the purity of Philippine Nile tilapia (Oreochromis niloticus) stocks: EBT = 0.2M EDTA - 0.5M boric acid - 0.9M tris buffer, pH 8.6; C-APM = 0.109M citric acid and buffer adjusted to pH 6.0 with N (-3 - aminopropyl) - morpholine.

Protein	EC No.	No. of Loci	Buffer
Adenylate kinase (AK)	2.7.4.3	1	EBT
Alcohol dehydrogenase (ADH)	1.1.1.1	1	C-APM
Aspartate aminotransferase (AAT)	2.6.1.1	3	EBT
Creatine kinase (CK)	2.7.4.3	3	EBT
Esterase (EST)	3.1.1.1	2	C-APM
α-Glycerophosphate dehydrogenase (α-GDH)	1.1.1.8	2	C-APM
Isocitrate dehydrogenase (ICD)	1.1.1.42	2	C-APM
Lactate dehydrogenase (LDH)	1.1.1.27	3	EBT
Malate dehydrogenase (MDH)	1.1.1.37	2	EBT
Malic enzyme (ME)	1.1.1.40	2	EBT
Phosphoglucomutase (PGM)	2.7.5.1	1	C-APM
6-Phosphogluconate dehydrogenase (6-PGD)	1.1.1.44	1	C-APM
Phosphoglucose isomerase (PGI)	5.3.1.9	2	EBT/C-APM
Sorbitol dehydrogenase (SDH)	1.1.1.14	1	C-APM
Superoxide dismutase (SOD)	1.15.1.1	1	EBT

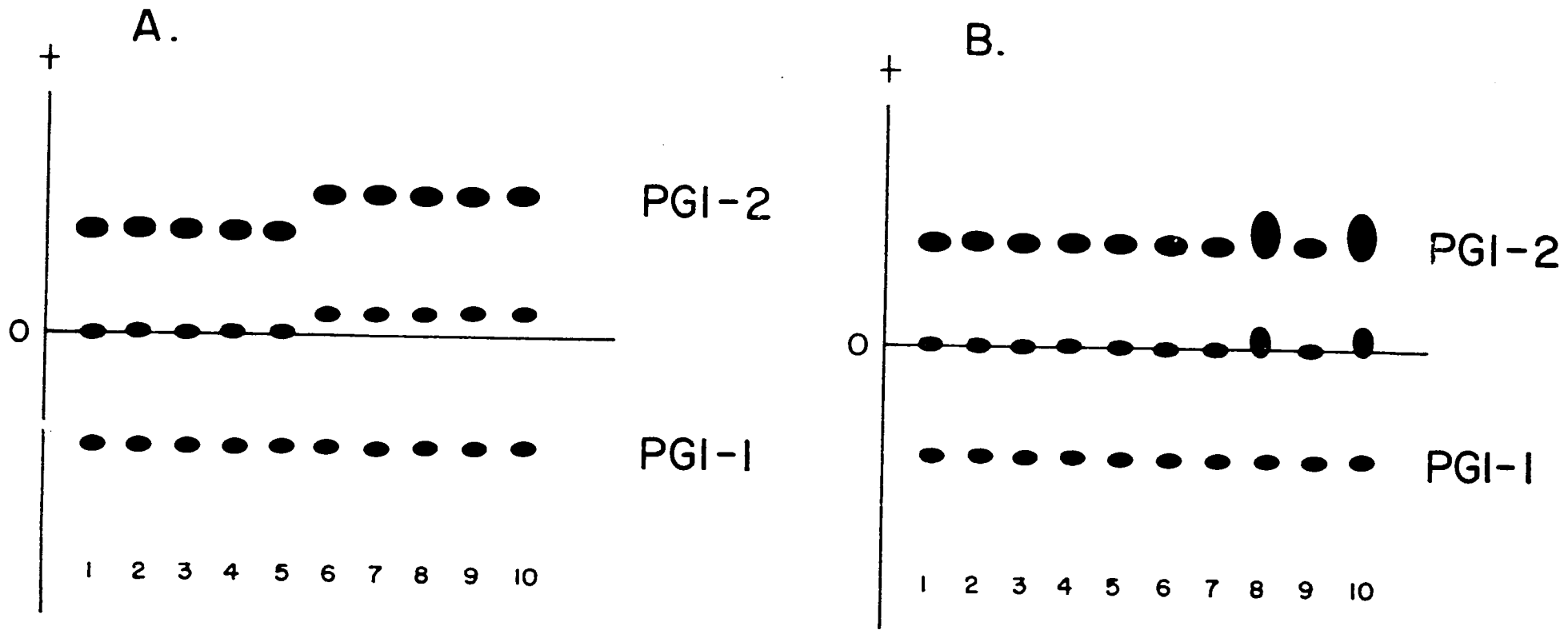

Fig. 1. A. Starch gel electrophoresis of phospho-glucose isomerases (PGI) in tilapia heart tissue. PGI-1 shows identical patterns for Oreochromis niloticus (samples 1-5) and O. mossambicus (6-10), whereas PGI-2 shows interspecific differences. B. As A. for samples of Philippine tilapia stocks: samples 8 and 10 are from hybrid stocks, the remainder from O. niloticus.

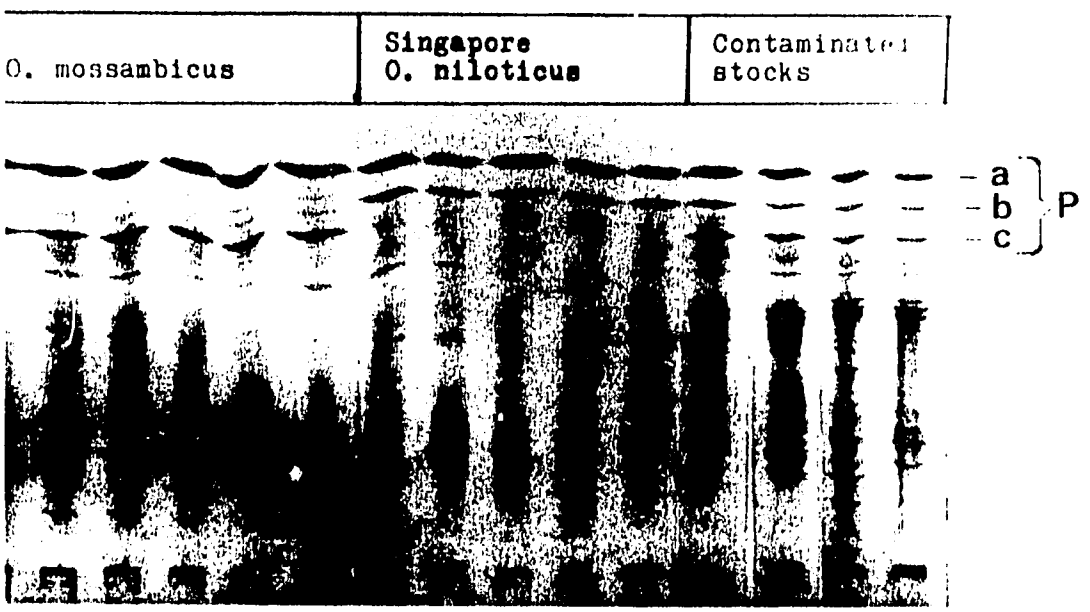

Fig. 2. Typical skeletal muscle sarcoplasmic protein patterns of tilapias from Philippine Stocks examined by isoelectric focusing on an Ampholine polyacrylamide gel plate at pH gradient 3-10. The parvalbumin region is designated P. Three banding positions are observed: a, pI = 4.4; b, pI = 4.7 and c, pI = 5.0.

Project Title		: Tilapia Seed Supply and Management in the Philippines
Cooperating Institutions		: Marine Sciences Center, University of the Philippines (UPMSC), Diliman, Quezon City
Duration		: 1 year beginning July 1983
Key Personnel	ICLARM	: Ms. Emma Escover, Dr. Ian R. Smith
	UPMSC	: Ms. Julie Macaranas,

Objectives

This economic analysis of tilapia seed supply in the Philippines is a continuation of the work initiated under the PCARRD-ICLARM Philippine Tilapia Economics project (see p. 16). It is also complementary to the UPMSC-ICLARM project on Genetic Characteristics of Food Fishes (Philippines) which is described on p. 52).

The primary objectives of this economics project are to analyze the relative profitability and costs of fingerling production of various land-based and water-based tilapia hatcheries operated by the private sector and to compare these results with those of government tilapia hatcheries. In so doing, it is hoped that some insights can be gained as to the advantages and disadvantages of large government-run centralized hatcheries vis-à-vis small-scale private decentralized hatcheries.

Data for the study are gathered from surveys of land-based and water-based hatcheries and a record-keeping project with 10 private hatchery operators which has been underway since October 1982. Sample broodstock from these 10 hatcheries will be examined by UPMSC to determine their genetic characteristics and the probable need for better broodstock management control.

ICLARM has provided the seed money for this project during 1983. A proposal to cover the 1984 costs of this economics study and the UPMSC component of the genetics studies has been submitted to the Agriculture, Food and Nutrition Sciences Division of IDRC of Canada. Preliminary discussions with IDRC staff have been extremely encouraging and a decision is expected before the end of November 1983.

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Project Title	:	Controlled Reproduction and Mass Fry Production of Commercially Important Fishes
Main Cooperating Institution	:	Council for Agricultural Planning and Development (CAPD), Taiwan
Other Cooperating Institutions	:	National Taiwan University, Taipei; National Taiwan Normal University, Taipei; Institute of Zoology (Academia Sinica), Taipei; Taiwan Fisheries Research Institute, Tainan
Duration	:	3 years, beginning July 1982
Key Personnel ICLARM	:	Drs. Ching-Ming Kuo and Wade O. Watanabe
CAPD	:	Dr. Jen-Chyuan Lee
Natl. Taiwan Univ.	:	Dr. Ho-Lieng Huang
Natl. Taiwan Normal Univ.	:	Dr. Stephen H. Shih
Academia Sinica	:	Mr. Y-L. Yu
Taiwan Fish. Res. Inst.	:	Mr. Y-Y. Ting

Objectives

- To develop improved methods for the controlled reproduction and mass fry production of commercially important cultured fishes in Taiwan.
- To establish pituitary banks; high quality broodstock of key species; techniques for induced maturation and induced spawning on demand; egg incubation; larval rearing; nursery procedures and defined nutritional and environmental conditions for optimum fry production.

Results

Methods for purification and bioassay of fish pituitary gonadotropins have been developed. This is aimed at the development of a major program of hormone characterization and production to further our understanding of fish reproductive physiology.

Attempts at induced breeding often produce unpredictable results mainly due to the failure of culturists to assay accurately the potency of the preparations used and difficulties have often been encountered in hormone bioassays because of species-specificity of fish gonadotropins. The system developed under the current cooperative project in which androgen production in rooster testis is used as a bioassay, has proved to be reliable and sensitive. Fig. 1 shows a series of bioassay (dose-response) curves illustrating results of this technique.

Induction of gonadal maturation and spawning of the Pacific eel (*Anguilla japonica*), milkfish (*Chanos chanos*) and seabass (*Lates calcarifer*), an important cultured finfish in Taiwan, is also an important research topic. Mature eels have been obtained in captivity by repeated administration of the analog of gonadotropin - releasing hormone and methods for completion of spawning are now being refined. The endocrinology of maturation is being studied in depth.

ICLARM's major role in the project is to coordinate research activities and also to take responsibility for research on final oocyte maturation and ovulation. Efforts have been made to document circadian rhythms in blood gonadotropin levels, blood and oocyte steroidal profiles, oocyte responsiveness to exogenous hormone stimulation and sites and pathways of steroid synthesis/metabolism.

Application of acquired knowledge of fish reproductive physiology for mass production of fry remains the main thrust of the project. Work has also been focused on the artificial propagation of the skipper goby (*Boleophthalmus chinensis*) and seabass. Success in the induced spawning of the former species has been achieved and refined methods of larval rearing and improved survival of fry are being developed.

Attempts have been made to develop mature seabass broodstock by using piscine pituitary gonadotropin preparations and luteinizing hormone-releasing hormone (LH-RH) analog. The artificial propagation of the seabass will be undertaken when the mature broodstock has been established.

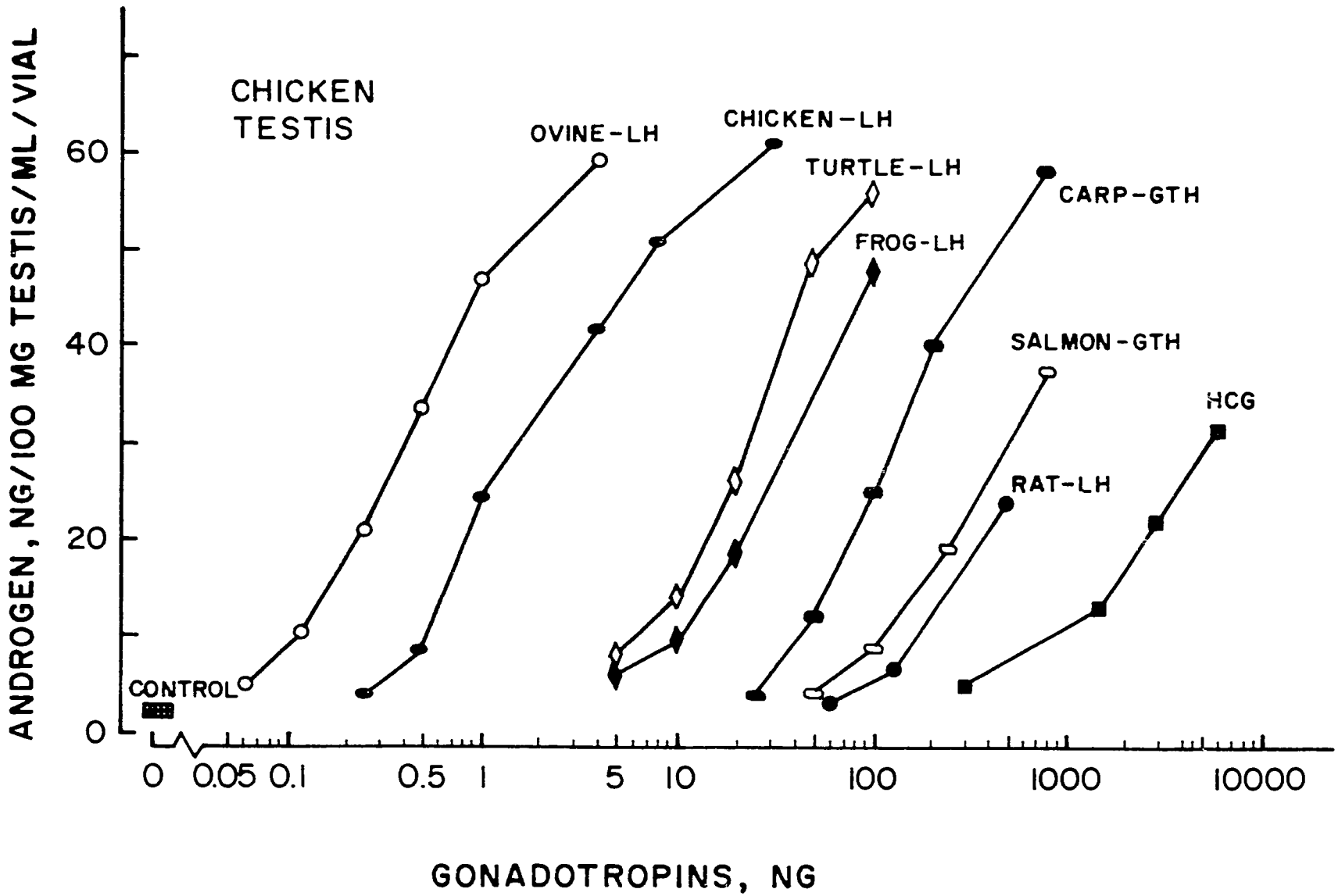

Fig. 1. Bioassay response curves for a series of vertebrate gonadotropins utilizing the androgen production response in rooster testis (from results first presented by J. Y-L. Yu and L-M. Wang, 29th International Congress of Physiological Sciences, Sydney, 28 August-3 September 1983).

Project Title : Controlled Reproduction of Commercially Important Marine Fishes

Cooperating Institutions : New Jersey Marine Science Consortium; United States Agency for International Development (USAID) (Cooperative Marine Technology for the Middle East); Egyptian Academy of Scientific Research and Technology; Israel Oceanographic and Limnological Research Ltd.

Duration : 1980 - 1983

Key Personnel

ICLARM	:	Dr. Ching-Ming Kuo
Egypt	:	Prof. A.R. El Bolock
Israel	:	Hillel Gordin

Objectives

- To foster international cooperation between Egyptian and Israeli scientists working on the artificial propagation of cultured fishes, principally mullet (Mugil cephalus) and gilthead seabream (Sparus aurata).
- To investigate the reproductive physiology of these species and to apply the results in developing techniques for controlled maturation and spawning by endocrine and environmental manipulation.
- To develop hatchery and nursery technology for the mass production and distribution of high quality fry and fingerlings.

Results

This program of international cooperation has involved active research projects in Egypt and Israel and exchange visits by Israeli and Egyptian investigators to participating American institutions: Auburn, Louisiana State and Texas A and M universities. ICLARM's role has been to advise on project development, to establish working plans, to follow-up on the progress of the project, and to participate periodically in the research.

In Israel, captive gilthead seabream and mullet broodstocks have been established. Mature mullet of 4 years and older are now being held. Efforts have been focused on the control of gonadal maturation of the seabream by manipulation of the photoperiod regime; induced breeding (by administration of gonadotropic hormones or by manipulation of environmental conditions) and refinement of hatchery technology, gearing towards the mass production of fry and fingerlings.

To date, spontaneous spawning of seabream has been routinely obtained by priming injections of human chorionic gonadotropin. Efforts have been continued to control spawning by injections of luteinizing hormone-releasing hormone (LH-RH) analog. Procedures and systems for egg incubation and larval rearing have been also established. The major task of the hatchery work has

been to improve larval survival through a comprehensive study of their ecological and energetic requirements and the development of intensive and controlled culture systems for live food organisms. The mass culture of a naked dinoflagellate (Isochrysis sp.) and the rotifer (Brachionus plicatilis) have been very successful. Furthermore, a small strain of the brine shrimp (Artemia salina) has been mass-reared: a useful advance for feeding small-mouthed larvae.

Efforts have also been made to further comprehend the reproductive cycle of wild and cultured mullet populations and the roles of various hormones. The artificial propagation of mullet remains a major thrust of the project. Parallel investigations and efforts have been made by Egyptian Scientists.

Project Title		: Water Quality in Waste-fed Aquaculture
Cooperating Institution		: The Asian Institute of Technology (AIT), Bangkok, Thailand
Duration		: 2 years beginning October 1983
Key Personnel	ICLARM	: Dr. John A. Colman Dr. Roger S.V. Pullin
	AIT	: Dr. Peter Edwards

Objectives

- To determine the effects of water quality factors on fish yields in a variety of waste-fed aquaculture systems (manured ponds, compost-fed ponds, sewage-fed systems and waste vegetation-fed systems, including the use of aquatic macrophytes).

- To investigate the chemical and biological basis of fish production in waste-fed aquaculture systems, concentrating on microphagous species (principally tilapias) dependent on plankton and the detrital food-web.

Results

As the project has only just commenced, progress has been limited to planning experimental work and establishing the required livestock and facilities. The project will involve data collection from AIT's ongoing sewage-fish and compost-fish projects and integrated farms both on-campus and in rural areas. AIT has obtained extrapolated yields of up to 7 tonnes/ha/yr from duck-fish culture in northeastern Thailand and 57 t/ha/yr of microalgae in sewage-fed stabilization ponds, suitable for planktivorous fish. Extrapolated fish yields approaching 20 t/ha/yr have been obtained in concrete ponds.

Project Title		: Applied Research on Coastal Aquaculture
Cooperating Institutions		: Department of Fisheries (DOF), Ministry of Agriculture and Cooperatives, Government of Thailand and the German Agency for Technical Cooperation (GTZ)
Duration		: 3 years, December 1981 - November 1984
Key Personnel	ICLARM	: Drs. Edward W. McCoy, Ronald F. Ventilla, Richard A. Neal, Roger S.V. Pullin, Mr. Michael Vakily (assigned by GTZ)
	Thailand	: Pairoj Lipikorn, Dr. Anant Saraya, Dr. Yong Musig, Mr. Kosol Mutarasint, Mr. Kachornsak Wetchakarun

Objectives

- To identify technical, biological and economic constraints hindering successful expansion of bivalve mollusc culture in the coastal zone, particularly of the green 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 and develop a lead station for research and development work on mollusc culture.
- To assist the Department of Fisheries to initiate work on introduction and/or improvement of appropriate technologies for mollusc farming.

Results

During 1983, the first 18-month Phase of the project was completed and a comprehensive report on all Phase I activities submitted to GTZ.

Significant progress was made towards achieving all the project's objectives. The different bivalve species suffer from some specific and some common constraints to culture expansion. For the green mussel (Perna viridis) there are technical constraints, particularly the culture method used: unthinned culture of natural spat settlement on poles. Thinning mussels during growout and the use of long line culture methods would achieve significant improvements in production and product quality. Post-harvest handling is poor and product deterioration is widespread. Moreover there remains a general lack of information available to Thai producers on green mussel biology and culture. The project is helping to remedy this.

In addition to these technical and information constraints, three economics/marketing subprojects on green mussels were completed. The first

determined market efficiency and showed that green mussel products are not available nationwide. Also green mussels are transferred between coastal provinces. For example, when mussels in Chonburi are in poor, 'thin' condition, mussels from Petchaburi province are transported to Chonburi markets. Further marketing and production cost studies in the Upper Gulf of Thailand involved students from the Department of Agricultural Economics at Kasetsart University and demonstrated a number of problems. The producer sells mussels by volume, using a bucket as a standard measure: 12-15 kg of mussels/bucket depending on size. The consumer purchases by weight. Product standardization measurement problems were encountered in the initial study. Some earlier reports of excessive market margins have not recognized these problems. A variety of products was investigated - small and medium-sized mussels used for drying and large mussels sold fresh in-shell or fresh shucked.

Low price remains a deterrent to expansion of green mussel culture. For example the market margin/bucket from producer to wholesaler for dried mussels processed into 'butterfly shape' was 6 Baht (about 27 US cents). Net returns to producers were marginal; however opportunity costs were low. Family labor was utilized in processing green mussels to increase income. For the future, there appears to be a large potential export market for frozen mussel meat, but the development of this will required attention to quality control.

The following scenario has been suggested from results so far for improvement of green mussel culture: gather natural seed on collectors; transport the seed to pollution-free culture areas; growout using long line methods with thinning and use the small mussels removed for drying or for further stocking; harvest the long lines at optimum size before spawning; improve post-harvest handling preferably by rapid shucking and icing; develop export markets for high quality frozen blocks of mussel meat. On this scenario, local supply of both fresh and dried mussel would still be supplied by local producers, however commercial markets and export would be supplied by producers and processors who could benefit from economies of scale to reduce costs.

For the cockle (Anadara granosa), the biological problems affecting the culture industry are seed supply and seed survival though growout to market size. There is also a serious lack of information on cockle biology and culture. However, economic considerations are also of paramount importance since much of the Thai production depends on Malaysian imports. Studies are underway to improve seed production and survival in Thailand and the cockle will be the major species focused during Phase II.

Work on other species has been limited to a study on the production, processing and marketing of the short-necked clam (Paphia undulata) the most valuable and arguably the most overexploited commercial bivalve species in Thailand and oysters (principally Crassostrea commercialis).

In addition to economics and marketing studies two very important special studies were completed in 1983 on pollution problems and post-harvest handling. A review of the literature on pollution and the public health aspects of bivalve consumption in Thailand led to an analytical study of trace elements (Table 1) in Thai bivalves and an investigation of microbial pathogen levels in culture area water samples and cultured molluscs. The trace metal results

are encouraging and indicate no public health risks. The data on microbial pathogens levels are still being assessed.

The post-harvest handling study was multidisciplinary and involved analysis of wastage during harvesting, methods to increase shelf-life and seasonal changes in the condition and biochemical composition of green mussels, cockles, oysters and short-necked clams. There are clear and very important condition cycles associated with gonad development, spawning times and environmental changes such as salinity reductions. These have important implications for harvesting times and sales value. Data from these studies are still being analyzed.

In addition to these studies, the availability of information on Thai bivalve culture was significantly improved by reviewing existing literature, with translations from Thai to English abstracts whenever possible and the convening of an in-country workshop. The latter comprised 25 papers presented, mainly in Thai, discussion sessions, and a tour of mussel and oyster production areas. This workshop involved contributions from DOF fisheries stations and Thai universities.

Table 1. Summary results of trace metal analyses in bivalve mollusc homogenates from representative commercial culture areas and markets in Thailand: all values are ranges in µg/g; W = wet weight basis, D = dry weight basis.

		Cd	Cr	Cu	Fe	Pb	Ni	Hg	Zn
Perna viridis	W	0.15–1.00	0.03–0.19	1.5 – 2.5	34–170	0.05–0.29	0.05–0.90	<0.02–0.02	10–14
	D	0.88–6.84	0.16–0.88	9.38–15.63	179–1000	0.31–1.53	0.26–3.88	<0.12–0.12	61–77
Anadora granosa	W	0.24–1.10	0.04–0.09	0.93–1.50	75–160	0.07–0.24	0.13–0.38	<0.02	13–20
	D	1.33–6.47	0.18–0.56	4.89–8.75	385–1000	0.47–1.41	0.65–2.31	<0.10	94–125
Crassostrea commercialis	W	0.40–0.84	0.05–0.10	21–38	19–29	0.04–0.11	0.15–0.53	<0.02	120–220
	D	2.05–3.82	0.24–0.59	100–181	105–147	0.20–0.53	0.60–252	<0.10	571–1048
Paphia undulata	W	0.05–0.16	0.07–0.27	0.83–1.40	84–190	0.11–0.25	0.26–0.38	<0.02	8.4–11.0
	D	0.25–0.80	0.32–1.50	4.55–6.50	442–1056	0.65–1.39	1.35–2.00	<0.10	42–58

Project Title : Marketing Systems of Shellfish Products

Cooperating Institutions : Kasetsart University, Thailand; Department of Fisheries, Thailand; German Agency for Technical Cooperation (GTZ); International Development Research Centre of Canada

Duration :

Key Personnel

ICLARM	:	Dr. Edward W. McCoy
Kasetsart Univ.	:	Dr. Chamnien Boonma, Dr. Ruangrai Tokrisna
Dept. of Fish.	:	Mr. Kachornsak Wetchagarun

Objectives

This project is complementary to the larger project "Applied Research on Coastal Aquaculture Phase I: Mollusc Culture" described on p. 64 and represents the initial activity of the Kasetsart University under the Fisheries Social Science Research Network. These activities are described in detail under the ICLARM Traditional Fisheries program statement and Fisheries Social Science Research Network project description beginning on p. 82.

The purpose of this project is to carry out a detailed analysis of the shellfish marketing system to determine product distribution, role of marketing intermediaries and price determination. Marketing efficiency will also be assessed. The study will be both descriptive and analytical. Identification of fresh and processed species marketed will be completed during a survey of wholesale markets, restaurants and processors. Subsequent surveys of marketing intermediaries and producers will be undertaken. Survey work was initiated in September 1983.

Project Title		: Regional Technical Assistance for Research and Training in Aquaculture
Cooperating Institutions		: A Project of the Asian Development Bank (ADB), Manila involving an ICLARM staff consultant and additional hatchery/nursery experts
Key Personnel	ADB	: Dr. Robert C. May
	ICLARM	: Dr. Roger S.V. Pullin
	Consultants	: Dr. V.G. Jhingran, Dr. Bangalore I. Sundararaj (Delhi University)

Objective

- Improvement of hatchery and nursery technology for the culture of carps (common carp, Chinese carps and Indian major carps) throughout Asia.

Results

Drs. V.G. Jhingran and Roger S.V. Pullin undertook missions to ADB and associated government carp hatchery/nursery projects in Bangladesh, Burma, Indonesia (South Sumatra), Nepal, Pakistan and Sri Lanka to advise on research and training for the improvement of carp seed production technology. Dr. Jhingran made followup visits to selected research stations in all these countries except Sri Lanka, to undertake experimental work timed to coincide with the spawning seasons and/or early rearing of cultured carps, including the common carp (*Cyprinus carpio*), Chinese carps (silver carp, *Hypophthalmichthys molitrix*; bighead carp, *Aristichthys nobilis* and grass carp, *Ctenopharyngodon idella*) and Indian major carps (catla, *Catla catla*; rohu, *Labeo rohita* and mrigal, *Cirrhinus mrigala*). Dr. B.I. Sundararaj joined the research teams for induced spawning studies in Bangladesh and Nepal.

Induced spawning trials were performed using pituitary preparations, luteinizing hormone-releasing hormone analog (LHRH-A) and steroid preparations. Results are still being analyzed. Larval survival was significantly improved at many locations by rotifer culture techniques and selective killing of insect predators and crustacean zooplankton with insecticides such as Sumitheon and Dipterex to enhance rotifer blooms.

Full details of all improved technology will be documented and presented at an international workshop in February 1984 in Manila and published as a hatchery/nursery manual.

Project Title		: Economics of Shellfish Processing in Thailand
Cooperating Institutions		: Kasetsart University, Thailand; Department of Fisheries, Thailand; International Development Research Centre of Canada
Duration		: 12 months beginning October 1983
Key Personnel	ICLARM	: Dr. Edward W. McCoy
	Kasetsart Univ.	: Dr. Chamnien Boonma, Dr. Ruangrai Tokrisna and other faculty members
	Dept. of Fish.	: Mr. Kachornsak Wetchagarun

Objectives

This study is a sub-project of the study "Marketing systems of shellfish products in Thailand" (see preceding project, p. 68). Its purpose is to analyze the processing sector to complete the economic analysis of the shellfish marketing system. Specifically, the study will estimate current demand for raw material used in shellfish processing and to evaluate existing techniques and potential for expanding shellfish processing in the future. Industry structure, processing costs and constraints to market diversification will be analyzed.

The project has been submitted to the Agriculture, Food and Nutrition Sciences Division of IDRC of Canada for funding. A decision is expected by the end of October 1983.

TRADITIONAL FISHERIES PROGRAM

Background

ICLARM's Traditional Fisheries Program is undergoing transition. Prior to 1983, the exclusive emphasis of the program was upon collaborative research with national institutions. This approach was exemplified by small-scale fisheries sectoral reviews in the Philippines, Malaysia and Indonesia and by the multidisciplinary investigation of the small-scale fisheries of San Miguel Bay in the Philippines which was undertaken in 1979-1982. All of these projects are substantially complete with final publications already out or due out soon.

Discussions with the International Development Research Centre (IDRC) of Canada and national institutions with which both ICLARM and IDRC had historically worked indicated that there was a crying need to develop a core of professional trained fisheries and aquaculture social scientists in Southeast Asia. The belief in the necessity of developing such a group of professionals derived not only from the all-too-common observation that shortages of trained social science researchers existed but also from the conviction of ICLARM that many of the pressing issues of traditional fisheries (and small-scale aquaculture) are of a politically sensitive nature and can thus best be addressed by national researchers. The latter perception is due to the fact that it is no longer possible to talk about increasing the harvest from most Asian fisheries through technological interventions, but rather management interventions must now be concerned with maintaining the harvest and how to allocate it equitably among competing users.

Because of the perceived need for additional social science researchers to address complex management issues in fisheries, ICLARM's traditional fisheries program has been shifting from its exclusive focus on research to an increased emphasis on training and development of institutional 'research capacity' at national 'centers of excellence' in fisheries social science.

Progress of Work

As a culmination of discussions with IDRC and select universities in Southeast Asia during 1981 and 1982, ICLARM launched the Fisheries Social Science Research Network in April 1983. The network has both research and training components. This network consists of Universiti Pertanian Malaysia, Kasetsart University (Thailand) and the University of the Philippines in the Visayas in addition to ICLARM. The Social Science Division of IDRC is funding the research component of the network's activities during 1983-1985 and additional support is expected from IDRC for a second 2-year phase. The Training Division of IDRC has provided a limited number of M.Sc. scholarships to the Network with additional funds for scholarships coming from other IDRC Divisions.

Universiti Pertanian Malaysia is contributing to network goals by offering a two-year M.Sc. in Resource Economics (Fisheries Specialization), the first of its kind in Asia, if not all of the tropics. UPM also offers a 5-month module course in fisheries and aquacultural economics and a short course in economics for aquaculturists. With these activities underway, UPM is becoming the center for professional fisheries economics training in Southeast Asia and each of the other network institutions are sending young faculty to UPM for training.

ICLARM's contribution to the network takes several forms. First, in addition to administrative coordination of research and training grants, we provide the network coordinator, Dr. Brian Lockwood, who is based at UPM until May 1984 to assist with teaching and curriculum development. Second, ICLARM provides technical advice to each of the network institutions' research programs in fisheries social science. Third, we provide information backstopping from our well-developed library and information service program.

The progress of the network to date has been excellent. The Malaysian and Thai research groups have been able to attract additional funding to complement those available through the IDRC grant to the network. Seven faculty members of network institutions have completed or are now enrolled in the UPM training programs. Our only real difficulties to date have occurred due to delays in IDRC approval for the second round of scholarships.

Although this particular issues of network scholarships is likely to be resolved soon, it points to a larger problem which has severely hampered the development of ICLARM's traditional fisheries program during 1983. This problem is the lack of sustained funding from ICLARM sources which has made long-term planning almost impossible.

For the traditional fisheries program to be sustained, external funding is required for: (1) network coordination; (2) program staff at headquarters; and (3) research activities. These priorities were apparent in early 1983 and efforts have been made during the year to locate possible sources of funding particularly for the first and second priorities above; none has met with success. IDRC and the Australian Center for International Agricultural Research (ACIAR) were approached to provide support for the network coordinator; both declined on the grounds they could only support research and that it is ICLARM's job to come up with the coordinator as a counterpart contribution.

The Fisheries Policy and Planning Division of FAO and ICLARM held several discussions during the year which led to the submission of a major 5-year project proposal "Management Options for Tropical Small-Scale Fisheries in Asia" that would have involved ICLARM headquarters staff and national researchers. Negotiations broke down over the unwillingness of FAO to initially consider covering ICLARM staff costs and to their later demand that the work be completed within the current calendar year. ICLARM withdrew the proposal and has not yet formally submitted it elsewhere.

Some limited progress was made to generate income to ICLARM through consulting work in small-scale fisheries. First, ICLARM signed a US$50,000 contract with USAID (Philippines) to provide 145 man-days of consulting time (J. Munro, I. Smith and D. Thomson, consultant) for a joint USAID-

Farm Systems Development Corporation project to introduce gasifiers and ice-making plants in remote Philippine fishing communities. Second, Dr. Lockwood will spend one month later in 1983 undertaking a survey of socioeconomic data collection and information systems for fisheries in Malaysia, Thailand and the Philippines on behalf of FAO. However useful financially, these activities and others of a similar nature that we have had to turn down due to lack of time, fall far short of providing the necessary income to sustain ICLARM's traditional fisheries program.

Consequently, 1983 has turned into a year devoted largely to completion of projects begun since 1979. All five San Miguel Bay reports have now been completed and four have been published. The impact of this project continues to be considerable, especially in the area of the multidisciplinary research methodology which has already been adopted by other institutions in their own research programs. The Indonesian Review manuscript is substantially complete and final chapters for the Malaysian Review are now underway after some considerable delay. Technical Report 12, "A Japanese joint venture: worker experience and national development in the Solomon Islands" by Sarah Meltzoff and Edward LiPuma was published in October and initial response has been highly favorable. The Fisheries Economics Reader (2 volumes to be published by the Obor Foundation in Bahasa Indonesia) is now almost ready for press with all but 2 of 26 articles now translated. Finally, a Fisheries Social Science Research Reprint Series was initiated and the first reprints are expected to be available by the end of 1983.

Advisory Services

In addition to the two consultancies to USAID and FAO mentioned above, Dr. Smith visited the Bay of Bengal Programme in Madras, India to advise on the BOBP-State Government of Tamil Nadu shrimp pen project in Killai Backwaters south of Madras. This project is designed to benefit small-scale fishermen who currently use the backwaters. BOBP retained Mr. Rathindra Roy as project consultant for the socioeconomic feasibility study of this project. He and Ms. Ediltraud Drewes of BOBP visited the Philippines for one week in October and consulted further with Drs. Ian Smith and Daniel Pauly regarding their final report. Subsequently, Dr. Pauly will be visiting Madras in November to advise on the seed supply component of this study.

Training

The formal training activity of the Traditional Fisheries Program in 1983 was support for the M.Sc. and module programs offered by Universiti Pertanian Malaysia. These activities are described above and in the project description for the Fisheries Social Science Research Network (p. 82).

Publications

Bailey, C. 1983. Book review. Sri Lankan fishermen; rural capitalism and peasant society by Paul Alexander. 1982. Monographs on South Asia No.7. The Australian National University, Canberra. ICLARM Newsletter 6(2):21.

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Lockwood, B.A. 1983. The ICLARM fisheries social science research network. ICLARM Newsletter 6(2):3-4.

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Workshop to Develop a Research Proposal/Workplan for a Comprehensive Study of Fish Marketing System of Peninsular Malaysia. Fraser's Hill, Malaysia, 21-23 January 1983. (B. Lockwood).

ACMRR Working Party on Management of Living Resources in Near-Shore Tropical Waters, Rome, Italy, 28 February - 4 March 1983. (I.R. Smith and D. Pauly).

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International Conference on Development and Management of Tropical Living Aquatic Resources. Universiti Pertanian Malaysia, 2 - 5 August 1983. (J. Munro, B. Lockwood, R.S.V. Pullin, J. Maclean).

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Program Plans for 1984

The major program activity of the Traditional Fisheries program in 1984 will be the continued expansion and growing maturity of the Fisheries Social Science Research Network. The network coordinator, Dr. Lockwood, will transfer to Manila in mid-1984 to assume full-time coordination of the network and an invitation will be extended to an Indonesian institution to join in the network early in 1984. Research activities begun in 1983 will continue through most of 1984; additional network scholars will be sent to UPM for M.Sc. and module training in fisheries economics. A proposal to extend the network's activities from 1985-1987 will be submitted to IDRC in early 1984. A major constraint yet to be resolved is funding for the coordinator's position for this second phase. ICLARM must make a commitment to pay the coordinator costs as part of its proposal to IDRC; without funding assured however, this will not be possible and ICLARM's whole participation in the network may be jeopardized. Attempts to raise the necessary funds will continue, of course, but with passing time and rejection by possible funding agencies we are less and less hopeful of success.

The proposal "Management options for small-scale fisheries" which was submitted to FAO has been rewritten and will be submitted elsewhere. Finally, an invitation to ICLARM from the Training Division of the Australian Development Assistance Bureau (ADAB) to submit a proposal to initiate and staff ICLARM's Education and Training Program in 1984 may offer the best potential for covering part (or all) of the network coordinator's costs. Not only is Dr. Lockwood an Australian but the network program has a heavy emphasis on training.

In addition to those proposals already mentioned, the International Food Policy Research Institute (a CG Center based in Washington, D.C.) and ICLARM plan to jointly submit a proposal to the Asian Development Bank for support of a full-time macro-economist who would be based at ICLARM and who would analyze development trends and policy issues in fisheries and aquaculture.

In summary, then, ICLARM's Traditional Fisheries program has already felt the effects of likely funding shortages in 1984 and beyond. Much of the effort of headquarters staff in 1984 will be directed towards fund raising for the program.

Traditional Fisheries Project Summaries

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Project Title	:	Small-Scale Fisheries of San Miguel Bay, Philippines: A Multidisciplinary Analysis
Cooperating Institutions	:	Institute of Fisheries Development and Research, College of Fisheries, University of the Philippines in the Visayas (UPV); the United Nations University (UNU), Japan; and Philippine Council for Agriculture and Resources Research and Development (PCARRD)
Duration	:	September 1979 to January 1982 (field work) February 1982 to January 1983 (report preparation)
Key Personnel UPV	:	Prof. Antonio Mines (Project Leader) Mr. Gregorio Bañacia (Field Leader)
ICLARM	:	Dr. Ian Smith (Economics) Dr. Daniel Pauly (Biology) Dr. Conner Bailey (Sociology) Ms. Luz Yater (Sociology)

Objectives

The primary objective was to conduct an in-depth study of the San Miguel Bay fisheries to facilitate this sector's inclusion in the Bicol integrated area development program, a plan from which fishing communities have generally been excluded. A second objective was to develop a multidisciplinary approach to tropical fisheries research for application elsewhere.

Results

The biological segment of this project involved estimation of fishing effort and catch per effort for all gear types, leading to reliable estimates of catch by month and by species groups.

Catches from the Bay were found to be 3 to 4 times higher than official statistics suggest. About 59% of the catch which totals 15,000 tonnes/year (excluding 4,000 tonnes of sergestid shrimp) is taken by some 5,100 small-scale fishermen, and the remainder by 95 trawlers of various sizes. Detailed assessments using surplus-production and yield-per-recruit models suggest that the Bay is overfished in the sense that an increase in effort by either the trawl or the small-scale fishery would not result in an increased catch from the San Miguel Bay as a whole, but rather exacerbate the present allocation problems between the small-scale and trawl fisheries. This is confirmed by the economic analysis which shows that small trawlers, representing only 3% of the Bay's fishing units and employing 7% of the fishery's labor force, earn the largest share of catch value and 50% of the pure profits (resource rents). The government fuel tax and oligopoly/oligopsony power of fuel suppliers/processors also divert part of the resource rents to these sectors. Serious consideration should be given to limiting effective fishing effort so as to maintain positive resource rents and to deal with the presently highly skewed distribution of benefits. The analysis

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of labor mobility showed that very limited alternative employment opportunities exist in the area, which explains the low opportunity costs of labor and the significant outmigration from the area. These complementary findings all argue for seeking solutions to the low incomes of the small-scale fishermen within rather than outside the fishery by reallocating use rights and catch in their favor.

Four technical reports, dealing with biology and stock assessment, economics of production and marketing, social aspects, and occupational and geographical mobility, have been published. A fifth report, which synthesizes the results of the first four and discusses options for management and research, is in press. The need for the creation of management institutions and mechanisms that control the level of effective fishing effort in the Bay and that address the equity issues related to distribution of benefits from the fishery is stressed. Enforcement is certainly one key element of successful management; a participatory mechanism for fishermen is equally important and may even facilitate enforcement. The final report examines a range of management goals and interventions and suggests that a combination of trawler licensing and area restrictions is more likely to be enforceable and produce a redirection of benefits to the majority of fishermen than would other techniques such as taxes and quotas. Given the overlapping jurisdiction of coastal municipalities and national government agencies, the creation of a single management authority for the Bay was recommended. This management authority would have responsibility for setting objectives, selecting interventions, enforcement and data gathering to monitor impact of management interventions.

Table 1. Summary of data on the San Miguel Bay fisheries (1980-1981). At time of study US$1.00 = ₱8.50.

Characteristics	Non-trawl gears	Trawl gears Mini	Trawl gears Small/Medium	Totals for the San Miguel Bay fisheries (all fishing units)
No. of fishing units	2,100	198	95	2,382
Total horsepower	2,592	3,008	13,200	18,800
No. of fishermen	4,625	376	600	5,600 in 3,500 households
No. of households owning fishing units	≈1,880	≈ 150	35	2,065
Average investment cost per fishing unit (₱)	250-13,000	9,200	55-70,000	15 + million current replacement cost
Percent of total catch				
including sergestid shrimps	44	25	31	19,133 tonnes
excluding sergestid shrimps	59	-	41	14,660 tonnes
Percent of total value				
including sergestid shrimps	44	14	42	₱53.5 million
excluding sergestid shrimps	52	-	48	₱46.2 million
Percent of pure profits (resource rents)[a]				
including sergestid shrimps	15[b]	35	50[c]	₱3 million
excluding sergestid shrimps	23	-	77	₱1.6 million
Crewmen incomes/mo (₱)	164-218	342	339-810[d]	-
Owner (non-fishing) incomes/mo (₱)	(-773)[e]-740	432	146[f]-1,693	-

[a] Does not include resource rents earned by the government and by fuel suppliers/processors.
[b] One-half of this is earned by fish corrals; 40% by motorized gill-netters.
[c] Small trawlers only; medium trawlers did not cover their opportunity costs.
[d] Highest incomes are earned by pilots on small trawlers.
[e] Owners of stationary liftnets incurred losses.
[f] Lowest incomes are earned by owners of medium trawlers.

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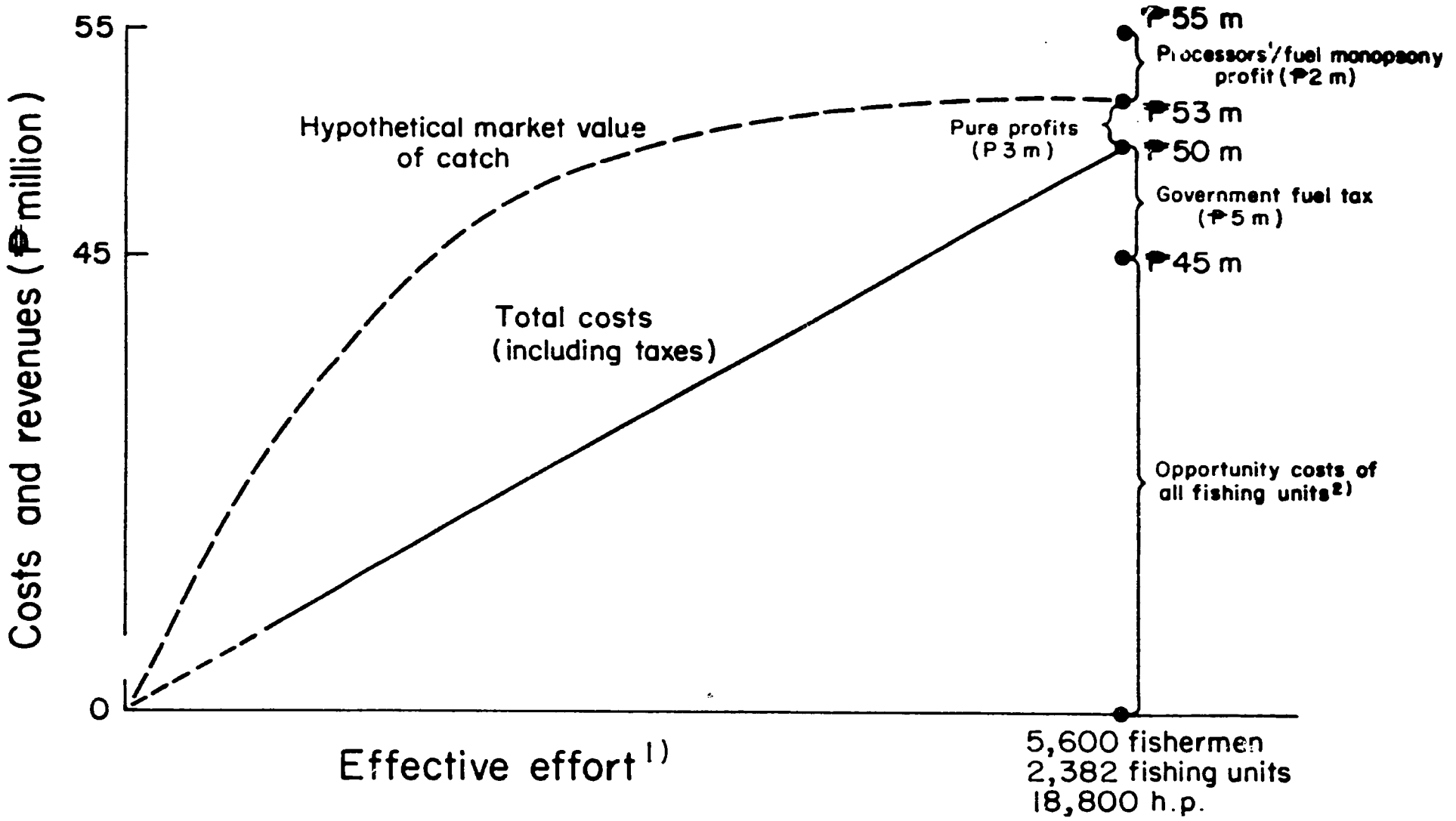

Fig. 1. Relationship between annual costs, revenues and fishing effort in the San Miguel Bay fishery with actual data for 1980-1981 only.

[1] Effective effort rather than nominal effort (e.g., no. of fishermen, no. of boats). Nominal effort may fail to capture increases in effective effort due to changes in other components of effort, such as engine size or gear efficiency. Effective effort is thus a composite of all of the components of effort.

[2] Represents direct and imputed costs of all inputs, valued at their social cost. For example, labor and capital at their opportunity costs; fuel valued at retail price less government taxes.

Project Title	:	Indonesian Small-Scale Fisheries: Research Review and Synthesis
Cooperating Institutions	:	Directorate General of Fisheries (DGF) and Research Insittute for Marine Fisheries (BPPL), Indonesia
Duration	:	October 1981 to December 1982
Key Personnel ICLARM	:	Dr. Conner Bailey (Sociology)
DGF	:	Ir. Firial Marahudin (Economics)
BPPL	:	Mr. A. Dwiponggo (Biology)

Objectives

The project is a multidisciplinary review of Indonesian small-scale fisheries by scientists from the Indonesian Directorate General of Fisheries, the Marine Fisheries Research Institute and Dr. Conner Bailey, who was based in Bogor. It brings together information from the scattered published and unpublished reports, mostly in the Indonesian language, of the considerable research previously carried out on Indonesian fisheries.

Results

The authors spent 15 months reviewing the literature and preparing an English-language manuscript. Extensive field work, including interviewing fishermen and researchers was carried out to supplement the literature database. The English version of the manuscript is currently being edited after which external reviewers' comments will be solicited. A Bahasa Indonesia version will be prepared after the English version is finalized. Publication of both versions is expected in 1984.

Project Title	:	Fisheries Social Science Research Network
Cooperating Institutions	:	Universiti Pertanian Malaysia (UPM), Serdang, Selangor, Malaysia; University of the Philippines in the Visayas (UPV), Iloilo; Kasetsart University, Bangkok, Thailand; One Indonesian University (yet to be identified); International Development Research Centre (IDRC), Canada.
Duration	:	1983 to 1985 (First phase)
Key Personnel UPM	:	Prof. Ishak Hj. Omar
UPV	:	Prof. Ma. Luisa Mabunay
Kasetsart University	:	Drs. Ruangrai Tokrisna and Chamnien Boonma
ICLARM	:	Dr. Brian A. Lockwood (Coordinator currently based at UPM)
	:	Drs. Ian Smith and Edward McCoy
IDRC	:	Drs. Elwood Pye and David King

Objectives

The underlying objective of this research network is to build national research capability. 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.

Social scientists, particularly economists, have had little professional interest in fisheries and aquaculture in Asia and the Pacific. There are a number of notable studies by anthropologists, sociologists and geographers but very few by economists, whose involvement in the problems of the sector has been mainly on a part-time or ad hoc basis. There are few economists in the region who would classify themselves, either by reason of training or occupation, as fisheries or aquaculture specialists. Consequently, in most countries of the region, no systematic program of economic research on the problems of fisheries and aquaculture has been carried out either by government fisheries agencies or in the universities.

Recently, the parallel interests of ICLARM and the International Development Research Centre (IDRC) of Canada came together in a joint decision to set up and fund the Fisheries Social Science Research Network. Both ICLARM and IDRC have histories of encouraging social science research in fisheries and aquaculture and, equally importantly, both have an interest in elevating such research from its present ad hoc status to that of a planned and sustained long-term program which would enable Asian and Pacific social scientists to make regular and constructive contributions to the management and development issues of the sector in their respective countries.

There are three pressing needs that must be addressed if fisheries social science research is to be effective. First, there must be continuity of effort and this implies strong institutional support over the long run. In attempting to meet this need the Network has selected cooperating institutions with care. The institutions are universities which have demonstrated a strong interest in developing a national-level program of primarily economic fisheries and aquaculture social science teaching and research and are willing to contribute substantial staff and other resources to this specialization. The Network will contribute research funds and technical assistance to enable the staff to develop a long-term research plan.

Second, only high quality research on issues felt to be relevant by fisheries agencies will gain for the program and institution the national recognition necessary to sustain the program in the long run. The Network will assist the cooperating universities in this regard by providing professional training opportunities for the specialist staff, both in research and teaching; professional input into both the teaching and research activities; and opportunities for professional exchanges between the staffs of all cooperating universities through regional workshops and meetings. One such workshop, to discuss the teaching of fisheries and aquaculture economics and course contents and curricula, was held at Universiti Pertanian Malaysia in November 1982.

The third need that the Network must address is for continuous working contact and cooperation between the researchers and fisheries program managers, government administrators and planners concerned with fisheries issues. This will help to ensure that the research and teaching activities of the Network program are geared to national needs and that the research results will feed directly into the national planning process.

Results

An important component of the Network is to help provide training facilities and opportunities in Asia for the teachers-researchers of the Network's cooperating universities. The aim, of course, is to improve research capacity and, in the longer run, to help each of the universities become the training center for its own nationals. For the foreseeable future, the main training center will be the Universiti Pertanian Malaysia, which now offers an M.Sc. program and a post-graduate non-degree course in fisheries and aquaculture economics. The UPM program is the first in Asia to offer a specialization in fisheries and aquaculture economics and it is expected to attract students from a wide range of fisheries institutions in Malaysia and the Asia-Pacific region. The UPM teaching program places considerable emphasis on the special conditions and problems of tropical fisheries and aquaculture, and students will be expected to apply their disciplinary skills to a fisheries or aquacultural program in carrying out their thesis research. In the current academic year which commenced early in July, M.Sc. scholars from Bangladesh, Indonesia, Malaysia, the Philippines and Thailand have enrolled in the program. Four are sponsored by the ICLARM Network and funded by an IDRC grant to ICLARM.

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For some years to come the Training component of the Network activities will be crucial to the overall objective of building research capacity. There exists no stock of trained fisheries or aquaculture economists at present and it is necessary, therefore, to train those who will lead the research teams and set up teaching programs in their own universities. The Network's funds are limited at present and additional sources are being sought. The Network has benefited from IDRC support for the four current Fellows and IDRC is expected to continue this support for a second group of Fellows in 1984. Moreover, the Network is a developing program that will need training assistance for many years to come.

The Network is already funding research projects in three cooperating universities. The fisheries economics group at Universiti Pertanian Malaysia is leading a major study of the Fish Marketing System in Peninsular Malaysia. The proposal for this study was developed in close association with the Malaysian Fisheries Development Authority (LKIM or MAJUIKAN) and the Malaysian Department of Fisheries; the study is being conducted in cooperation with researchers from Universiti Malaya and Universiti Kebangsaan Malaysia. In addition to Network funding, the project has received a large grant from LKIM. The UPM project is a good example of close cooperation with government fisheries agencies extending in this case from planning through funding and implementation.

The fisheries economics group at Kasetsart University in Thailand are studying the marketing system for shellfish and will later expand the study to include fish and other marine animals. This study has also attracted additional funding from an ICLARM-GTZ (German Agency for Technical Cooperation) project to augment that provided by the Network.

The fisheries social science group at the University of the Philippines in the Visayas includes a fisheries economist (who participated in the non-degree course at UPM last year), an historian, a psychologist and a management specialist. This group will work together on some aspects of their study of small-scale fisheries in Iloilo Province, and separately on topics of special interest, such as household consumption patterns and preferences for fish and other meats, social relationships in the marketing system, management of fish processing industries, and the psychological characteristics of fishing households and attitudes towards their source of livelihood.

The second round of research in each university will include the thesis research of their staff member studying at UPM. A fourth cooperating university will be identified in Indonesia later this year.

Because the Network is in its infancy and is attempting something new, it has started in only four countries and only four universities. In due course it is hoped that the program can be extended to other countries and universities in the Asian and Pacific region. The Network aims to assist in the development of a fisheries economics profession in Asia capable of sustaining a long-term research and training program.

Project Title	:	Energy Technology for Philippine Small-Scale Fisheries
Cooperating Institutions	:	Farm Systems Development Corporation (FSDC); U.S. Agency for International Development (USAID), Philippines mission
Duration	:	6 months, beginning 15 September 1983
Key Personnel **ICLARM**	:	Mr. David Thomson, Consultant Drs. John L. Munro and Ian R. Smith
FSDC	:	Mr. Manuel LaPeña
USAID	:	Mr. Lawrence Irvin, Ms. Baby Silva

Objectives

The U.S. Agency for International Development (USAID) and the Farm Systems Development Corporation (FSDC) are in the process of designing a project to assist municipal (artisanal) fishermen in the Philippines. The project will be co-financed, and FSDC will be the implementing agency.

The purpose of the project is to increase the income and socioeconomic security of artisanal fishermen by decreasing their fuel consumption costs and improving the sales environment for their fish. The FSDC will extend credit to fishermen's associations to purchase both gas fed refrigeration equipment and gasifiers to run small fishing boats. The primary fuel source will be biomass-based producer gas in either direct combustion or to fuel diesel or gasoline engines.

ICLARM has been retained by USAID to provide assistance in the planning for this project, particularly as it relates to fisheries stock assessment, economic viability and community management.

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Project Title	:	Socioeconomic Data and Information on Fisheries in Southeast Asia
Cooperating Institution	:	Food and Agriculture Organization (FAO) of the United Nations
Duration	:	1 month beginning mid-November 1983 and up to 1 month additional in early 1984
Key Personnel ICLARM	:	Dr. Brian Lockwood
FAO	:	Mr. Rolf Willman

Objectives

FAO is preparing a manual on recommended socioeconomic information and data collection methodologies for small-scale fisheries. ICLARM is providing the services of Dr. Brian Lockwood who will conduct a one-month survey of existing information systems in Thailand, Malaysia and the Philippines. The second half of the consultancy will involve a workshop in Rome during which FAO staff and regional consultants including Dr. Lockwood will finalize the manual.

Status of Upcoming Proposals

1. **Fisheries Social Science Research Network (Phase II: 1985-1987):** Proposal will be submitted to IDRC by 15 March 1984. Chances of approval are good if ICLARM can guarantee to provide the network coordinator.

2. **Management Options for Tropical Small-Scale Fisheries in Asia:** Proposal has been rejected by FAO. Alternative sponsors are sought.

3. **Macroeconomic Policy Issues of Asian Fisheries:** Proposal will be prepared with the International Food Policy Research Institute (IFPRI) in early 1984 and will be submitted to the Asian Development Bank.

RESOURCE DEVELOPMENT AND MANAGEMENT PROGRAM

Background

The objectives of the Resource Development and Management Program continue unchanged from those stated in previous annual reports; namely, to enhance the abilities of fisheries scientists in the tropics to assess fisheries resources and to translate the results of such assessments into recommendations for the management and conservation of the stocks. The great importance of social and economic factors in addition to the biological features of exploited stocks are constantly borne in mind.

Although progress in tropical fish stock assessment has been slow, there are encouraging signs that the situation is changing as a result of the adoption of length-frequency based stock assessment techniques and the concurrent development of relatively inexpensive programmable calculators and microcomputers. Some of this progress on a world-wide basis can be directly attributed to work conducted at and pioneered at ICLARM.

One of the most significant turning points reached in tropical fisheries science has been the recognition that recruitment to tropical fish stocks is highly variable and that many tropical demersal stocks may be recruitment limited. A major avenue for future investigations is the degree to which recruitment could be enhanced by stocking specific habitats with hatchery-reared recruits of suitable, commercially important species.

In 1982, ICLARM's Program Advisory Committee recognized the economic potential of giant clams (family Tridacnidae) and approved the development of a project for rehabilitation of clam fisheries through a program of support of research on hatchery techniques and juvenile rearing, reef restocking or extensive mariculture, biological and socioeconomic studies. Giant clams are an everyday part of the diets of most Indo-Pacific coastal people. Additionally, the dried adductor muscles fetch high prices in Southeast Asia. However, the most important feature of the tridacnids is that by virtue of a symbiotic relationship with certain micro-algae, they are largely phototrophic and require no external sources of food. They are thus the only self-feeding potential farm animal known to mankind. Yields of 60 tonnes of flesh/ha/yr are theoretically feasible, even at modest stocking densities.

Progress of Work

Operations of the Program during 1983 were grouped around four basic projects. These were the Tropical Fish Stock Assessment Research Project, the Network of Tropical Fisheries Scientists, the Management-Oriented Fisheries Research Project and the International Giant Clam Mariculture Research Project.

The Tropical Fish Stock Assessment Research Project has continued to concentrate upon the problems of multispecies, multigear fisheries. Major achievements of the project have included the completion of four length-frequency based stock assessment programs for microcomputers and the integration of these programs into a wider systems approach to the assessment of

multispecies, multigear fisheries. The proceedings of the ICLARM/CSIRO workshop on the "Theory and Management of Tropical Fisheries" were published during the year, as was a volume on Caribbean coral reef fishery resources. Dr. Pauly's book entitled "Fish Population Dynamics in Tropical Waters: a Manual for Use with Programmable Calculators" is now in press and will be published in early 1984.

The Network of Tropical Fisheries Scientists completed its first full year of operations with membership standing at over 200 in 52 countries. A substantial portion of the operating costs of the Network are met by the FAO/-DANIDA Training Project in Fish Stock Assessment and by FAO. Two numbers of the newsletter "Fishbyte" were published and were received enthusiastically by members. The Network also distributes stock assessment and management manuals, reprints and computer programs gratis to members. Six scientists visited ICLARM during the year under the sponsorship of the NTFS Visiting Scientist scheme. These visits enable members to analyze data using the ELEFAN suite of programs developed at ICLARM and to generally develop their expertise in stock assessment methodologies.

One of the ancillary objectives of the Network is to create Stock Assessment and Management Modules (SAMMs) within the umbrella of our Management-Oriented Fisheries Research Project. A SAMM consists of a small number of NTFS members in a particular country or institution provided with the necessary training, microcomputer and scientific support. The scientific support could range from periodic visits by ICLARM staff to stationing a staff member in a country for several years. The latter course requires outside funding. Operational modules are in Indonesia, Peru and the Philippines and all have enjoyed considerable success in the assessment of local stocks. Additionally, a formal request has been received for development of a SAMM in Zambia and this will be activated early in 1984.

The International Giant Clam Mariculture Research Project was launched in January 1983. Activities concentrated mostly upon catalyzing the necessary scientific interest and developing a comprehensive research proposal. In its final form, the proposal calls for the support of a major scientific initiative at James Cook University of North Queensland (JCUNQ) and at various institutions in the tropical Indo-Pacific, the development of a pilot scale hatchery in the equatorial Indo-Pacific and the investigation of economic and social problems which might arise in relation to various forms of giant clam cultivation.

The project is envisaged as a collaborative effort between JCUNQ and ICLARM with JCUNQ responsible for the major scientific program and ICLARM for the development of a pilot hatchery. A proposal for support of the Australian module, prepared in close collaboration with ICLARM, was submitted to the Australian Centre for International Agricultural Research (ACIAR) in November. A grant of $_____ over a __ year period starting in January 1984 was confirmed in December.

A potential hatchery site has been identified in the Solomon Islands and negotiations are in progress and a funding submission in preparation. A short-term appointment was made for preparation of a preliminary design of a giant clam hatchery and a review of processing techniques for tridacnid adductor muscle.

Advisory Services

Dr. Pauly visited Peru at the invitation of GTZ for consultations on assessment of the demersal fisheries in the period 30 April - 7 May 1983. Additionally, he spent two periods totalling 14 days in Burma as a consultant to the UNDP/FAO Burma Fisheries Development Project advising on the analysis of previous survey results, conducting preliminary training of Burmese scientists in stock assessment techniques and preparing plans for future research programs of the Burmese Sea Fisheries Survey and Research Unit.

Dr. Munro was engaged for over a month in the period between October and December in consultations on methods for evaluating the extent of resources and the suitability of various sites for a USAID project which aims to cut operating costs by fitting Philippine fishing boats and ice plants with motors powered by charcoal-burning gasifiers.

Training

Dr. D. Pauly participated as a lecturer in the FAO/DANIDA Fish Stock Assessment Training Courses in Mombasa, Kenya, in 1983 and in Cochin, India, in November 1983. These courses draw heavily upon techniques and approaches which he has developed.

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Meetings Attended, Papers Presented

Roundtable Discussion of Increasing Benefits from African Reservoirs Fisheries, Cairo, Egypt, 11-13 January 1983. (D. Pauly)
D. Pauly. Recent Developments in the Methodology Available for the Assessment of Exploited Fish Stocks of Reservoirs.

ACMRR Working Party on the Management of Living Resources in Nearshore Tropical Waters, Rome, Italy, 28 February - 4 March 1983. (D. Pauly)

D. Pauly and I.R. Smith. The Research Process and Communication of Results: Lessons Learned from a Multi-Disciplinary Analysis of a Tropical Small-scale Fishery.

FAO Expert Consultation on the Abundance of Neritic Stocks, San Jose, Costa Rica, April 1983. (D. Pauly)

D. Pauly and N. Navaluna. Monsoon-Induced Seasonality in the Recruitment of Philippine Fishes.

D. Pauly and I. Tsukayama. On the Seasonal Growth, Monthly Recruitment and Monthly Biomass of the Peruvian Anchoveta (Engraulis ringens) from 1961 to 1979.

International Conference on Development and Management of Tropical Living Aquatic Resources, Kuala Lumpur, Malaysia, 2-5 August 1983. (J.L. Munro)

J.L. Munro. A Cost-Effective Data Acquisition System for Assessment and Management of Tropical Multispecies, Multigear Fisheries.

I.R.E.P. Workshop, Halifax, Canada, 26-30 September 1983. (D. Pauly)

D. Pauly. Recruitment Variability of Tropical Fishes.

World Fisheries Conference, Rome, Italy, 10-19 October, 1983. (J.L. Munro)

Gulf and Caribbean Fisheries Institute, Port-of-Spain, Trinidad and Tobago, 14-18 November 1983. (J.L. Munro)

I.R. Smith and J.L. Munro. Management Strategies for Multispecies Complexes in Artisanal Fisheries.

Program Plans for 1984

It is envisaged that considerable effort will be devoted to expanding the Network of Tropical Fisheries Scientists. Activities will include increased distributions of manuals and other materials, publication of three numbers of the Newsletter, FISHBYTE, and visits to ICLARM of a large number of Network members under the NTFS Visiting Scientist scheme.

In the Tropical Fish Stock Assessment Research Project, the long-awaited manual by Dr. D. Pauly on fish stock assessment using programmable calculators will be published. The suite of ELEFAN programs will be edited into a single volume. The major thrust in the Project will be towards integrating the ELEFAN programs into a single length-frequency based stock assessment system for microcomputers. Consideration is being given to preparing and marketing software packages for fisheries assessment and management.

A conference on length-frequency based stock assessment techniques is proposed for the fall of 1984, possibly to be held at Bellagio, Italy and co-sponsored by a major middle-Eastern research institute.

In the Management-Oriented Fisheries Research Project, the Indonesian module will draw to a close around the middle of the year and this will form the basis for several substantial publications co-authored by the Indonesian participants and Dr. D. Pauly. A module is planned for Zambia and this will be initiated early in the year. Consideration is being given to continuing the Philippine module and it is expected that the Peruvian module will be

greatly expanded, with substantial external support. Other possible modules are under consideration elsewhere in Africa, Asia and Latin America.

For the Giant Clam Project, plans call for the establishment of the major scientific program at James Cook University of North Queensland, and for identifying, funding and developing the hatchery. The most likely site is at Guadalcanal in the Solomon Islands, but firm arrangements have not yet been confirmed. Efforts will be made to obtain funding for a marketing investigation and for studies of the economics of various nursery and hatchery options. Additionally, the project will catalyze research on giant clams at a variety of Indo-Pacific institutions and seek funds for such research where necessary.

Resource Development and Management Project Summaries

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Tropical Fish Stock Assessment Research Project 95

Network of Tropical Fisheries Scientists 97

Management-Oriented Fisheries Research Project 98

International Giant Clam Mariculture Research Project 100

Project Title	:	Tropical Fish Stock Assessment Research Project
Cooperating Institutions	:	Predominantly in-house study, with informal linkages with various research institutions.
Duration	:	Continuous from July 1979
Key Personnel	:	Dr. Daniel Pauly Dr. John L. Munro Mr. Morfio Sumiran Ms. Maria Lourdes Palomares

Objectives

- To understand the dynamics of exploited tropical fish communities.
- To develop stock assessment methods which are straightforward, are readily applicable to tropical stocks and which do not require costly hardware for their implementation.

Results

The first two programs in the ELEFAN (Electronic LEngth Frequency ANalysis) have been distributed by Dr. D. Pauly and have now achieved wide recognition. They have been translated by their users to a variety of programming languages and for operation on a number of different models and makes of microcomputers and also for several mainframe computers.

During the course of the year, the fifth and probably final program in the ELEFAN suite of microcomputer programs was completed, revisions were made of ELEFAN I and II and user's instructions for ELEFAN III and IV completed. Additionally, a program, ELEFAN 0 was developed for the handling of length-frequency data files. These programs and sets of user's instructions will be consolidated into a single volume and published in early 1984. Also, consideration is being given to marketing the ELEFAN suite as a complete software package suitable for a wide variety of microcomputers.

Work continued on basic stock assessment techniques and methods of parameter estimation. A method for estimating natural mortality rates from length-frequency and gear-selectivity data was presented by Dr. J.L. Munro at the Development and Management of Tropical Living Aquatic Resources conference in Malaysia. This method forms the basis of the ELEFAN IV program devised by Dr. J.L. Munro and M.L. Palomares.

Additionally, an integrated systems approach to length-frequency based stock assessments has been devised by J.L. Munro, and the development of this approach (which will incorporate the ELEFAN programs) into a single microcomputer based stock assessment program is now being contemplated.

Work in the final revision of the manual by Dr. D. Pauly on "Fish Population Dynamics in Tropical Waters: A manual for use with programmable calculators" was delayed by the pressure of other work and the volume is now expected to be published early in 1984.

A volume entitled "Caribbean Coral Reef Fishery Resources", edited by Dr. J.L. Munro was published in October. This is a reprinting and updating of a series of reports on investigations conducted in Jamaican waters in 1969-1973. The original reports had a very limited distribution and the reprinting will ensure that a much wider distribution and readership is attained.

Project Title : Network of Tropical Fisheries Scientists

Cooperating Institutions : Fishery Resources and Environment Division, Fisheries Department, FAO, Rome, Italy.
plus
Individual member scientists in institutions throughout the world.

Duration : Continuous from April 1982

Key Personnel : Dr. John L. Munro
Dr. Daniel Pauly
Ms. Ferdinandina Santos

Objectives

- To enhance communication between fisheries scientists working on the assessment, conservation and management of tropical stocks.

- To enhance the output of these scientists by improving access to literature, providing free database searches, distributing manuals and other literature and publishing a newsletter at regular intervals. The technical focus is on the estimation of the biological, fishery and socioeconomic parameters which determine the magnitude of harvests and the application of those parameters to models to arrive at scientifically sound management measures for tropical stocks.

During 1983, the Network benefitted greatly from partial funding by the FAO/DANIDA Training Course in Fish Stock Assessment and by the Department of Fisheries of FAO.

Membership rose rapidly during the year and now stands at over 200 members in 52 countries. The increasing proportion of third-world national scientists is a pleasing feature of the membership.

During the course of the year, six members visited ICLARM to work on stock assessment problems. These visits totalled 36 man-weeks and were of great benefit to the participants.

Two numbers of the NTFS newsletter "FISHBYTE" were produced and received an enthusiastic response from members.

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Project Title	:	Management-Oriented Fisheries Research Project
Cooperating Institutions	:	Department of Fisheries, Universities and Research Institutes in participating countries (currently including Philippines, Indonesia and Peru).
Duration	:	Continuous from 1982
Key Personnel ICLARM	:	Dr. Daniel Pauly Dr. John L. Munro
BPPL (Indonesia)	:	Mr. Dwiponggo
UPV (Philippines)	:	Mr. N. Navaluna
IMARPE (Peru)	:	Ms. I. Tsukayama

Objectives

- To strengthen the capabilities of the participating countries to manage their fisheries by creating stock assessment and management modules (SAMMs) in various countries and institutions. Each SAMM will develop a small nucleus of well-trained researchers.

- To train fishery scientists in the interpretation of fishery data (especially in extracting a maximum of information from available data) and in formulating implementable management options. 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 administration setting and regulations affecting fisheries.

- To help determine, in the countries involved in the project, the basic information requirements for stock assessment and fisheries management.

- To produce well-documented reviews of the various fisheries investigated and original studies on tropical fish population dynamics.

- To 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.

Results

Three modules were operational at the end of 1983; in Indonesia, Peru and the Philippines.

Indonesia

This module is based at the Research Institute for Marine Fisheries in Jakarta and scheduled to remain operational for a period of 18 months from

March 1983. The members of the module have embarked on a program of analyzing accumulated length-frequency data to extract growth and mortality estimates using the ELEFAN I and II programs on a Radio Shack TRS 80 Model III microcomputer supplied by ICLARM. Dr. D. Pauly visited Jakarta twice during the year, the first time to purchase and set up the computer, train the participants and initiate the analyses and on the second occasion, in October, to review progress. To date, the module has generated estimates of growth parameters for over 60 species of fishes. Additionally, the microcomputer has been much used by a number of other Indonesian scientists and has clearly made its mark simply by virtue of its accessibility and ease of operation.

Peru

The work of the Peruvian module has concentrated very heavily upon the analysis, at ICLARM, of accumulated catch and length-frequency data for the Peruvian anchoveta (Engraulis ringens), using the ELEFAN I, II and III programs. The principal collaborator at Instituto del Mar del Perú (IMARPE) is Ms. Isabel Tsukayama.

A preliminary analysis of the available data provided estimates of anchovy biomass and recruitment on a monthly basis and of seasonal growth over an eighteen year period for the northern stock of E. ringens (Fig.). The module sponsored the participation of Ms. I. Tsukayama and Ms. H. Santander at the FAO Expert Consultation to Examine Changes in the Abundance and Composition of Neritic Stocks, held in Costa Rica in April 1983 where a joint paper with preliminary results was presented by Dr. Pauly and Ms. Tsukayama. Detailed estimates of this sort have never previously been available and illustrates the power of length-frequency based techniques, particularly when applied to short-lived tropical stocks.

The second phase of this module has concentrated upon an analysis covering thirty years of data for the Northern and Central stocks of the Peruvian anchovy and analyses of these data are rapidly moving ahead.

Philippines

The Philippine module has concentrated upon a small project involving the testing of a hypothesis concerning the relationships between wind-based turbulence and water transport indices and fish recruitment. This is being conducted as a joint project between Mr. N. Navaluna of the Institute of Fisheries Development and Research (IFDR) of the University of the Philippines in the Visayas (UPV) and Dr. D. Pauly. Dr. Pauly presented a preliminary joint paper on the topic at the FAO consultation in Costa Rica mentioned above.

An "Atlas of the Growth, Mortality and Recruitment of Philippine Fishes" by J. Ingles and D. Pauly is now in press and should be published in early 1984.

Project Title	:	International Giant Clam Mariculture Research Project
Principal Cooperating Institution	:	James Cook University of North Queensland
Other Cooperating Institutions	:	Department of Primary Industry, Fisheries Research Branch, Queensland, Australia University of Papua New Guinea De La Salle University, Manila, Philippines Silliman University, Dumaguete City, Philippines University of the Philippines, Quezon City, Philippines Fisheries Division, Ministry of Agriculture and Fisheries, Suva, Fiji Ministry of Lands, Energy and Natural Resources, Honiara, Solomon Islands and the IUCN/WWF Conservation for Development Programme in Indonesia
Duration	:	1983-1988
Key Personnel	:	Dr. John L. Munro, ICLARM Prof. C. Burdon-Jones, JCUNQ Dr. J. Lucas, JCUNQ

Objectives

- To create a foundation of scientific knowledge which will enable giant clams to be raised in sufficient numbers in hatcheries to make reef restocking or extensive mariculture feasible.
- To reverse the trend of the larger species towards extinction.
- To develop a new industry in the equatorial Indo-Pacific based upon the extensive cultivation of an esteemed traditional food resource, which will provide increased food supplies and exportable products.
- To ultimately create maricultural systems for the only phototrophic, and thus self-feeding potential farm animal known to mankind.

Results

Principal activities have related to the development of a research proposal aimed at catalyzing research on tridacnid clams and laying the foundations for future work.

A close working relationship has been established with James Cook University of North Queensland and a proposal, prepared in collaboration with ICLARM, has been submitted by JCUNQ to the Australian Centre for International Agricultural Research (ACIAR). A grant of A$____ million over 3 years has been made to JCUNQ as a result of this proposal. Additionally, a submission to the Australian Development Assistance Bureau (ADAB) has been made for development of a giant clam pilot hatchery in the Solomon Islands. The result of this grant application is not yet known.

Dr. R. Ventilla was seconded to the Giant Clam Project from ICLARM's Coastal Aquaculture Project in Thailand for a period of two months and conducted a postal questionnaire survey of the status of and degree of exploitation of tridacnid stocks throughout the Indo-Pacific. An excellent response was received, which confirmed that tridacnids are heavily exploited throughout the region and are a normal part of the daily fare of islanders and coastal people throughout the region, except the western coast of Peninsular Malaysia and Thailand, where they are not consumed and are exploited only for their shells. In most heavily populated areas, tridacnids are grossly overexploited, particularly in Indonesia and the Philippines, where many local stocks are now extinct.

Additionally, Dr. Ventilla prepared a report on the processing methods used in Japan for preparing dried scallop muscles and developed outline plans for a tridacnid clam hatchery.

INFORMATION SERVICE

During 1983, the Information Service has continued to increase its range of activities as well as publication rate. Highlights include the successful launching of a Fisheries Forum proposal, confirmation of a selective information service and the first training course in aspects of information.

Publications

Volume. ICLARM's publication output in 1983 was the highest to date, with the production of a major publication in the Conference Proceedings series and another in Studies and Reviews, eight Technical Reports and one Translation, as well as the quarterly Newsletters and Annual Report. Further, continued demand for previous publications required the reprinting of five titles during the year. In the five technical series, the number of new titles (11) represents an increase of 50% over the total for 1979-1982.

Distribution. The overall dissemination of ICLARM publications is now an impressive figure. Over 26,000 books have been distributed in toto from the five technical series and well over 80,000 Newsletters.

The use of a distributor in the U.S.A. took effect in July with the air shipment of almost one tonne of ICLARM books to International Scholarly Book Services in Oregon.

Exhibitions. ICLARM books were included in a nationwide agricultural book display in China, beginning September; in "bookexpos" at various times in Singapore, Malaysia and the Philippines; and at the Frankfurt Book Fair in October, at two separate booths, sponsored by the Philippine Book Developers Association and the German Agency for Technical Cooperation, respectively. The latter was part of an exhibition of publications of the International Agricultural Research Centers.

Library

The library has grown in both acquisitions and usership. Book and monograph holdings total 4,300, serial holdings increased from 1982 by nearly 100 titles to 390. External users of the library have increased from about 100 in 1981 to 590 in 1983.

ICLARM's Contribution Series, which includes all items published by ICLARM staff or by external authors on commission, was advertised for the first time in the April 1983 Newsletter. Many of the contributions are offered free, while others are at cost of xeroxing and postage.

Response to this new service has been extremely good. It is expected to increase awareness of ICLARM's work on the part of Newsletter readership and the scientific community in general.

Computer Literature Searching

Through 1983, a free service continued for external users of the Center's online teletype connection with the DIALOG system of computer databases. Overseas as well as domestic enquiries were handled.

Review Competition

A $500 prize was offerred in the last Newsletter of 1982 for the best (unpublished) review received by the end of September 1983. Despite the offer, and airmailing of usually surface-mailed Newsletters throughout Southeast Asia, only three enquiries and two reviews were received. Increased participation will be planned in the future.

Audio-visuals

A comprehensive sound-slide show on ICLARM's objectives and programs was finalized early in the year. It has proven useful for visitors and staff alike. Copies have been made for members of the ICLARM Board and PAC.

A second audio-visual was made by a group of Indonesians during their 4-week visit to ICLARM (see Training).

External Information Services

In September, the Canadian International Development Research Centre confirmed its intention to support ICLARM's proposed Selective Information Service in which an Information Scientist will be appointed to ICLARM staff to provide a question/answer service in the Center's areas of expertise. The project will include preparation of bibliographies and reviews in identified areas. Assistance to other information centers will also be provided.

Involvement in other information systems in 1983 has included participating in the establishment of a Philippine Aquatic Science and Fisheries Information System and of a National Information System for Science and Technology.

Asian Fisheries Forum

As forecast in the 1982 Report, the enthusiastic response to a circular proposing a regular Fisheries Forum and Fisheries Society resulted in an ICLARM-sponsored meeting in Manila in May, attended by seven senior scientists from five countries. The group endorsed the concept of a regular scientific meeting, probably biennial or triennial, whose location would rotate around the region. Importantly, the group expanded the Forum from the originally proposed Southeast Asian region to include all of Asia, in order to reflect better the Indo-West Pacific faunal zone which encompasses most of Asia.

The Manila group formed itself into a Foundation Council to plan the first Forum and has sought additional members from other Asian countries. The first Forum meeting is expected to be in early 1986, at which it is planned to present a draft constitution for an Asian Fisheries Society. The proposals for both Forum and Society received unanimous support at an international aquatic sciences meeting in Malaysia in August. ICLARM was asked to provide a secretariat for the Foundation Council, pending elections of officers at the first Forum meeting.

Training

The first external training course in fisheries information by ICLARM was held in June. Four Indonesian officers from the Agency for Agricultural Research and Development (AARD) spent a month based at ICLARM. Training was carried out in four modules: publication, librarianship, information and visits to other information centers.

Meetings Attended, Papers Presented

Working Group on the Proposed Development Plan for a Philippine Aquatic Sciences and Fisheries Information System Project, Manila, January, March, July, August 1983. (J.L. Maclean)

Seminar Workshop on the Design and Planning of the National Information System for Science and Technology, Manila, 25-28 April 1983. (J.L. Maclean)
J.L. Maclean. Impact of the national information system for science and technology on the training of users.

Philippine Library Association, Inc., National Congress on Library Development, Manila, 18-20 May 1983 (H.C. de Castro)

Congress of Southeast Asian Librarians (CONSAL), Sixth, Singapore, 30 May-3 June 1983 (R.M. Temprosa)

International Conference on the Development and Management of Living Aquatic Resources Management, Malaysia, 2-5 August 1983 (J.L. Maclean)
J.L. Maclean. An Asian Fisheries Forum.

Association of Special Libraries of the Philippines (ASLP), Seminar on Systems Study for Information Specialists, Manila, 15-17 September 1983 (H.C. de Castro)

UNESCO-UPILS Asian Regional Seminar on Local Data Bases and Their Use, Manila, 10-14 October 1983 (R.M. Temprosa)

First Meeting of Information Officers of the International Agricultural Research Centers, Frankfurt, 18-20 October 1983 (J.L. Maclean)

Third International Conference on Scholarly Publishing, London, 19-22 October 1983 (J.L. Maclean, part only)

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[1] Fixed term appointment ended on 15 May 1983.
[2] Fixed term appointment.
[3] Fixed term appointment ended on 31 August 1983.
[4] Fixed term appointment commenced on 1 June 1983.
[5] Resigned 31 March 1983.
[6] Commenced 16 June 1983.
[7] Commenced 17 October 1983.

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[8] Resigned 31 March 1983.
[9] Commenced 6 September 1983.
[10] Commenced 1 March 1983.
[11] Resigned 27 June 1983.
[12] Resigned 5 October 1982.
[13] Commenced 1 November 1982.
[14] Resigned 15 September 1983.

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[15] Resigned 12 June 1983.