ICLARM FIVE-YEAR PLAN (1988-1992)
Part 1. Directions and Opportunities

February 1988

ICLARM

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

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Part 1. Directions and Opportunities

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ICLARM STATEMENT OF PURPOSE

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

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

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

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

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

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

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

ICLARM Articles of Incorporation
1977, Manila, Philippines

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FOREWORD

ICLARM's tenth anniversary in 1987 as an international nongovernmental center for fisheries research and development coincided with my own fiftieth year of involvement in international fisheries activities. It is with pride and satisfaction that, as a member and current chairman of its Board of Trustees, I joined in celebrating the first decade of work by this unique organization.

The ICLARM approach involves working side by side in the laboratories and universities of countries seeking assistance. It is highly cost-effective. But more to the point, cooperation is on a face-to-face, hand-to-hand basis. There is full awareness of the inhibitions, limitations and opportunities, whether technical, cultural, economic or political, which circumscribe the development process.

The ICLARM Board of Trustees is most grateful to those associated with the Center in its first ten years. We trust that they will concur with our belief that the need for research in fisheries management and aquaculture development is great and that ICLARM deserves continuing and increased support in the years ahead.

The process of developing this Five-Year Plan began in 1986 as documentation for the first meeting of ICLARM's Support Group in October that year. The first draft was distributed as a document entitled "Preparing for ICLARM's Second Decade: Program and Finances of the International Center for Living Aquatic Resources Management". This document was an effective brief for Support Group members, but it became clear that additional and more specific details on ICLARM's plans were desired. This point of view was shared by ICLARM's Board of Trustees and staff. The document which follows is the first result of this planning process, a process that is expected to become an integral and ongoing part of ICLARM's activities. A draft Plan was distributed to selected colleagues and donors in September 1987, and reviewed and approved by the Center's Program Committee and the ICLARM Board of Trustees in November 1987.

The Five-Year Plan deals primarily with broad program priorities rather than in the very specific details of individual activities within each program, further information on which can be found in various other ICLARM publications, especially Annual Reports.

Budget details of the Five-Year Plan are available as a separate document - Part 2. Projected Budgets. They were separated because of likely changes during the Plan period.

I would like to thank, on behalf of the Board, those colleagues and representatives of donor organizations who kindly read and commented upon the contents of the draft Plan. We hope your views and advice have been adequately represented herein and seek your continued support in carrying out the activities called for in this worthy Plan.

Roy I. Jackson, Chairman
ICLARM Board of Trustees

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EXECUTIVE SUMMARY

With its first decade just recently complete, ICLARM now has the necessary experience through scientific programs in fisheries, coastal zone management and aquaculture and a successful modus operandi, to know which research approaches are likely to be successful and which are not. Some shifts will take place in the next five years in the focus of the Center's programs and the manner in which they will be conducted. On the whole, however, the Center's program will build upon its highly successful first decade.

The need for an international center such as ICLARM, to deal with pressing environmental, institutional, nutritional, technical and socio-economic issues is as pressing today as it was ten years ago. Deterioration of coastal environments and of living standards for most residents dependent upon coastal and inland waters for livelihood continues to be a most pressing problem. Research contributions have begun to make an impact but much more remains to be done.

There is no shortage of national institutions with which ICLARM can link in its research programs. The challenge faced by a relatively small institution such as ICLARM, however, is how to pursue an international research and training program without becoming too diffused in its efforts to the point that impact at the international level disappears. Not only, of course, do pressures to narrow one's program come from national scientists but increasingly they also come from funding agencies primarily following bilateral approaches. To work effectively in this environment, ICLARM has chosen to pursue an international program that is strongly based on *networking*.

Activities and Programs Planned

Networks must have a strong core that helps drive the various activities. From ICLARM's experience it is insufficient to link national institutions in networks without providing research leadership, a strong information component and training opportunities. ICLARM's Network of Tropical Fisheries Scientists (NTFS) provides such an example for tropical fisheries research, where dynamic methods research activity at ICLARM headquarters, complemented by a newsletter focusing on methods (and debate about them) and by training opportunities, has led to significant scientific advances. The Asian Fisheries Social Science Research Network (AFSSRN) is beginning to develop a similar approach, and the newly formed aquaculture network is expected to follow suit.

Aquaculture, however, poses several potential problems for a small international research center such as ICLARM. The sector is extremely diverse, and needs to be supported by a strong carefully focused research

program with high potential for impact on production of selected species. Due to the relative newness of scientific approaches to aquaculture research and systems, it has been ICLARM's experience that networking alone is insufficient to bring about the scientific advances that the sector requires. ICLARM believes that aquaculture will require a strong core program at one or more centralized facilities with an international mandate and with which network member institutions can interact. This is the basic framework that ICLARM proposes for its aquaculture program for the next five years.

In response to this need, ICLARM plans to develop modest research facilities of its own. The two new facilities proposed - one for aquaculture genetics of freshwater species and one for freshwater aquaculture farming systems, both in Southeast Asia - will join ICLARM's Coastal Aquaculture Center in the Solomon Islands, the first phase of which was constructed in 1987. Each of these three research and training facilities and their respective staff will serve as the core of research networks, thus linking the ICLARM activity directly with selected national programs. The Center's work is directed primarily towards systems suitable for small farms, and includes an African component. Impact of ICLARM's work on species and systems of initial concentration - tilapias, carps and giant clams - is expected to be considerable.

ICLARM's *Resource Assessment and Management* Program, with its focus on stock assessment, economics and management options for small-scale fisheries, does not require physical facilities. Computer hardware and software and linkages with national groups are at the core of the Center's approach to its stock assessment and fisheries management research, training and networking. This program's impact will continue to be very high and will be expanding in the coming five years from Asia to Latin America.

During the past year, ICLARM's Resource Assessment and Management Program has expanded to include a large ASEAN/US Coastal Resources Management Project. The first four-year phase of this project includes the development of management plans for selected areas in the six ASEAN countries. The project, and ICLARM's role in it, were favorably evaluated in January 1988. ICLARM foresees a continuing and expanding role in this field and has initiated linkages with several groups active in this area, such as the International Union for the Conservation of Nature (IUCN) and the United Nations Environmental Programme (UNEP). These linkages plus the lessons learned from the ASEAN/US project will lead, within the next few years, to a more defined long-term program in this new area than presently exists for ICLARM.

This Program area will be the focal point of development of planning and management information systems, incorporating all its present research with further interdisciplinary research towards integrated, computerized aquatic resources management systems.

Similarly, ICLARM's *Social Science* research network has not required a scientific laboratory per se, focusing as it does on resource management and aquaculture systems and development issues. This Southeast Asian network has been addressing through training and research a key constraint to

interdisciplinary research in both these areas; the lack of well-qualified social scientists. The Network's ability to address key policy issues will be enhanced by expanded national participation.

These successful programs can continue their work in this fashion for the foreseeable future. Both the Resource Assessment and Management and Social Science activities, however, need additional staff to become more effective, as will the aquaculture research and training units.

The Center's *Information* Program is expected to continue its excellent publication and distribution record and to embark on information research activities in its own right. As information systems evolve, and particularly as hardware which gives access to such systems develops rapidly, ICLARM plans to remain at the forefront of those working to assist third-world countries to benefit from these systems.

Staffing

The above expanded activities of ICLARM will necessitate a concomitant increase in numbers of professional scientific staff. During the financial crisis recently endured by ICLARM, the Center's core scientific staff have been reduced below effective levels. Core staffing now needs to be increased and quite substantially so to undertake the activities outlined in the Five-Year Plan. It simply is not possible to manage for long a program of ICLARM's diversity and promise with the core professional staff now in place. Currently, none of the Center's three program leaders have other senior scientific staff to help lead their activities; staff have become too compartmentalized due to the highly restricted and short-term nature of much of ICLARM's support; the Center has no Deputy Director General or staff to assist with necessary planning and fundraising activities; key positions in education and information programs remain vacant. This is not to mention the staff required for the proposed aquaculture research and training units. Clearly, the Center's professional staff must be increased in number.

Facilities

The aquaculture themes identified for the plan period will require modest research facilities to serve as core units for research and training networks. These two units will be for genetics and integrated farming. It is proposed that these units be located on the campuses of or otherwise nearby to host institutions in the Philippines and Thailand. ICLARM's Coastal Aquaculture Center will be inaugurated in the Solomon Islands in April 1988.

ICLARM also has no permanent headquarters facility of its own. Since its incorporation in the Philippines ten years ago, ICLARM has occupied rented office space in Makati, the business center of Manila. It is time for the

Center to have a permanent headquarters facility of its own. The University of the Philippines in Quezon City has set aside a one-hectare parcel of land for this purpose and a fundraising effort for a 3,000-4,000 square meter headquarters building has begun.

Finances

The major constraint to expansion of the staff and pursuit of the above program activities is financial. ICLARM has been struggling to maintain its core program for the past four years since the withdrawal of support from the Center's founder, the Rockefeller Foundation. Increased core grants from USAID (USA) and AIDAB (Australia) quite literally 'saved' ICLARM in 1985.

The Center has recently achieved some considerable improvement in and diversification of its core support. In late 1986, the ICLARM Support Group, under UNDP leadership, was formed. This was followed in 1987 by word of new core grants for the first time from several European countries including France, the Federal Republic of Germany and Denmark. In December 1987, the World Bank approved a US$300,000 grant to ICLARM from a fund established especially to assist Centers, such as ICLARM which are not yet formal members of the Consultative Group on International Agricultural Research (CGIAR). ICLARM is optimistic that some form of linkage with the CGIAR will be established in 1988. It is hoped that this affiliation will bring new financial support for certain aspects (e.g., genetics and integrated farming) of the aquaculture program. Restricted core proposals are pending with other groups and the number of supporters of ICLARM has grown to sixteen from only half that number four years ago. While these grants do not meet the full requirement of ICLARM as outlined in this Five-Year Plan, they nevertheless provide an element of initial security and conviction that can form the basis of sounder program planning for the organization.

The Five-Year Plan forecasts annual budget growth from US$3.89 million in 1988 to US$7.57 million in 1992. ICLARM support in 1987 was $3.7 million, of which 29.7% was special project in nature. Thus, the Five-Year Plan envisions reasonable growth in total annual budgets, given the reduced base initially, but this also will entail shifts in support away from special projects to unrestricted and restricted core support.

If ICLARM is able to increase its budget and staff in this manner, it will be better positioned to achieve its full potential in the aquatic resources management areas that are its mandate. Summary budgets for the Five-Year Plan period (1988-1992) can be found in the separately published Part 2 of this Five-Year Plan.

OVERVIEW OF THE ICLARM PROGRAM AND FINANCES

Rationale for ICLARM

Tropical third-world countries are extremely dependent on aquatic resources for food and income. For half the population of the third world, fish constitutes one-third or more of animal protein intake; in many third-world countries, it makes up more than half. Indeed rice together with fish is probably the most common dish in the tropics. As important as food intake is the fact that extremely large numbers of people earn income from these aquatic resources. The result of their dependency has been increasing pressure on living aquatic resources and their environments.

Coastal environments in the tropics, including the coral reefs offshore and the river basins that form integral parts of these environments, are steadily deteriorating. Siltation from overexploited uplands accumulates on coral reefs, permanently damaging many of them. Coastal mangrove forests are rapidly disappearing and pollution is increasing. Coastal fisheries have become scenes of intense competition between trawlers on the one hand, which have rapidly increased in numbers with the availability of low-cost credit, and small-scale fishermen, on the other hand, who eke out an increasingly marginal existence. The growing number of landless laborers, many of them recent migrants from the agricultural sector to coastal communities, is alarming. Ironically, incidence of malnutrition is especially high in tropical coastal fishing communities which have become increasingly market-oriented to meet just their basic needs.

A crisis of major proportion exists for the living aquatic resources sector in tropical third-world countries because these economically and environmentally important yet fragile systems are widely mismanaged. Increasingly around the world these marine, coastal and inland ecosystems are overexploited, even irreparably damaged, by diverse and competitive users. If managed to yield food and other products on a long-term sustainable basis, however, these systems can be of immense value to humankind for decades to come.

Since the 1970s, annual yields have begun to decline from a number of major fisheries. Coastal fisheries, upon which small-scale fishermen depend, have been put under particular pressure as competition has increased. So far worldwide, the exploitation of new resources has offset this decline, but rates of increase in aquatic food production are falling far behind rates of increase in population. It is clear that new unexploited resources are limited in number and that better control over use of aquatic resources and enhancement of habitats are the keys to sustaining, if not increasing, present levels of productivity. Management is essential to deal with this overfishing,

but as yet, effective institutions that take into account the interests of the majority of producers, who are small-scale, have failed to develop in most countries.

The crisis facing the aquatic resources sector thus has environmental, nutrition, income and employment dimensions, all requiring management approaches, and is not simply a production constraint solvable through standard development approaches. The management of these resources will require carefully formulated policies and programs to minimize the economic and social disruption that may initially result from the introduction of management.

Aquaculture, as part of these aquatic systems, offers considerable hope of increased growth in production, but the transition from hunting to scientific farming of aquatic resources is only just now beginning. Aquaculture is relatively widespread throughout southern and eastern Asia and is being promoted and developed rapidly. The contribution of aquaculture to meeting national nutritional needs will depend to a considerable extent on the skills of farm managers in adopting appropriate technologies and managing them effectively.

Of approximately 80 million tonnes fisheries production in 1985, however, less than 10% was generated by aquaculture. The rate of growth of the aquaculture sector (almost 10% annually in recent years) is amongst the highest of all food sectors, so the future does appear promising. For the near-term future, however, the world's growing population will remain primarily dependent upon capture fisheries for the bulk of its aquatic food supply.

Objectives of ICLARM

ICLARM, incorporated in the Philippines in 1977, is one of about 20 international, nonprofit, autonomous research centers which concentrate upon those critical aspects of food production and resource management that are not covered adequately by other research organizations, and which are of wide importance, regionally or globally. As such, ICLARM's role is to complement and support the activities of national and regional research institutions in fisheries, aquaculture and coastal zone management in tropical third-world countries. Short course and individual training are an important part of ICLARM's program and will become even more so in the future.

The stimulation and strengthening of global research activities by the Center are directed toward the improvement of the nutrition, income and employment opportunities of lower income people in these countries. The Center's mandate, as stated in its Articles of Incorporation, can be found on page iii. The Center's interdisciplinary research is designed to increase utilization and promote rational management of aquatic resources toward these goals through several major interactive areas: Aquaculture, Resource Assessment and Management, Social Science research, Education and Training, and Information (Fig. 1). ICLARM is the only such research center

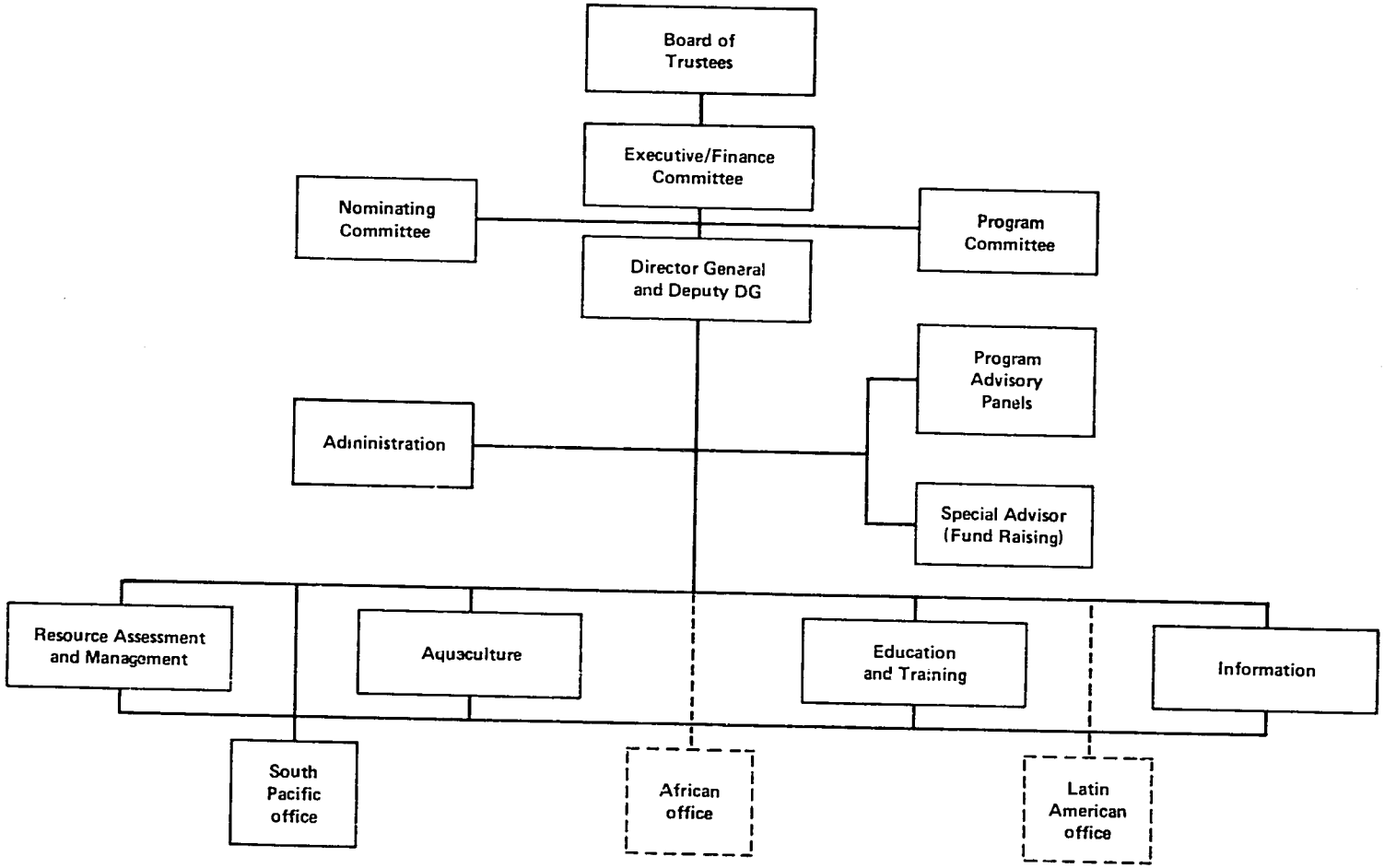


Fig. 1. ICLARM structure showing current program areas, current regional office and possible future regional offices (dotted lines).

in the tropics that deals with the full range of interdisciplinary research issues in the fisheries and aquaculture continuum (Fig. 2). This continuum is the guiding force linking ICLARM's programs.

Operation of ICLARM

ICLARM is one of the smallest of the international agricultural research centers, and perhaps not coincidentally, very cost-effective. The flexibility that characterizes the Center's program is made possible not only by a small, dedicated and highly productive staff, but also by the way in which ICLARM carries out its research. The Center was designed to function in a fashion similar to the other international agricultural research centers, except that it has no large centralized research facility of its own. ICLARM's physical facilities are small and usually developed in partnership with national and regional institutions. The Center's facilities, including those planned for genetics and aquaculture systems research, are modest by international standards and devoted to selected topics in the Center's aquaculture program.

Much of the Center's work is carried out through research and training networks involving participation of national institutions. The "multiplier" effect of the Center's research, training and information activities is high and contributes to increased individual and institutional capabilities. This approach has produced high quality results and important conceptual advances, for example in the fisheries stock assessment and management field. This focus upon cooperation is also highly appropriate in that it assists more of the Center's colleagues in the tropics to develop sustained careers for themselves in the fisheries, aquaculture and coastal zone management fields, an involvement that is essential if the complex development and management problems facing the sector around the world are to be dealt with successfully.

ICLARM is neither a funding organization nor a consulting firm. Rather it is a unique and very active research institution with a dynamic program of long-term research, methodology development, training and information dissemination. The Center focuses particularly on "upstream" research of a strategic and long-range nature and in addition pursues "downstream" or more applied and adaptive research through cooperative research activities with national and regional organizations. ICLARM is designed to complement the work of international governmental organizations, such as the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Development Programme (UNDP), that undertake development projects in the aquatic resources sector. The Center's research has always had a strong interdisciplinary flavor.

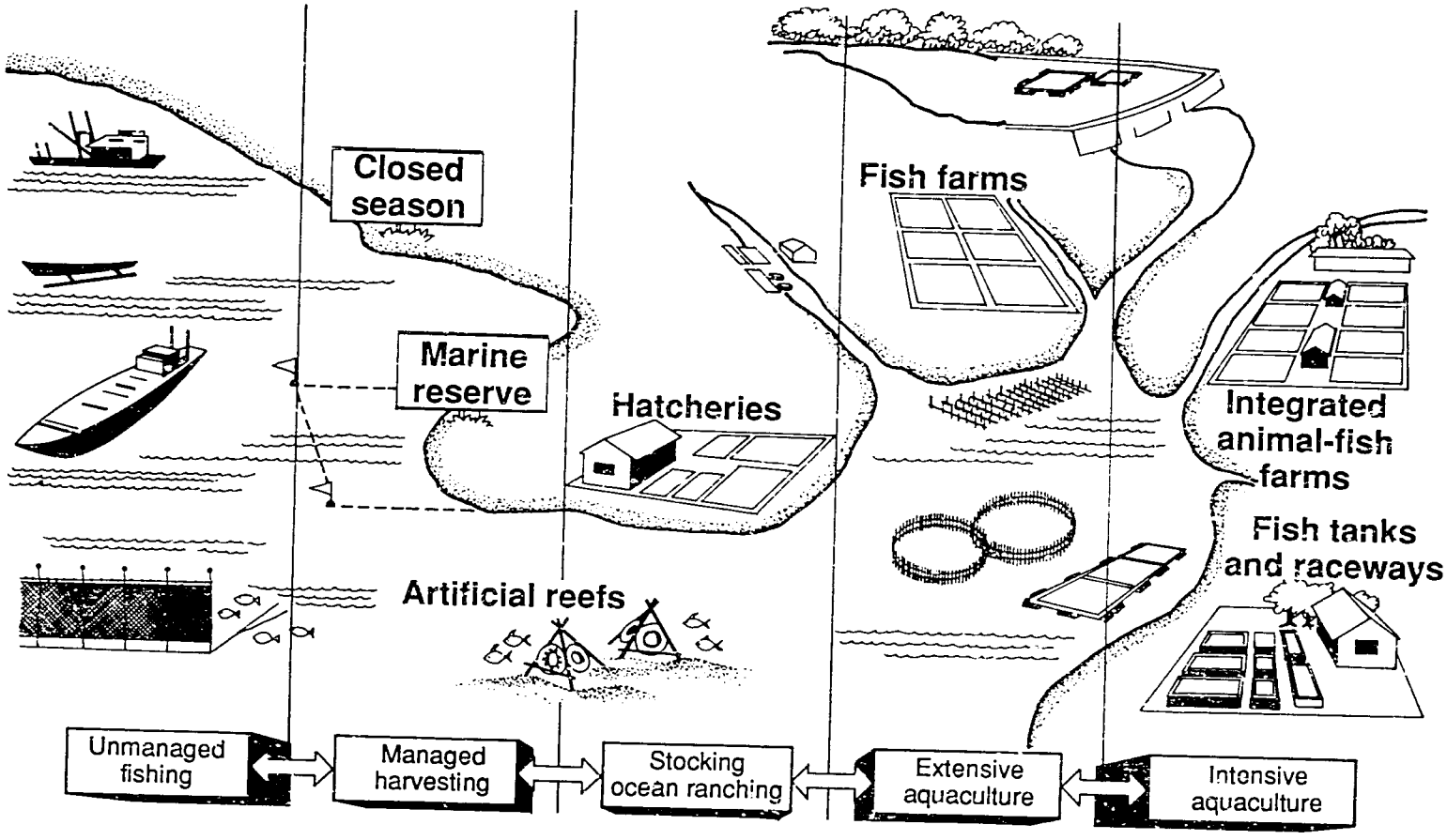
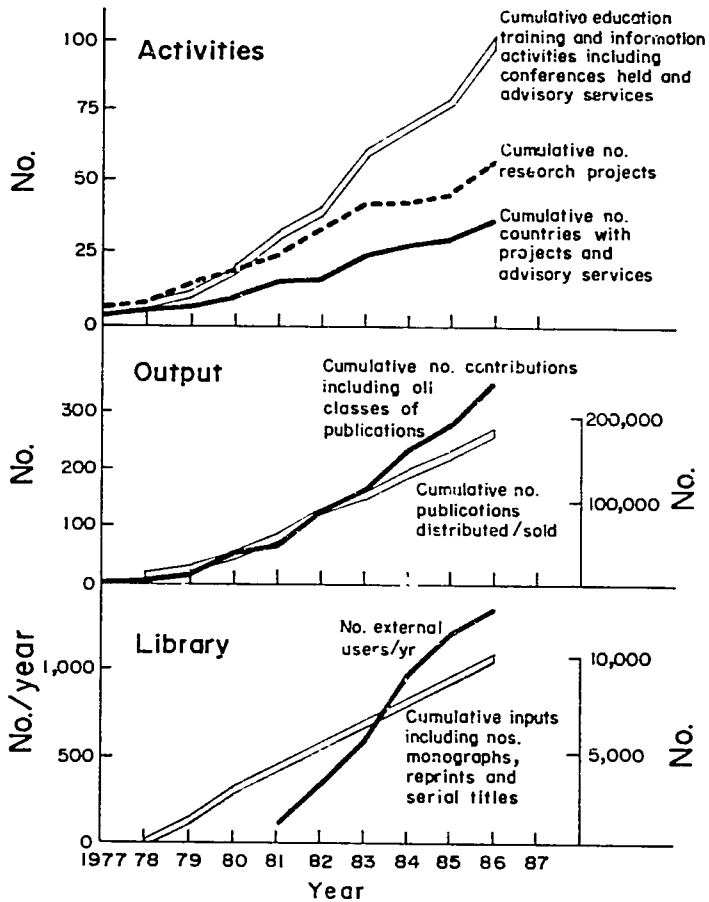
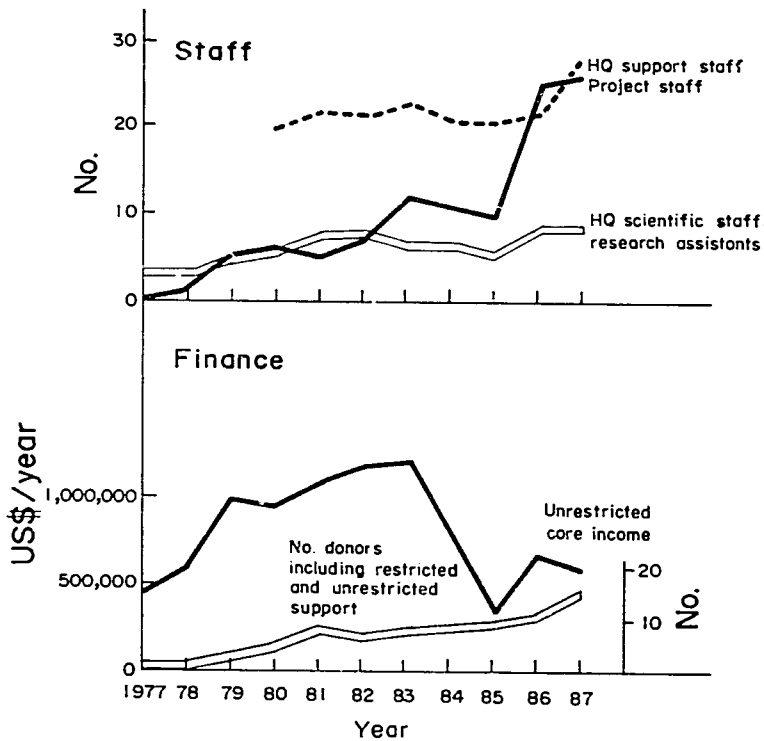


Fig. 2. Utilization of aquatic resources: a continuum of activities requiring a comprehensive, interdisciplinary approach to research such as has been initiated by ICLARM.

ICLARM at a glance





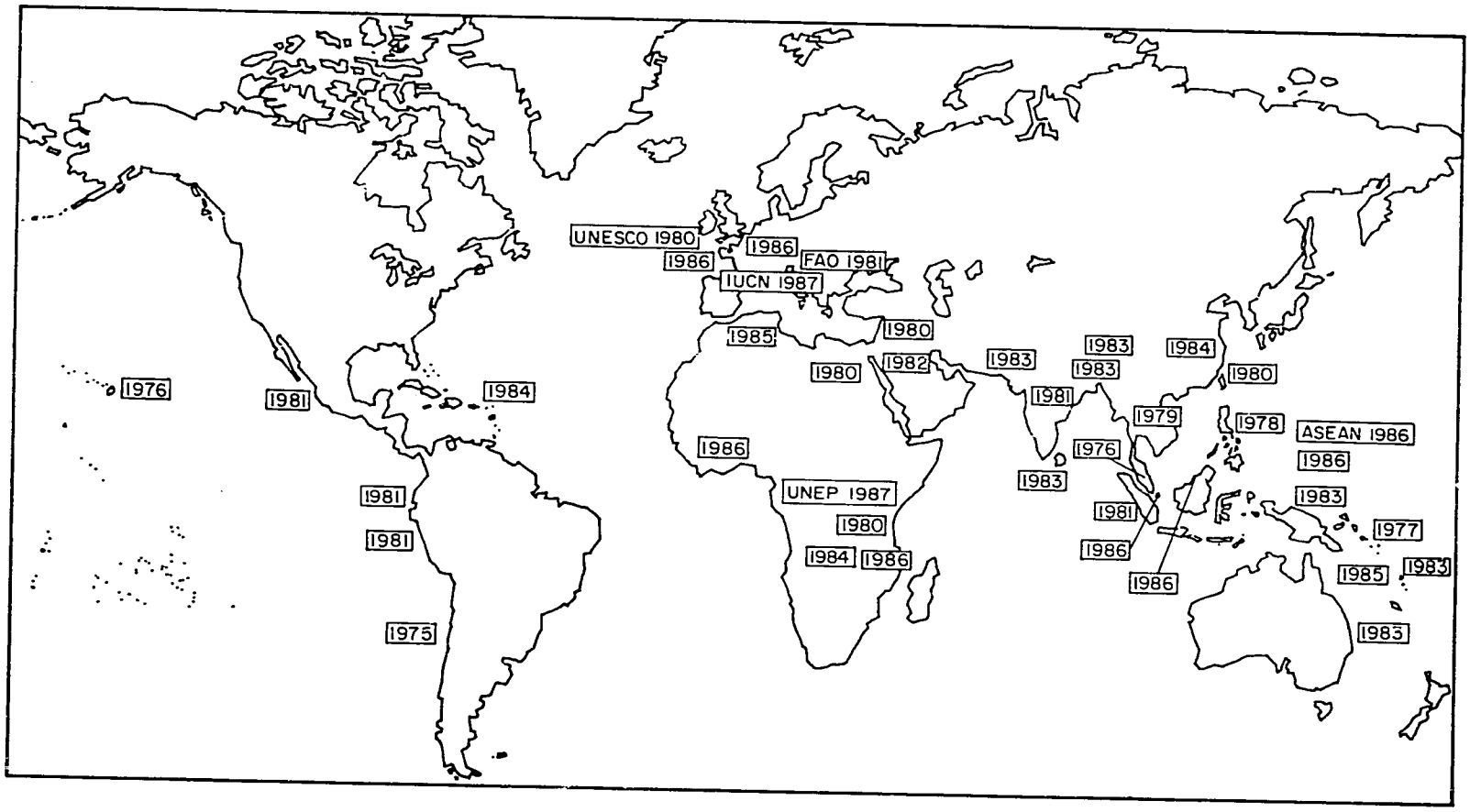


Fig. 3. ICLARM's activities have steadily expanded during its first decade of research and now span the globe. Shown above are the first years of activities with various countries/agencies. Other features of the Center's growth over the 1977-1987 decade are shown graphically on the facing page.

Programs

ICLARM's program began with an initial focus on Southeast Asia and the Pacific and has grown substantially since that time, both programatically and geographically (Fig. 3). The Southeast Asian location for ICLARM headquarters was selected because of the prominent fisheries and aquaculture sectors of this region, and the critical need for research there. Most of the top fishing countries in the tropics are in Asia and virtually all worldwide aquaculture production comes from this region.

The Center now has several interrelated program areas (Fig. 4), refined to manageable themes during the Center's first decade:

- *Resource Assessment and Management* - focuses on development of interdisciplinary methodologies for multispecies stock assessment and management; coastal zone management research and planning; and the economic and sociological problems of small-scale fisheries.
- *Aquaculture* - addresses constraints to sustainable increases in aquaculture production through focus on genetics of major cultured freshwater species; technology for low-cost culture systems, including coastal aquaculture systems; and management of aquaculture enterprises and farming systems.
- *Social Sciences* - contributes fundamental inputs into ICLARM's other programs to make them interdisciplinary in nature, and coordinates the Asian Fisheries Social Science Research Network which focuses on issues of fisheries management and aquaculture systems.
- *Education and Training* - opportunities for Visiting Scientists provided in all ICLARM programs; provides supervision of students working towards higher degrees and training through cooperative research; short courses in stock assessment and management; assistance in curriculum development.
- *Information* - assists ICLARM cooperative research programs and networks through worldwide data and information linkages; produces Naga, the ICLARM Quarterly and seven technical series; engages in research on worldwide fisheries information quality and use and means of their improvement.

Staffing

ICLARM pursues the above program of work through the leadership of a relatively small number of core staff in Manila, working closely with selected field activities in cooperation with national and regional research organizations. This approach, facilitated by the high productivity of the small core staff, has enabled the Center to achieve with its cooperators an enviable publication record of almost 400 contributions in just ten years of operation.

Currently, ICLARM senior professional personnel number 6 permanent staff in programs and administration and 11 in project-specific fixed-term

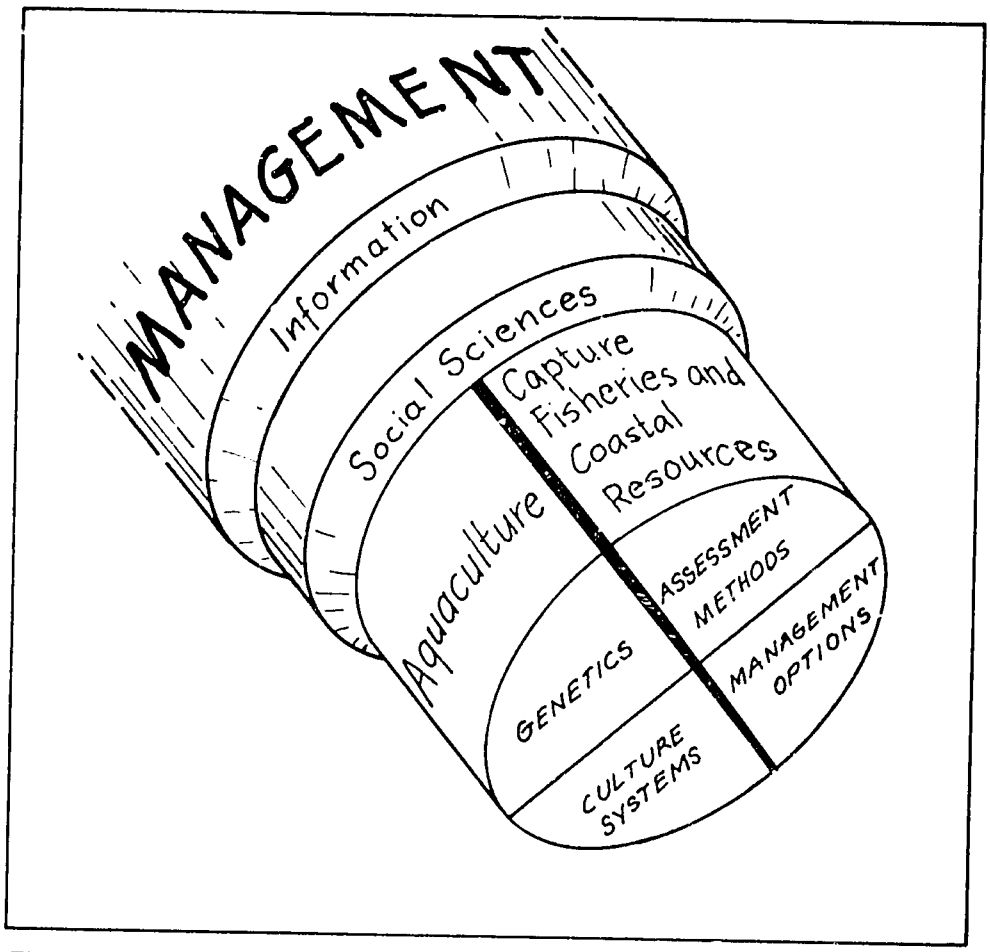


Fig. 4. ICLARM's core research and training areas are in aquaculture, capture fisheries and coastal resources. Embracing these elements are research and training in information and the social sciences. Appropriate management of living aquatic resources is the ultimate result of the various interdisciplinary research efforts.

contracts (one of the former and 6 of the latter serve outside ICLARM's Manila headquarters). Twelve mid-level professional staff and 28 support staff complete the Center's personnel in Manila. One regional office became operational in 1985 in the South Pacific. The Center also now has a number of important activities in Africa, where its first staff member was assigned in 1986, and growing linkages in Latin America.

The full staff complement of ICLARM is thus relatively small. Five senior professional positions are currently vacant at headquarters and will be filled when funding is available, as will the new positions under the Center's proposed expanded aquaculture program.

The Center strives to maintain a balance between the core staff in Manila, who have accomplished much in way of scientific advance and methodology development, and the more applied work of the field staff. Achieving this balance, of course, requires the right mix of long-term unrestricted or program financial support and restricted project-specific funds.

Achievements of ICLARM

During the first ten years of ICLARM's existence, its program in tropical fisheries research has had considerable impact (Fig. 5). The Center's more significant accomplishments are the contribution to the shifting of thinking from resource development (expansion) to management concerns and approaches, development of cost-effective resource assessment methods, the strengthening of third-world research and training capabilities, and the demonstration of the usefulness of interdisciplinary research in both fisheries and aquaculture. The management rationale guides ICLARM's whole program.

The US Agency for International Development (USAID) has evaluated ICLARM's programs twice since it began funding the Center in 1979. The 1982 review team concluded "ICLARM's multidisciplinary approach to aquatic resources problems of a general nature in tropical areas, which includes a higher than usual socioeconomic component, is a fundamental step towards establishing the scientific and technical bases on which development and management (current and future) can be based."

The Center's Resource Assessment and Management Program has had considerable impact, some specific examples of which follow (p. 16).

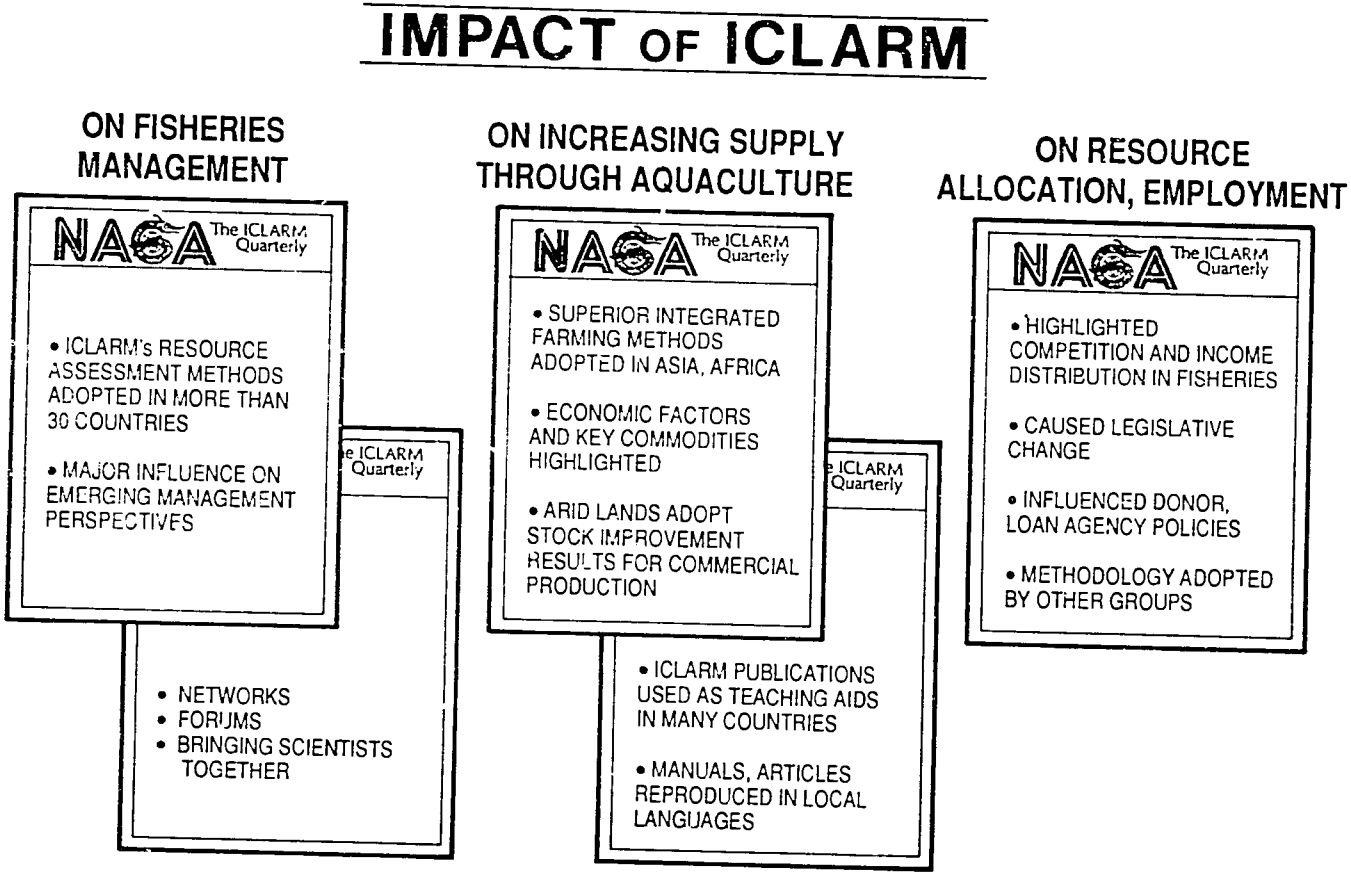


Fig. 5. Graphical representation of some ICLARM achievements, portrayed in a poster as headlines in Naga, the Center's quarterly magazine.

- *Development of extremely cost-effective techniques for fisheries stock assessment.* At the heart of the management problem because they permit prediction and complementary development of economic models, these techniques developed by ICLARM scientists are now in regular use in over 30 tropical countries, including those such as Peru, Indonesia, the Philippines and Thailand which have some of the world's largest fisheries.
- *Management of the Network of Tropical Fisheries Scientists,* a worldwide grouping of over 800 scientists in 73 countries. Effective not only as a communications tool with its own scientific newsletter published by ICLARM, this network has led to considerable advances in fisheries management and improvement in scientific techniques by network members beyond those developed initially by ICLARM staff.
- *Pilot interdisciplinary research studies for small-scale fisheries* which have very effectively brought worldwide attention to the needs of coastal fishing communities and for development of effective management institutions.

The Center's Aquaculture Program has also had some notable successes, among which are:

- *Development of superior methods for integrating fish production with livestock production systems.* Asian farming systems have benefitted from this research which has demonstrated fivefold increases in fish yields and which is now being extended to rice-fish systems. ICLARM is playing an increasingly important role in bringing African and Asian aquaculture scientists together. The success in this field with Asian cooperating institutions has attracted international support for ICLARM's new programs with African institutions, especially those in the southern African region.
- *Genetic improvement of freshwater fish.* Preliminary work conducted by ICLARM, with Asian, American and European counterparts, shows considerable potential for improved performance of certain freshwater species, especially tilapias.

In Social Sciences research:

- *Establishment of the Asian Fisheries Social Science Research Network,* the primary focus of which to date has been on economic aspects of Southeast Asian aquaculture systems and to a lesser extent on capture fisheries. This activity has led to the establishment of the first Asian M.Sc. program on fisheries/aquaculture economics (in Malaysia), training of over 10 new degree holders, and support for over 30 specific research studies by Network institutions in the space of only three years. The Network's research will expand in 1988 and beyond to include additional institutions and a greater concentration on fisheries management and aquaculture farming systems research.

The above sample of accomplishments are indicative of ICLARM's global program and its success.

ICLARM also receives continuous feedback on the Center's usefulness from many individuals and institutions around the developing world, where ICLARM literature is widely used. NAGA, the ICLARM Quarterly (formerly the ICLARM Newsletter), reaches 3,500 readers globally and publication exchanges are made with a large number of third-world country institutions.

More than 40 cooperative research projects have been initiated in various countries in Africa, Asia and Latin America and scientific linkages are operational with many institutions. Seven major reviews have been published and eight international conferences and workshops have been conducted by ICLARM, which subsequently published the proceedings. Requests for participation by ICLARM in various research topics far surpass the Center's ability to respond; research and information networks have been used very effectively to increase the multiplier effect of ICLARM's work.

The number of agencies with which ICLARM has had linkages in its first decade either as donors or in cooperative activities exceeds one hundred. Highlights of the Center's work and support are shown on the following pages.

The need for and usefulness of an independent, international, nongovernmental fisheries research organization working in cooperation with national institutions have been clearly established; the challenge currently facing ICLARM is to increase the levels of financial support that would allow this potential to be fully realized.

Financial Support and Continuity

Despite the apparent relevance and success to date of ICLARM's programs, the Center has never enjoyed full professional staffing or adequate funding. Since 1977, unrestricted core support has come from a relatively small number of contributors and in dollar terms the level of such support in 1987 was lower than it was four years previous. Partially offsetting this has been an increase in the levels of restricted core support. Special project and restricted funding that supports cooperative activities with the Center's cooperating institutions has increased considerably as ICLARM struggled to survive, but such support cannot fully take the place of unrestricted and restricted core support for the Center itself.

Since 1977, ICLARM has received unrestricted and restricted core program support from a number of donors including Australian International Development Assistance Bureau (AIDAB), Ford Foundation, German Agency for Technical Cooperation (GTZ), the Royal Norwegian Agency for International Development (NORAD), Rockefeller Foundation, UNDP and USAID. New core support was received in 1987 from the governments of France, Federal Republic of Germany and Denmark. Additional support for cooperative research projects has come from these donors and the Asian

Some Highlights of ICLARM's Development

1975-76	:	Startup activities in the South Pacific based in Hawaii under Director Philip Helfrich
January 1977	:	ICLARM Articles of Incorporation registered in the Philippines
March 1977	:	ICLARM office opens in Manila under first Director General, John Marr: international Program Advisory Committee approves research program thrusts
November 1977	:	First major conference - fish behavior and its use in the capture and culture of fishes - held at the famous Bellagio center, Italy. Two later conferences were held there, in 1980 and 1985.
January 1978	:	First major project begins: applied research on integrated farming in the Philippines
July 1978	:	Research on small-scale fisheries begins
July 1978	:	ICLARM Newsletter launched
September 1978	:	Library of international standards established
July 1979	:	Research on tropical stock assessment begins
July 1979	:	New Director General appointed: Dr. Ziad Shehadeh, with departure of first DG, John Marr
August 1979	:	Regional conference on integrated farming systems held; proceedings still benchmark publication
August 1979	:	USAID becomes ICLARM's second core donor, with Rockefeller Foundation
September 1979	:	First major multidisciplinary fisheries research project - of San Miguel Bay, Philippines - begins with the University of the Philippines. Becomes a model study in the region
November 1979	:	First technical publication appears
January 1980	:	First ELEFAN program - Electronic LEngth-Frequency ANalysis - announced
January 1980	:	Australian Development Assistance Bureau (ADAB), now AIDAB, becomes ICLARM's third core supporter
March 1980	:	ICLARM buys its first computer - 48K RAM
April 1980	:	First training visit in stock assessment begins. Such visitors have since come from 11 countries
May 1980	:	First cooperative activity with FAO: lectures given at FAO/DANIDA stock assessment training course in Kenya; activity continuing to date

Some Highlights of ICLARM's Development (Continued)

December 1981	:	GTZ funds first major ICLARM project: Thailand coastal aquaculture
January 1982	:	Asian Fisheries Social Science Research Network (AFSSRN) commences, coordinated by ICLARM, partially funded by IDRC of Canada
April 1982	:	Network of Tropical Fisheries Scientists (NTFS) and its newsletter "Fishbyte" begin
November 1982	:	Dr. Richard Neal appointed third DG
January 1983	:	International Giant Clam Mariculture Project starts up; includes six countries
May 1983	:	ICLARM convenes a small meeting which leads to launching of the Asian Fisheries Society - now with nearly 1,000 members
March 1984	:	Selective Fisheries Information Service for tropical researchers starts
June 1984	:	Release of first tropically oriented textbook on fish population dynamics, integrating text with software
July 1984	:	ICLARM funding crisis - Newsletter headline. The crisis deepens in 1985
February 1985	:	First international conference on length-frequency analysis and the ELEFAN programs: methodology now adopted in more than 30 countries
June 1985	:	Dr. Ian Smith becomes ICLARM's fourth DG
August 1985	:	HQ moved to cheaper building in Manila
October 1985	:	South Pacific Office begins in Townsville, Australia, staffed by John Munro
November 1985	:	ICLARM literally saved by early arrival of AIDAB core grant and new funding by Norway
November 1985	:	First major aquaculture research and training project in Africa begins, funded by GTZ
January 1986	:	The Association of Southeast Asian Nations (ASEAN) and USAID cooperate in a regional coastal resources management project; ICLARM is selected to coordinate activities in the six countries
January 1986	:	NTFS reaches 500 members; attracts funding from NORAD in addition to FAO and DANIDA
January 1986	:	"Naga, the ICLARM Quarterly" replaces "ICLARM Newsletter"
March 1986	:	Number of agencies with which ICLARM has had linkages reaches 100
March 1986	:	Ford Foundation provides major grant for ICLARM's small-scale fisheries program

Some Highlights of ICLARM's Development (Continued)

June 1986	:	Instituto del Mar del Peru invites ICLARM to help organize major workshop on their marine resources following joint major advances in analysis of anchoveta fishery
August 1986	:	UNDP announces first grant to ICLARM
October 1986	:	ICLARM signs first memorandum of understanding with an African nation - Malawi - through GTZ-funded project
October 1986	:	Solomon Islands provides land to ICLARM for a Coastal Aquaculture Center, now under construction near Honiara
November 1986	:	ICLARM Support Group of donors formed, led by UNDP
March 1987	:	France and the Federal Republic of Germany pledge first core support to ICLARM
March 1987	:	Asian Development Bank offers first technical assistance grant to ICLARM - for integrated farming
March 1987	:	UNEP designates ICLARM as INFOTERRA Special Sectoral Source for information on living aquatic resources management
March 1987	:	ICLARM, with Thai Department of Fisheries, holds its biggest international symposium, on tilapia in aquaculture, attended by 258 people from 40 countries
March 1987	:	ICLARM hosts TAC consultant, Dr. Clarence Idyll, during his work to identify appropriate CGIAR role in aquaculture research. His report recommends ICLARM as implementing agency
May 1987	:	Second Support Group meeting; donor interest growing
July 1987	:	ICLARM publishes major work with GTZ and IMARPE on Peruvian anchoveta fishery, at times the world's largest fishery
August 1987	:	DANIDA provides unrestricted core support
September 1987	:	ICLARM holds first training workshops in Africa on Southeast Asian aquaculture technology, through GTZ-funded project
December 1987	:	Year end brings new grants from World Bank, BMZ, GTZ, IFAD, DANIDA, USAID, and increased grant from AIDAB.

Development Bank, FAO, IDRC of Canada, Kuwait Institute for Scientific Research, New Zealand, Planters Products, Inc., San Miguel Corporation, the Skaggs Foundation, UK Overseas Development Administration (ODA), United Nations University, Australian-Pacific Science Foundation, FAO/SIDA Bay of Bengal Programme, and the European Economic Community through the Volunteer Service Organization. At the end of 1987, ICLARM was notified of major new unrestricted support from the World Bank from a fund specifically established to assist International Centers not yet part of the CGIAR system.

The Center has no endowment from which it could earn interest income and depends entirely upon grants from donor organizations. While the number of donors that have supported ICLARM is diverse and growing, the Center continues to operate under conditions of some considerable uncertainty due to the short-term nature of this support. The years 1983-1985 were particularly difficult as the Center experienced declining income, especially of an unrestricted nature, and almost literally collapsed at the end of 1985 to little more than a short-term project implementor. In 1986, ICLARM began to recover from this situation (Fig. 6), but long-term donor commitments remain few in number and the Center is still heavily dependent upon restricted, short-term income. This situation is expected to change for the better during the 1988-1992 Five-Year Plan period.

Over the past four years, ICLARM has never been more than a few months from insolvency. Funding shortages have not only led to cutbacks in core staff, but also have contributed to a dangerous compartmentalization of staff and activities as the Center's dependence on short-term, highly restricted and special project support increased.

To help overcome these problems the ICLARM Support Group was formed in late 1986, under UNDP leadership. The Support Group is leading to more diversified and longer-term support for the research, training and information activities of the Center. Initial results, as evidenced by donor response at the latest Support Group meeting in May 1987, appear very encouraging. The Support Group is also expected to assist ICLARM in gaining some form of recognition from the CGIAR with which the Center seeks membership or affiliate status. ICLARM's host government, the Philippines, strongly endorses such a linkage.

In 1987, the Technical Advisory Committee (TAC) of the CGIAR commissioned a consultant to examine aquaculture research priorities and to recommend an institutional framework for undertaking the work. This issue may come before the CGIAR for discussion in May 1988. In the meantime, with the assistance and advice of Support Group members, ICLARM is also exploring other long-term alternatives, some of which are quite encouraging. For example, discussions are to be held on March 1988 with other natural resource management centers outside the CGIAR system, regarding possible closer cooperation and joint fundraising.

To achieve its full potential, ICLARM is working for an increase in support and a semblance of financial continuity. The following sections of this Five-Year Plan provide details of the Center's programs and ample reasons

why ICLARM's activities warrant increased and sustained donor support. The Center's Five-Year Budget (1988-1992) can be found in Part 2 of this Five-Year Plan.

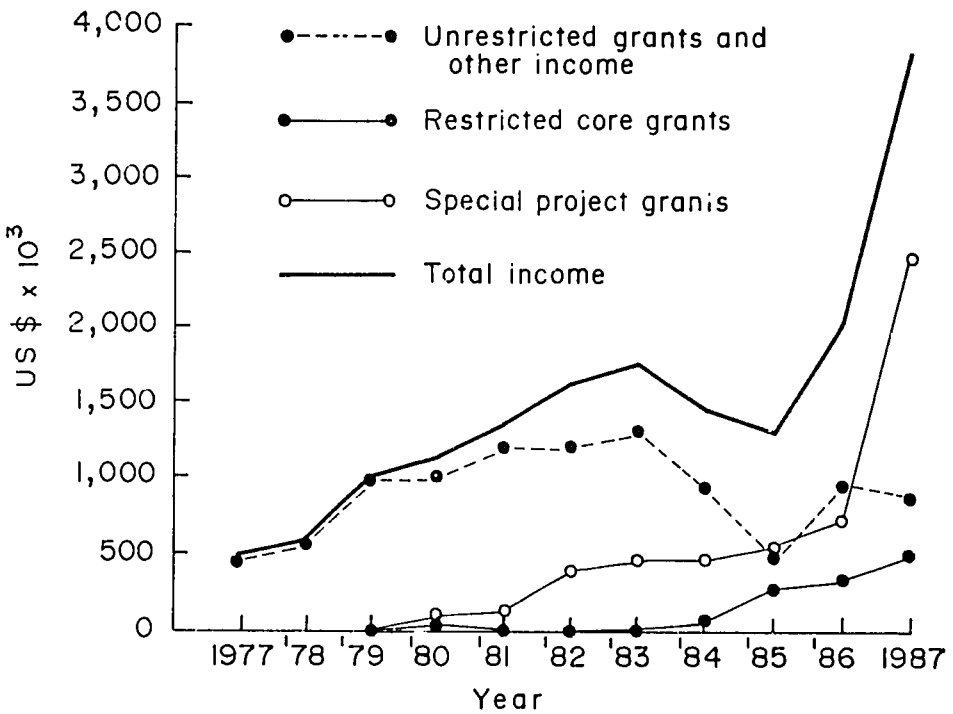


Fig. 6. ICLARM income profile, 1977-1987.

THE ICLARM FIVE-YEAR PLAN (1988-1992)

Background

During the first ten years of ICLARM's life, its core programs have been guided not only by the Board of Trustees, but also by considerable advice received from others. These individuals have included scientists, educators and representatives of donor agencies. An international group of scientists and educators was convened by ICLARM for its first Program Advisory Committee meeting in March 1977 and met three times subsequently in 1980, 1982 and 1983. USAID, one of ICLARM's major providers of unrestricted core support, evaluated the Center's programs twice; first in 1980 and then again in 1982. ICLARM was reviewed by the World Bank in October 1987 and then again by USAID and the Australian International Development Assistance Bureau (AIDAB) in early 1988.

Restricted and special project activities of ICLARM with cooperating institutions have also been reviewed on a regular basis by their respective donors. The most recent of these was a USAID review of the ASEAN/US Coastal Resources Management Project in January 1988. ICLARM serves as coordinating agency for this major ASEAN activity. In May 1987, the Asian Fisheries Social Science Research Network was reviewed by IDRC of Canada, one of the network's two major donors. ICLARM's programs thus have benefitted considerably from external advice over the past ten years. These advisory groups and reviewers have been unanimous in their praise for the work of ICLARM.

The First Meeting of the ICLARM Program Advisory Committee in 1977 provided a framework for the Center's research, training and information programs which has stood very well the test of time. The major themes of the Center's programs in fisheries stock assessment and management, small-scale fisheries, and integrated agriculture-aquaculture farming systems remain as valid today as they were ten years ago, though the exact focus may have shifted somewhat in each case. The experience of the past decade also has opened up new research possibilities for ICLARM, such as coastal zone management and mariculture of giant clams, and has suggested more effective ways to pursue certain parts of the program. Therefore, a new planning document was deemed desirable by ICLARM management and donors alike. The following Five-Year Plan, covering the year 1988-1992, is the result. It was approved by the ICLARM Board of Trustees at the Annual Meeting in December 1987.

Building on the Past

ICLARM's planned activities over the next five years are mainly a continuation of the momentum built up over the past decade. To be otherwise would be to fly in the face of sound advice. While present activities have been considerably tempered by donor's wishes and pockets, the activities proposed in the Five-Year Plan reflect more fully the Center's mandate - research towards wise management of aquatic resources, whether in ponds, rivers or the sea - than does the *status quo*. Complete details on current activities of ICLARM, as distinct from future program directions, can be found in various ICLARM reports. A five-year budget has been prepared separately in view of the probability of alterations during the period, and comprises a companion volume to this Five-Year Plan.

Because different aspects of ICLARM's activities have begun at different times and progressed at different rates, the pattern of activities during any time period (1988-1992 in this case) is a mixture of investigating problems (documentation); finding solutions (research); integrating the results of research (syntheses); and further refinement and integration towards holistic management information systems.

In Resource Assessment and Management, the lack of appropriate methodologies to assess tropical stocks was identified very soon after ICLARM began ten years ago and much progress has been made in this field. The program now is in an advanced stage of integrating stock assessment methodology into an expert system. The stock assessment and social science components of ICLARM's small-scale fisheries research need now to be more fully integrated after successful completion of initial joint activities. Other elements of this program, such as the ASEAN/US Coastal Resources Management Project, are at an earlier stage. This project is presently ending its documentation phase, and beginning the development of pilot plans in selected areas in cooperation with institutions in the six ASEAN nations.

In Aquaculture, the multiplicity of farming types, cultured species and problems has meant a long documentation phase in all aspects of the Program. The necessity for new physical facilities under ICLARM management to carry out international quality research in two key areas - genetics and farming systems - if aquaculture is to progress as a science, has become recently a forcible conviction.

One facility, a Coastal Aquaculture Center in the South Pacific, is nearing completion of its first phase now in the Solomon Islands and the other two required units are planned to be built in Asia during the coming five years. Much of ICLARM's long-term basic research previously proposed in these two crucial areas, genetics and farming systems, has been delayed as a result of the lack of such facilities. Once the facilities and the associated networks with national institutions are in place, research can begin in earnest towards providing improved breeds of first priority species and improved farming systems.

In the area of the economic and social aspects of aquatic resource management, ICLARM's activities became channelled primarily through the

Asian Fisheries Social Science Research Network following its commencement in 1983. Research in Network institutions is now moving towards broader fisheries and aquaculture management needs in parallel with the goals of both the Resource Assessment and Management Program and Aquaculture Program. Several exciting new initiatives in small-scale fisheries management, including evaluation of artificial reefs as potential stock enhancement and management tools, are proposed.

Information research is just beginning. Documentation of the many problems and issues related to information dissemination, retrieval and use are underway, the goal being to improve all these aspects and hence to accelerate the progress of fisheries science in tropical countries.

The Broader Environment

The fact that ICLARM has no endowment and thus depends entirely upon grants from other organizations, foundations and governments to pursue its work program, can make planning for a future five-year period a rather difficult exercise, if not the pursuit of purely wishful thinking. Compounding this problem are, first, that most grants currently received by ICLARM are for periods of time considerably shorter than five years, and second, that many of these are quite restricted or narrowly special project in nature, with objectives often defined by the donor. These funding perspectives of donors, common not only to those that support ICLARM but also to those supporting other international agricultural research institutions, have led some observors to ask whether it is ICLARM's donors, rather than its Board of Trustees, that set research priorities for the Center. While this is not quite the case yet, there is no doubt that ICLARM's programs are highly influenced by donor perspectives and priorities and that maintaining the Center's independence and flexibility to pursue long-term research has become more difficult with time.

Sustainable development and economic advance for the still growing numbers of rural poor, be it in agriculture or the aquatic resource areas on which ICLARM specializes, require more than repeated series of short-term projects. ICLARM will continue to strive for longer-term resource management perspectives, while at the same time promoting production through its aquaculture program.

It is the uncontrolled exploitation of natural resources, renewable or otherwise, that is creating such a bleak environmental future for many third-world countries in the tropics. In this context, there is a critical and leading role for nongovernmental nonprofit organizations such as ICLARM to play to encourage more responsible long-term management of these resources. Such a role can rarely be fulfilled through short-term project-specific support and deserves longer-term commitments from those that support organizations such as ICLARM.

These points notwithstanding the Five-Year Plan that follows and the activities contained within it are based on the premise that ICLARM will be

able to attract the necessary long-term funding to pursue the activities outlined. This position is taken with some degree of confidence because the problems tackled by the Center are of an increasingly critical nature, and are recognized as such by a growing number of donors and groups around the tropics with which ICLARM cooperates.

AQUACULTURE PROGRAM

Rationale

Aquaculture is a diverse set of technologies designed for rearing aquatic animals and plants and has been the topic of considerable discussion, speculation and promotion. With few exceptions, its technologies are poorly developed in comparison to the husbandry of poultry and mammals. In particular, warmwater aquaculture in tropical and subtropical regions is largely dependent on traditional methods involving more art than science, often with seed collected from wild stocks. Agricultural research, in contrast, has led to rapid strides in production during recent years. No advances of similar magnitude have been made for aquaculture, particularly in the tropics where protein needs and potential for increasing aquaculture production are greatest.

With the exception of work on common carp, oysters, salmon and trout, aquaculture research is a relatively new activity when compared with agricultural research. Most domestic mammals were domesticated 7,000-9,000 years ago and have been subjected to selective breeding programs for centuries. Research during the past 50 years on poultry and livestock, for example, has involved thousands of scientists at numerous research institutions around the world, and there have been major advances in modern husbandry as a result. In contrast, aquaculture research efforts have been small and scattered and have originated largely within the past 15 years. A strong research effort along classical animal husbandry lines is lacking, especially for the most important tropical species.

Many national laboratories, international agencies and private producers are now placing emphasis on aquaculture as an important future source of food. However, they mostly pursue short-term adaptive research and technology transfer, neglecting longer-term, more basic research. Frequent shifts in priorities by governmental groups and by international assistance agencies, their emphasis on 'quick development results', their focus on extension of poorly developed technology, and the scattered and disjointed nature of support for research efforts have all hampered the organization and funding of vital longer-term research, particularly for tropical species. Moreover, there is a general lack of well-trained aquaculture researchers in third-world countries. Hence, research methodologies and rigorous experimentation are poorly developed in many tropical aquaculture research institutions.

A further problem has been the tendency of researchers, educators and their supporting donors worldwide to view aquaculture as a 'part of fisheries' and therefore to isolate aquaculture research and training from agriculture. Aquaculture is a food producing system and must be seen in the broad context of food production by other systems - not only capture fisheries but

also agriculture. This viewpoint is essential for the success of aquaculture development and the avoidance of failures. In particular, it makes no sense to separate freshwater aquaculture from agriculture. Agricultural research and extension are well developed. Aquaculture research and extension are not and can benefit from a close relationship with agriculture. This is a new perspective for aquaculture and aquaculturists, which needs more active promotion and evaluation.

It is the function of ICLARM's Aquaculture Program to help to bring this new perspective to tropical aquaculture research and to provide leadership in research and training for the development of those sectors of tropical aquaculture most likely to provide income to small-scale farmers and fishermen and to provide fish (a high quality protein food) to domestic markets and consumers.

Fish have many advantages as farm produce. They are a highly nutritious and valuable traditional food in much of Asia and Africa. They are excellent converters of low grade feeds into high quality animal protein because, unlike terrestrial livestock, they do not need to use dietary energy to maintain body temperature or posture. Finfish are better feed converters than any feedlot livestock apart from dairy cattle on a feed: whole product basis. Most attractive of all is the concept of producing natural fish food, like phytoplankton, in the fishpond. Tropical fishponds can produce up to 30 t dry weight phytoplankton/ha/year which can be converted into fish flesh at ratios as good as 2:1.

Another attraction of most aquaculture operations is that they are relatively nonpolluting. This is particularly true for Asian integrated agriculture-aquaculture farming systems which recycle organic wastes through ponds to valuable fish flesh. Coastal aquaculture of bivalve molluscs is another example of a nonpolluting operation. ICLARM's Aquaculture Program concentrates on systems like these rather than the more intensive Western-style aquaculture such as cage culture of carnivorous fish, which is akin to feedlot livestock production and which can cause localized pollution problems.

The environmental impact of the aquaculture systems developed through this program's focus will, therefore, be positive. The program will also follow accepted international codes of practice and procedures for all introductions and transfers of aquatic organisms. This is very important for safeguarding the purity of natural genetic resources, particularly the tilapias of Africa. ICLARM has already taken a strong lead on this issue with respect to recommendations for controlling freshwater fish and marine bivalve transfers and introductions.

ICLARM's aquaculture program began ten years ago amidst considerable diversity of international opinion on aquaculture research priorities. ICLARM sought first to establish a successful track record in collaborative activities, sharing and wherever appropriate strengthening the facilities of existing national institutions, whilst developing a strategy for long-term work. Twenty-five projects were completed with 20 cooperating institutions together with various ancillary activities, such as training,

workshops, conferences, reviews and advisory services. This project-by-project approach, rather than a longer-term program, was partly necessitated by financial constraints. Despite its limitations, however, it provided ICLARM with a clear perspective on the most appropriate focus for the future development of the program. This focus, the structure and the future development of the program to meet its objectives are now explained. The history of the program, its future development and expected impact are shown in Fig. 7.

Focus

The spectrum of potential aquaculture research issues is extremely broad. Based on its work during the previous decade, ICLARM has come to focus on two research themes as being of major importance for the expansion of tropical aquaculture:

- The *genetic improvement* of cultured organisms, especially those low in the food chain that are cultured by small-scale farmers, in less capital-intensive aquaculture systems, to supply domestic markets; notably tilapia (an African fish, viewed as an 'aquatic chicken'), carps (common carp, Chinese carps, Indian major carps and other local species) and molluscs (particularly the bivalves - clams, cockles, mussels and oysters).
- The *development of technology for low-cost inland (freshwater) and coastal aquaculture systems* in which the above species can be grown on organic wastes and natural aquatic foods (bacteria, detritus, plankton and plant material).

The main program activities are interdisciplinary, cooperative research and training, combining the biological and social sciences. The latter are important in planning research for development of aquaculture. Biotechnical feasibility is not enough. Sociocultural factors such as religious attitudes, the role of women in food production, property rights and attitudes to risk are critical. In addition to generating important research results and strengthening third-world country institutions, the various activities undertaken provide leadership in the improvement of research methodology.

Geographical Scope

The geographical scope for these ICLARM activities is the entire tropical and subtropical belt. Aquaculture is most developed in Asia, where it has tremendous scope for future growth. However, established systems and recent advances in Asian aquaculture have tremendous relevance for aquaculture development in Africa, Latin America and other regions. For example, most African countries lack a history and tradition of aquaculture comparable to those of Asia. They have common problems of protein malnutrition and poverty with many of Asia's third-world countries, but have

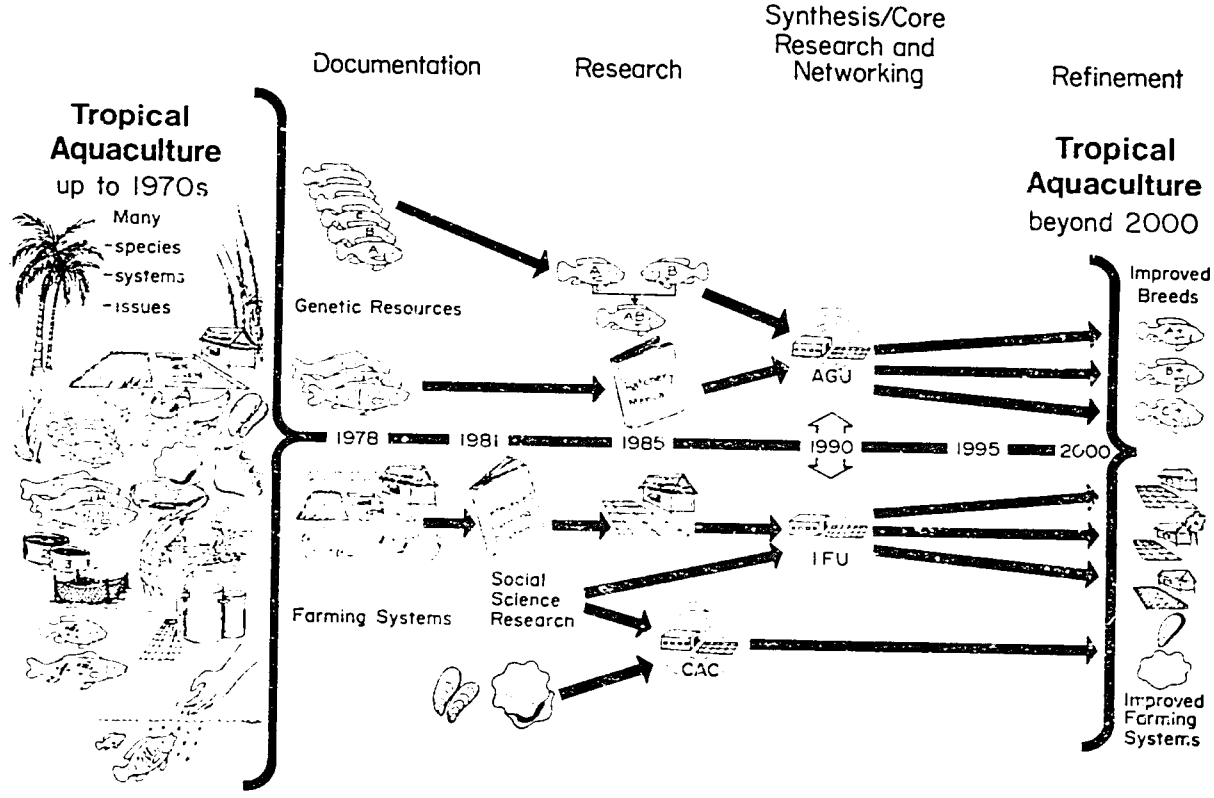


Fig. 7. Development and goals of the Aquaculture Program, showing the selection of and focus on only a few species and issues from the present multiplicity of species, systems and problem areas. AGU = Aquaculture Genetics Unit with its network activities; CAC = Coastal Aquaculture Center and associated network activities; IFU = Integrated Farming Unit and network activities.

relied largely on traditional agriculture and capture fisheries for food production. Africa is the world's least developed region with respect to aquaculture. Even the modest progress made earlier is now suffering decline. The reasons for this are complex and include, among others, lack of a strong research base and institutional support for aquaculture development and lack of trained personnel. There is an urgent need to upgrade the research and training capacity of African institutions, particularly universities. Fundamental sociological and economic questions regarding land tenure, labor availability, acceptable farming practices and the scope for aquaculture development in the context of other food producing systems, are also critically important and need thorough appraisal in Africa. The Program will give high priority to these issues.

Where aquaculture development makes sense in Africa, the primary need is for low-cost technology suitable for broad implementation in rural areas. The criteria for suitability are success in fish production and income improvement over a wide range of conditions of input availability and prices, experience, social circumstances and markets. Systems are needed which are relatively insensitive to changes in inputs and management skills. Integrated farming systems and methods for improving fish production from the numerous farm dams and small reservoirs have excellent prospects. In this respect, the Asian experience is invaluable. Tilapias and carps, which are available throughout much of Africa, will thrive in wastefed pond systems without major reliance on expensive inputs such as inorganic fertilizers and feeds. Coastal aquaculture in brackishwater lagoons also has considerable potential, especially in West Africa.

ICLARM's African Project Office established in 1987 in Malawi, the lead nation for fisheries and aquaculture development for the Southern Africa Development Coordination Conference (SADCC) countries (Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia and Zimbabwe), provides a modest beginning and a base in Africa for ICLARM's outreach in cooperative research and training. These activities will be pursued through the development of Memoranda of Agreement not only with government fisheries departments but also with universities in SADCC and other countries. Proposals to interested donors for specific activities will be prepared now that the initial activities, funded by the German Agency for Technical Cooperation (GTZ) are underway.

Coastal aquaculture of molluscs, especially bivalves, historically most developed in Asia, could be much more widely implemented in other tropical waters of suitable quality, such as the South Pacific. There is also interest in aquaculture development in Latin America, the Caribbean and some subtropical regions such as the southern part of the People's Republic of China. ICLARM is establishing aquaculture information and training linkages with individuals and institutions in these regions and countries.

The potential for aquaculture in the South Pacific, in particular, is still largely untapped, although new ideas, technologies and changing economic potentials have suggested that a number of new approaches would be worth pursuing, especially in the context of the present lack of income-earning

opportunities in this region. The farming of giant clams is one such idea that has led ICLARM to develop a Coastal Aquaculture Center in the Solomon Islands. Here the viability of various methods of giant clam farming and other innovative approaches will be tested.

ICLARM's aquaculture program activities are therefore expanding beyond their primary focus on Asian aquaculture systems to assist aquaculture development in other regions. This involves the establishment of mutually beneficial information, research and training linkages.

Structure

The aquaculture program is currently in a transitional phase from a fixed term project-by-project structure towards a sustained core program with associated network activities. Current activities are summarized by research theme in Table 1. Further details can be found in ICLARM annual reports. The future structure of the program is depicted in Fig. 8: three separate research units (with associated network activities) and a small core staff at ICLARM's Manila headquarters to coordinate activities, provide scientific leadership for further program development and to maintain a global Network of Tropical Aquaculture Scientists (NTAS). Interregional cooperation is the major feature of all activities such as Africa-Asia cooperation for the genetics and integrated farming themes and Asia-Pacific cooperation in coastal aquaculture. For all elements of the program, contributions to research and training activities are envisaged to include linkages with developed-country institutions and exploratory linkages to other regions.

The three research units are:

1. An Aquaculture Genetics Unit (AGU)
2. An Integrated Farming Unit (IFU)
3. A Coastal Aquaculture Center (CAC)

There are advantages to be gained from having two units (genetics and integrated farming) for freshwater aquaculture research, in addition to the Coastal Aquaculture Center: 1) 'insurance' against loss of important genetic material, by replicating collections between the units and around network institutions; 2) ICLARM's strong interaction with institutions in the two host countries and with their tilapia culture and integrated farming sectors, from which will emerge clear examples of aquaculture development through research, for emulation elsewhere; 3) building upon ICLARM's past cooperative research efforts with institutions in both countries, particularly by siting the units in or adjacent to campuses with appropriate locations, facilities and support services, to reduce establishment and running costs.

The Aquaculture Genetics and Integrated Farming Units will be established in tropical Southeast Asia, probably in the Philippines and Thailand, respectively. The Coastal Aquaculture Center is already under construction in the Solomon Islands. Their associated network activities will link research and training efforts with national and regional institutions.

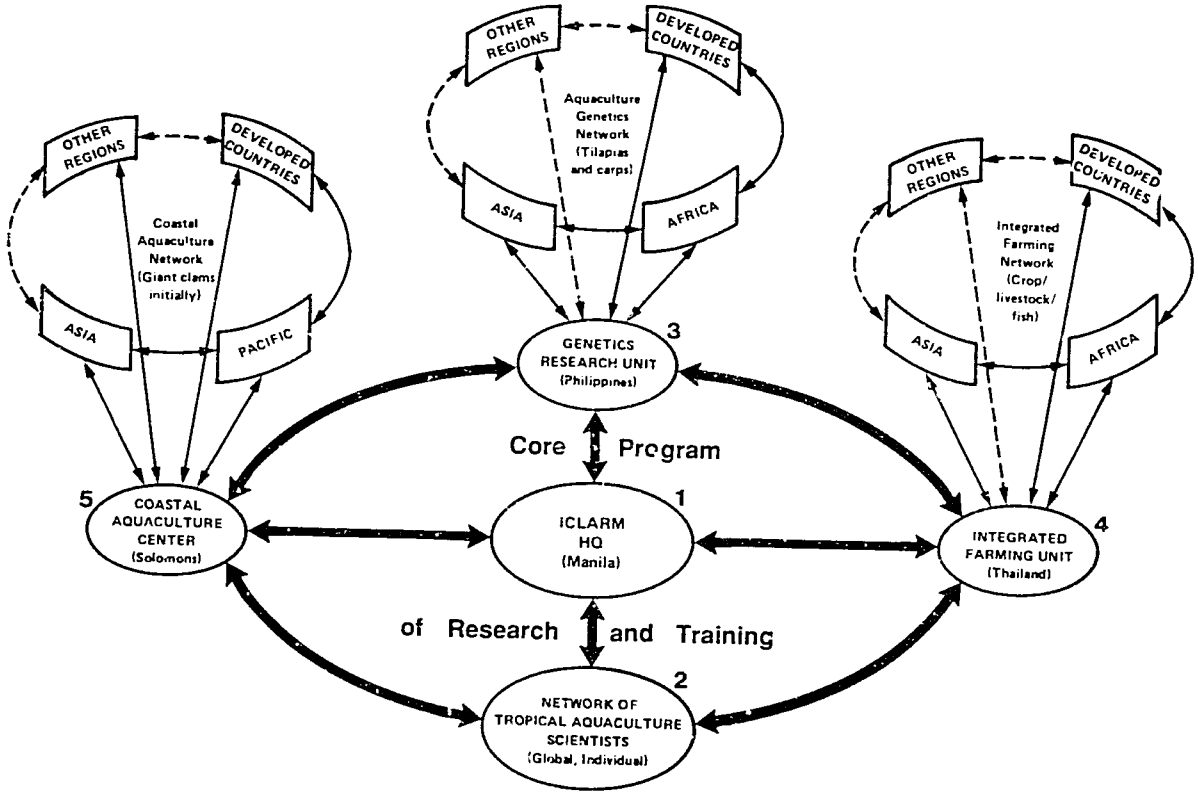


Fig. 8. Diagrammatic representation of the components of ICLARM's Aquaculture Program: 1, ICLARM Headquarters (HQ) (Manila); 2, the Network of Tropical Aquaculture Scientists (NTAS), coordinated by HQ; 3, the Aquaculture Genetics Unit (AGU) (Philippines) and its associated network institutions; 4, the Integrated Farming Unit (IFU) (Thailand) and its associated network institutions; and 5, the Coastal Aquaculture Center (CAC) (Solomons) and its associated network institutions. The broad arrows (⟷) indicate the linkages between the HQ, NTAS, AGU, IFU and CAC that together constitute the Core Program of Research and Training. The narrow arrow (⟷) indicate interregional institutional networks coordinated from the AGU, IFU and CAC. The regions labelled with capital letters are those containing prominent institutions and research groups participating in network activities. Broken arrows (⇠ ⇢) indicate possible linkages to other regions (see text).

Table 1. Structure of ICLARM's Aquaculture Program in 1988—The Program is a collection of projects under the Center's major research themes (G = genetics; I = integrated farming systems; C = coastal aquaculture). Explanations of acronyms are given on the following page.

Project Title	Theme(s)	Cooperating Institution(s)	Duration	Donor(s)
1. Evaluation of Farmed Tilapia Stocks	G	UPMSI; NFFC/ BFAR	1984-on-going	IDRC; RF; ICLARM
2. The Federal Republic of Germany-Israel Fund for Agricultural Research in Third-World Countries: Aquaculture Project				
Subproject 1. Utilization of Tilapia Genetic Resources for Expansion of Aquaculture	G	ARO; HU; IAE	1986-1989	BMZ
Subproject 2. Optimal Management of Aquaculture Pond Systems in Developing Countries	I	ARO; KU; T/IIT	1986-1989	BMZ
3. Research for the Development of Tropical Aquaculture Technology for Implementation in Rural Africa	I	DOFM; UM	1985-1991	GTZ
4. Development of a Research Framework for Integrated Agriculture-Aquaculture Farming Systems	I	UNDP; WB	1986-1988	UNDP
5. Development of Aquaculture and Fisheries Activities for Resettlement of Families from the Saguling and Cirata Reservoirs, West Java, Indonesia	I	IOE/PU; PLN; UPT; WB	1986-1989	WB
6. Technical Assistance for a Reappraisal of and Development and Testing of New Rice-Fish Farming Systems	I	CLSU; IRRI/ ARFSN	1987-1989	ADB
7. Coastal Aquaculture Center	C	GSI; GPG	1986-on-going	APSF; ODA; SF
8. International Giant Clam Mariculture Project	C	CORD; FDWS; JCU; DPIQ; UPNG; SU; UPMSI; MAFF; MNR; TDRI; UNT; MMDC	1983-1988	AIDAB; NZ
9. Network of Tropical Aquaculture Scientists	G;I;C	Individual membership	1987-on-going	ICLARM
10. Technical Assistance for Genetic Improvement of Tilapia Species in Asia	G	BFAR; CLSU; UPMSI	1988-1991	ADB; ICLARM

List of Acronyms for Table 1

ADB — Asian Development Bank
AIDAB — Australian International Development Assistance Bureau
ARFSN — Asian Rice Farming Systems Network
APSF — Australia and Pacific Science Foundation
ARO — Agricultural Research Organization, Israel
BFAR — Bureau of Fisheries and Aquatic Resources, Philippines
BMZ — Bundesminsterium für Wirtschaftliche Zusammenarbeit
CLSU — Central Luzon State University, Philippines
CORD — Center for Oceanological Research and Development, Jakarta, Indonesia
DPIQ — Fisheries Research Branch, Department of Primary Industry, Brisbane, Queensland
DOFM — Department of Fisheries, Malawi
FDWS — Fisheries Division, Western Samoa
GPG — Guadalcanal Provincial Government, Solomon Islands
GSI — Government of Solomon Islands
GTZ — German Agency for Technical Cooperation
HU — University of Hamburg
IAB — Institute of Aquatic Biology, Achimota, Ghana
IDRC — International Development Research Centre, Canada
IOE/PU — Institute of Ecology; Padjadjaran University
IRRI — International Rice Research Institute
JCU — James Cook University of North Queensland, Australia
KU — University of Kiel
MAFF — Fisheries Division, Ministry of Agriculture and Fisheries, Suva, Fiji
MMDC — Micronesian/Mariculture Demonstration Centre, Koror, Republic of Palau
MNR — Fisheries Department, Ministry of Natural Resources, Honiara, Solomon Islands
NFFC — National Freshwater Fisheries Center
NZ — New Zealand, Ministry of Foreign Affairs
ODA — Overseas Development Administration of the United Kingdom
PLN — Indonesia Power and Light Company
RF — Rockefeller Foundation
SF — L.J. and Mary C. Skaggs Foundation, USA
SU — Silliman University, Dumaguete City, Philippines
T/IIT — Technion, Israel Institute of Technology
TDRI — Tropical Development Research Institute, Overseas Development Administration, United Kingdom
UM — University of Malawi
UPMSI — Marine Science Institute, University of the Philippines, Quezon City
UPT — Dinas Perikanan Province and Unit Pelaksaman Technic, Saguling/Cirata
UNDP — United Nations Development Programme
UPNG — University of Papua New Guinea, Port Moresby
UNT — University of Newcastle-upon-Tyne
WB — World Bank

This networking will be vital in ensuring complementarity of the program's activities with national and regional programs. It will also provide opportunities for visiting researchers to participate in program activities. Networking activities will be highly interactive between the three progrm areas shown in Fig. 8, particularly the development of improved tilapia and carp breeds for integrated farming systems. Genetics and integrated farming system research will be combined in some institutions.

The Network of Tropical Aquaculture Scientists (NTAS), which began in early 1988, will function in the same mode as the ICLARM Network of Tropical Fisheries Scientists (NTFS) which links over 800 scientists in 73 countries. It is for individuals not institutions. Because aquaculture is such a large, diverse field of study, membership is confined to research scientists whose major work is in the following ICLARM priority areas:

1. Genetics of finfish cultured in the tropics
2. Tropical integrated agriculture-aquaculture farming systems
3. Coastal aquaculture of tropical molluscs

The main purpose of the NTAS is to link together aquaculture scientists working in the tropics, especially those working in isolation and having difficulty in accessing relevant information. The principal vehicle for communication is a newsletter ("Aquabyte") for exchanges of informal notes, news and views on research. Members are encouraged to write articles on research methods, experimental design, data analysis and interpretation. Information on microcomputer methods and development of software for the chosen research fields are emphasized.

Further details on the three research units and associated network activities follow, discussed according to the various objectives and priorities chosen under ICLARM's aquaculture research themes - genetic improvement and technology for low cost inland and coastal aquaculture systems.

Objectives and Priorities

1. Genetic improvement of cultured fish

a) Objectives

Inadequate attention has been paid to genetic improvement of cultured fish, particularly in third-world countries, most of which lack professional fish geneticists and the facilities to initiate and carry out long-term genetic research programs. This is arguably the greatest hindrance to increasing cultured fish production. Genetic improvement has been a key factor in increasing agricultural production. Genetic improvement of rice and other crops has become a highly developed science producing disease-resistant, adverse soil- and climate-tolerant varieties, while in modern livestock production, breeding programs have given superior performance with respect to survival, growth rate, feed utilization, carcass composition and fecundity. In contrast, tropical aquaculture uses breeds which are nearly all relatively

undomesticated and close to wild types. There is also evidence for the tilapias that genetic deterioration from inbreeding and interbreeding between farmed and wild fish is widespread, especially in Asia, the location of the major tilapia industries.

A common misconception is that it will be many years before fish genetic research can impact on production, but this is not so. For the African tilapias, the documentation of wild and captive genetic resources, their conservation, evaluation and use in simple hybridization and breeding programs could lead to significant yield increases within only a few years. This is possible because tilapias have a generation time of only 4-6 months and can be bred year-round in the tropics. The carps have longer generation times (normally several years) but significant culture performance improvements are also possible for these fish, which are extremely popular in China, Indonesia and the Indian subcontinent. The research methods established for coldwater fishes (for example, the genetic gains achieved in the Norwegian salmon industry) can be applied to tilapias and carps. For tilapias, an improvement of 4-8% per generation can be expected in growth rate, the most important culture performance trait. This research theme is exactly the type of long-term basic research theme that should be tackled by an international center such as ICLARM.

b) Priorities

The first ICLARM priority in this research theme is tilapia, concentrating on the Nile tilapia *(Oreochromis niloticus)* which has wide appeal throughout the tropics. Tilapia culture in tropical and subtropical Asia is very important. For example, 50,000 t/year are cultured in the Philippines, a similar quantity in Taiwan and large but poorly documented amounts in other countries. All the significant Asian tilapia industries depend upon poor genetic resources - the descendants of a few introductions to Asia of a very few fish. Most of these introductions have come by way of Israel and other intermediate nontropical sources. The solution is to bring more diverse tilapia genetic material directly from Africa to Asia and to use it to develop improved breeds for tilapia culture worldwide. This is ICLARM's top priority in its aquaculture program, to be pursued through long-term core program research and linkages with a select group of cooperating institutions.

A similar effort is possible for the carps (common carp, Chinese carps, Indian major carps and some other local carps such as *Puntius* and *Labeo* spp.) but is of second priority for ICLARM because of the lower potential of carps in many locations. Carp genetic resources are found mainly in China, central and eastern Europe and the Indian subcontinent. The indigenous carps of Africa have yet to be screened for culture potential. Carp genetic improvement research is included in the program's networking activities.

THE AQUACULTURE GENETICS UNIT AND NETWORK ACTIVITIES

It is broadly agreed that the site for a coordinated thrust in fish genetics research should be in tropical Asia but at present there are no suitable facilities for the core program envisaged.

Using criteria for selecting sites for an international center, ICLARM is seeking an appropriate site in the Philippines for an Aquaculture Genetics Unit in association with one or more existing institutions, to be constructed when funds permit. It will occupy a 3-4 ha site, having a modest laboratory and hatchery, ponds and tanks and a small scientific and support staff. It will concentrate primarily on tilapia genetic improvement and secondly on training in this field. The unit will receive tilapia founder populations (principally *O. niloticus* collected from its wide geographical range in Africa) and will develop improved breeds. The unit will incorporate a tilapia germplasm collection, duplicated at one or more network institutions, and will be responsible for an international registry of tilapia strains.

Selective breeding research will be done at the unit and in the national institutions participating in the associated network activities. Any genetic gain will be transferred rapidly to the culture industry through supplying information and improved breeds to national research and extension organizations and thence to farmer cooperators. Germplasm and improved breeds will be distributed through the network to member institutions for cooperative research and adaptive field trials, especially in integrated farming systems.

For the tilapias, ICLARM attaches particular importance to developing interregional (Asia-Africa) linkages so that Asian researchers and culturists can access tilapia germplasm to produce improved breeds, while African researchers and culturists can benefit from Asian experience in developing aquaculture systems. The tilapia genetic resources of Africa are a global asset and the need for aquaculture development in Africa is a global concern. ICLARM follows the view of CGIAR centers operating in Africa that there should be a responsible attitude to exchange of germplasm between source and recipient countries to safeguard the interests of both.

ICLARM's plans include the development of network linkages with African national institutions in an international effort to promote the documentation, conservation and wise use of tilapia genetic resources, many of which are threatened by environmental degradation and mixing through poorly controlled fish and water transfers. Conservation of wild habitats, establishment of culture collections (for *native* tilapias in African countries, to avoid contamination of wild stocks) and appropriate exotic species in Asia and cryopreservation of tilapia sperm will all be important components of this effort. Detailed recommendations on all of these aspects have been compiled in the proceedings of an ICLARM workshop on Tilapia Genetic Resources for Aquaculture, 23-24 March 1987, funded by the Federal Republic of Germany. Among the wideranging recommendations agreed by the 37 participants from Africa, Asia and the developed countries was that

ICLARM should lead such international efforts by establishing an international registry of tilapia strains. The initiation of this and indeed the rate of progress in the attainment of all the objectives described above will depend upon obtaining financial support for the proposed program structure, facilities and staffing.

The genetics unit and network activities will link the research efforts of aquaculture geneticists in Asia, Africa, developed-country universities and other regions. Major features of activities will be workshops and training courses and the improvement of research methodologies.

2. Technology for low-cost systems

This second program theme of ICLARM is highly interactive with the genetic improvement theme, because the cultured organism and its culture environment must be studied together. A truly interdisciplinary research approach is required, combining biology, economics and sociology. Related social science work will be conducted in part by the Asian Fisheries Social Science Research Network, which is coordinated by ICLARM (see p. 67 to 77). Here also the focus is on systems appropriate for small farms where the research rationale is guided by issues of income and employment generation and by concerns for equitable distribution of benefits from aquaculture technology. This program theme is subdivided into two components: freshwater and coastal aquaculture.

a) Objectives: freshwater aquaculture

For freshwater aquaculture, the program focus is on the integration of aquaculture with agriculture -- otherwise known as crop-livestock-fish integrated farming. Organic wastes (such as composts, livestock manure and sewage) have been used as fishpond fertilizers for centuries in Asia. They stimulate production of natural aquatic feeds, and therefore reduce or eliminate completely the need for farmers to provide inorganic fertilizers and fish feeds, which are often prohibitively expensive.

Such systems are very productive, profitable and beneficial in terms of cash generation and nutritional improvement for farming households (particularly in the tropics). For example, in an ICLARM cooperative research project in the Philippines, yields of up to 10 tonnes of fish/ha/year were demonstrated from freshwater ponds using livestock manure as the sole input. Backyard ponds (approximately 200 m^2) in Thailand, supplied with farm and household wastes, have yielded an average 175 kg of fish/year, sufficient to supply the entire animal protein needs of a household of five members. The fish used in such systems are tilapias and carps.

However, the scope for improvement in productivity and profitability of such systems and their sustainability has been little studied. Research groups investigating this in the tropics are scattered and lack access to

information, ideas and linkages which could accelerate their progress. In most aspects of systems technology, animal husbandry and farm management, these groups face common problems. Above all, they lack appropriate methodologies to investigate and improve these interactive systems. Moreover, the necessity for an interdisciplinary, 'whole farm' approach, such as is common in farming systems research, is not yet widely appreciated by aquaculture researchers and educators, and in this area ICLARM expects to play a leadership role.

b) Priorities: freshwater aquaculture

The first priority is technology development for viable crop-livestock-fish integrated farming systems in Asia and Africa. The challenge in this area of research is to examine existing farming systems and to develop, through research, technology for the integration of a fish culture subsystem into these farming systems to improve productivity, profitability and human nutrition. First, we must study how to manipulate and optimize systems in Asia and then, after very careful appraisal of African farming systems and their economic and social context, to transfer and adapt promising technology for use in Africa.

The second priority is development of systems models, based on analysis of existing data sets and new experiments which are interactive with the modelling work. Systems modelling, including biotechnical and economic factors, is an important tool for understanding the potential and constraints of integrated farming systems. The priority for ICLARM work in this area is to apply this technique to existing data sets (from African and Asian farms and experimental stations) and then to test/improve models by further experimentation and application.

THE INTEGRATED FARMING UNIT AND NETWORK ACTIVITIES

The development of integrated farming technologies requires a long-term research effort. This is possible only in a dedicated facility which is currently lacking. ICLARM is planning such a facility, an Integrated Farming Unit, in tropical Southeast Asia, in cooperation with institutions experienced in this field, principally the Asian Institute of Technology (AIT), Bangkok, Thailand; a well-established, independent, nongovernmental, regional institution with its aquaculture research and education (M.Sc.) program focused on crop-livestock-fish farming.

An Integrated Farming Unit facility is envisaged similar in size to the Aquaculture Genetics Unit previously described. It will require experimental ponds and plots, tanks, animal houses, laboratory facilities and a scientific and support staff to complement existing facilities. It will lead associated network activities with selected institutions, principally in Africa and Asia,

with linkages to a select number of universities in developed countries and other regions. The research program will focus on how to integrate a fish subsystem into existing Asian and African farming systems, for the benefit of small-scale producers. Rice-based and maize-based systems will be investigated through the network, the former in Asia and latter in Africa, facilitated by ICLARM's linkages with aquaculture institutions and development of new linkages with other groups -- principally the relevant International Agricultural Research Centers of the CGIAR system, universities, FAO/UNDP projects and other development initiatives.

The Integrated Farming Unit and network institutions will pursue in-depth research on subsystem interactions in crop-livestock-fish systems, including biological, technical, economic and sociological constraints to their implementation by small-scale farmers. Investigation of cost-effective inputs (agricultural by-products) to fishponds and methods for maximizing productivity and profitability by manipulation of terrestrial and aquatic food chains will be carried out. Adaptive field trials will be undertaken by participating network institutions and by farmer cooperators.

ICLARM's cooperative project with the Government and University of Malawi, entitled Research for the Development of Tropical Aquaculture Technology for Implementation in Rural Africa, which commenced in 1985, has funding from the German Agency for Technical Cooperation (GTZ) up to 1991 and concentrates on integrated farming research and development issues in Africa. Through the project, with leadership from ICLARM HQ and linkages with other African and Asian institutions, researchers will study the biological and social aspects of implementing viable crop-livestock-fish integrated farming in rural Africa. The research and training activities have a broad scope from socioeconomic surveys to critical research on the use of agricultural by-products as fish feeds and pond fertilizers.

c) Objectives: coastal aquaculture

Bivalve molluscs are amongst the most attractive organisms for coastal aquaculture because, with the exception of a few hatchery operations, they require no artificial feeding. They also offer considerable potential to generate income for displaced coastal fishermen seeking alternative activities. ICLARM has focused on the bivalve molluscs in cooperative research and training on coastal bivalve culture in Southeast Asia. The Center's program now focuses primarily on culture of the largest bivalves, giant clams, in a long-term project embracing selected countries in Southeast Asia and the South Pacific.

This focus arose from recognition of the technical feasibility of nonintensive giant clam culture in coral reef environments in the Indo-Pacific region. Giant clams are phototrophic, like plants, and therefore the world's only self-feeding potential farm animals. Stocks of the two largest species have been seriously depleted throughout the Indo-Pacific region and in some cases extinguished by intensive harvesting and poaching by foreign fishing

vessels; the latter because of extremely high prices paid in Asia for the large muscle which closes the shells. This overexploitation of natural stocks suggests that giant clam culture for local food production and export could have major potential in the tropical Indo-Pacific. It appears to offer islanders in relatively remote areas the possibility of export earnings and local food supplementation from an activity which is in harmony with traditional lifestyles.

The need for an experimental giant clam hatchery in a representative equatorial Indo-Pacific environment was identified early in ICLARM's planning process. Such a facility would provide an assured output of seed at known cost and be the basis for nursery and growout systems in various habitats and locations. It would also provide the opportunity for developing a selective breeding program for giant clams and for further studies of many other aspects of giant clam culture. The logical site for such a hatchery was the South Pacific where there is a general lack of income-earning opportunities and where giant clams are important food items as well as highly exportable commodities.

Since construction of a hatchery would provide facilities which could be used for other aquaculture purposes, a more general facility was proposed, where a variety of new techniques and approaches could be investigated towards development of several viable coastal aquaculture opportunities. After exploring several alternatives, ICLARM in 1987 began to construct this Coastal Aquaculture Center in the Solomon Islands, at the invitation of the government.

COASTAL AQUACULTURE CENTER AND NETWORK ACTIVITIES

The overall objective in the development and operation of the Coastal Aquaculture Center is to develop economically viable aquaculture systems which will be of significance to the economies of Pacific island nations in particular and to tropical coastal areas in general.

The chosen site was the Solomon Islands. In addition to being one of the few countries in the region with good stocks of all species of tridacnid clams, the Solomon Islands offer a great diversity of sites and habitats for coastal aquaculture undertakings, ranging from deep fjords to atolls and from coastal shelves to immense lagoon systems.

In the context of giant clam culture these habitats offer the opportunity of testing and developing a wide variety of nursery and growout systems, all supplied from a centrally located hatchery. By virtue of its location in the central western Pacific the hatchery is also strategically located to supply seed clams in the future to other undertakings in the region, subject of course, to proper and rigorous quarantine precautions.

ICLARM is currently establishing the Coastal Aquaculture Center on a 4.8-ha site on Guadalcanal Island, near Honiara, the national capital. A Giant Clam Hatchery is the first facility to be developed at the Center and is

a collaborative undertaking by ICLARM and the Division of Fisheries, Government of Solomon Islands, with the cooperation of the Guadalcanal Provincial Government. This activity follows a three-year collaborative project with James Cook University, Townsville, Australia, during which a network of cooperating institutions was established under the International Giant Clam Mariculture Project (see Table 1). The network is managed by ICLARM.

By the end of 1987, the Coastal Aquaculture Center comprised a laboratory/hatchery building; staff housing; four chalets for visiting scientists and research assistants; broodstock, nursery and settlement tanks; and freshwater and seawater pumping equipment. With the Center operational, networking activities will be enlarged. This will concentrate on giant clams initially, but will also incorporate research and development on other molluscs and promising coastal aquaculture systems of relevance to tropical countries.

Within the Pacific region, there have been few successful aquaculture enterprises. Attempts over the past three decades at oyster, mussel, milkfish, tilapia, and rabbit fish culture have all failed. More recently, however, cultivation of the seaweed, *Eucheuma* sp. has been successful and penaeid prawns are now farmed by various corporate ventures in scattered locations. Owing in substantial part to ICLARM initiatives, the potential of giant clam culture has now been recognized and there is intense interest in this topic throughout the region. However, other aquaculture possibilities have never been seriously addressed, in some cases because the appropriate technologies and methods have only recently been developed; in others because the economic potentials have not been recognized. A third aspect is that relative costs of high-quality seafoods have increased in recent years, leading to improvements in the potential profitability of a variety of aquaculture ventures.

Finally, there has never been a permanent regional facility for aquaculture in the South Pacific region and much of the failures of the past in this field can be traced to the transient nature of projects and the inappropriate advice of many short-term consultants.

d) Priorities: coastal aquaculture

The prime focus of the Coastal Aquaculture Center for the foreseeable future will be on the culture of giant clams. While a satisfactory initial scientific basis has now been laid for giant clam culture, there are still many topics which need to be investigated before there is an adequate understanding of most aspects of the subject. Of high priority are further studies of the basic ecology and biology of giant clams, management of fisheries for giant clams (including studies of the feasibility of supplementing natural stocks with hatchery-reared seed clams) and the development of cost-effective hatchery and nursery systems. Much more work is needed on reproductive condition and seasonality and spawning induction in

broodstock. Knowledge of the genetic characteristics of giant clams is minimal. Improvements in hatchery and nursery methodology are possible and will have a strong bearing on the economics of giant clam culture. Aspects of the growout systems include practical considerations in addition to investigations of social and legal aspects of clam nurseries and farms.

Studies of the economics of giant clam culture and product development will be of particular importance in the planned programs. Other areas with strong possibilities for fruitful research -- some of which ICLARM will investigate over the coming five-year period with a view to planning research -- include: culture of other molluscs with good commercial potential; ranching and culture of reef fish species; culture of marine algae of commercial importance, especially *Eucheuma;* and prospects for mass collection of valuable fish and crustacean seed supplies for later culture. There will be network linkages and cooperative activities in all these work areas. The Coastal Aquaculture Center is expected to become a regional source of information, training and research supervision for higher degrees in aquaculture. The degrees themselves would be offered by a regional university, such as the University of South Pacific which has its main campus in Fiji and outreach activities throughout the region.

Program Development

The Aquaculture Program structure, depicted in Fig. 8 (p. 33), will take at least five years to complete and will depend upon available funding. During the next five years, most if not all of the current program activities listed in Table 1 (p. 34-35) will become parts of the core program and network activities. Table 2 describes the likely development of the program. The network activities in Aquaculture Genetics, Integrated Farming and Coastal Aquaculture will be established without waiting for the completion of construction of the respective research units. Rather, these activities will be established by building on the program's existing linkages and projects; with Philippine institutions to receive and begin initial evaluation of the first importations of new tilapia genetic material from Africa; with AIT and African and Asian research groups for development of integrated farming research methods and with institutions already participating in giant clam research. The NTAS became operational in early 1988.

The construction and staffing of the research units will depend upon the progress of negotiations with cooperating institutions and donors. Construction of the Coastal Aquaculture Center is almost complete and broodstock giant clams have already arrived. In broad terms, it is intended that the first harvests of cultured giant clams will be test marketed in 1992 (possibly earlier if putative markets for scallop-sized clams materialize). By that time a substantial array of potential products will have been developed, selected village groups in the Solomon Islands will be maintaining ocean nurseries and growout systems, the hatchery will be producing 750,000 one-year old clams per year and progress will have been made on major topics

Table 2. Approximate timeframe for the future development of ICLARM's Aquaculture Program.

Program Component/Activity	1988	1989	1990	1991	1992	1993
A. Manila Headquarters (HQ)						
1. Acquisition of additional facilities and staff	⊢———	———	———			
2. In-house research, training and information activities	⊢———	———	———	———	———	———
3. Organization of conferences and workshops	⊢———	———	———	———	———	———
4. Coordination and organization of reporting, reviews and other publications	⊢———	———	———	———	———	———
5. Organization of activities of the Network of Tropical Aquaculture Scientists; publication of 'Aquabyte'	⊢———	———	———	———	———	———
6. Advisory services	⊢———	———	———	———	———	———
B. Aquaculture Genetics Unit (AGU) and Aquaculture Genetics Network Activities						
1. Planning/siting/agreements/securing funding for AGU	⊢———	———				
2. AGU construction and staffing/initial germplasm collection		⊢———	———			
3. AGU tilapia breeding programs start			⊢———			
4. Establishment of network activities; initial coordination from HQ		⊢———	———	———	———	———
5. Network cooperative research and training: tilapias and carps		⊢———	———	———	———	———
6. AGU fully operational				⊢———	———	———
C. Integrated Farming Unit (IFU) and Integrated Farming Network Activities						
1. Planning/siting/agreements/securing funding for IFU	⊢———	———				
2. IFU construction and staffing		⊢———	———			
3. IFU research program starts			⊢———			
4. Establishment of network activities; initial coordination from HQ		⊢———	———	———	———	———
5. Network cooperative research and training: crop-livestock-fish farming		⊢———	———	———	———	———
6. IFU fully operational				⊢———	———	———
D. Coastal Aquaculture Center (CAC) and Coastal Aquaculture Network Activities						
1. Establishment of network activities; coordination from CAC	⊢———	———				
2. CAC cooperative research and training: coastal aquaculture, focus on giant clams	⊢———	———	———	———	———	———
3. CAC fully operational		⊢———	———	———	———	———

relating to genetics, selective breeding, pathology and cultivation systems. A good understanding of the economics of giant clam culture should then be available. At the end of the fifth year (1992), giant clam culture is expected to be recognized as a new industry in the South Pacific region.

ICLARM hopes for rapid recognition by donors of the importance and likely impact of the proposed genetics and integrated farming units and their proposed network activities, so that similar rapid progress can be made. It should be mentioned here that the most likely components of the program to be supported by any future involvement in aquaculture research of the Consultative Group on International Agricultural Research (CGIAR) are those devoted to inland aquaculture; that is, those on genetics and integrated farming.

A summary budget for the Program for 1988-1992 is included in the complementary document, ICLARM Five-Year Plan, Part 2. Projected Budgets.

RESOURCE ASSESSMENT AND MANAGEMENT PROGRAM

Rationale

Fresh water and table salt are the only products consumed by people which are not derived from the earth's biosphere. All other things that we drink and eat were either parts of plants or of animals which themselves directly or indirectly relied on plants. A similar situation exists for textiles and paper, essential elements of our material well-being and of our literacy, respectively, and for the various compounds that form the basis of the pharmaceutical industries. Thus, whether we live in countries that are industrialized or not, developed or not, we still depend totally, to meet our bodily and cultural needs, on photosynthetic processes and biological production.

This undisputable fact, one may think, should be reason enough for a major part of human activities and material research to be directed, worldwide, toward the management and improvement of the earth's productive capacity - especially in view of the rapid increases of the world's population. However, one does not need to be an alarmist to note that it is precisely the opposite which is happening. Worldwide, and particularly in tropical third-world countries, where population growth is most rapid, the very basis of the earth's biological production is being gradually and quite literally eroded away.

The major causes for this degradation, as far as terrestrial habitats are concerned, are large-scale monoculture, the resulting losses and/or impoverishment of top soil, overgrazing of rangeland and other marginal habitats, and deforestation and the resulting erosion. All of these processes, directly or indirectly affect aquatic habitats and their biotic production, the areas of concern of ICLARM's Resource Assessment and Management Program.

The open-access nature of most aquatic resources and their increasing overexploitation, particularly in the last decades, has turned much of the debate between conservationists and resource managers over rates of use into a sterile exercise. The point here is that "tapping of aquatic resources" is usually followed by a rapid, totally uncontrolled expansion of "harvesters", leading to overexploitation and overcapitalization of the fisheries, past any rationally definable optimum.

This situation is documentable for the majority of fisheries throughout the world, tropical and otherwise, as well as for mangrove coastal zone areas. The prevention of further environmental degradation, the rehabilitation of productive systems and habitats and the rebuilding of exploited resources and animal populations are commonly shared goals for these systems. The

task for ICLARM and its cooperators is how research, and associated training and information activities, can contribute to progress in the right direction.

Most fisheries of the world, whether temperate or tropical, inshore or offshore, small-scale or commercial, may be described as "overcapitalized": there are too many fishermen and too many boats chasing too few fishes. However, politicians are often unable to acknowledge constraints resulting from resource limitations, and usually comply with the demands of the most vociferous segments of the fishing industry. This usually prevents long-term solutions to the overexploitation problem; rather, "quick fix" solutions, such as further subsidies and/or inconsequential legislation are implemented. Indeed, it is still rare for the overfishing problem to be generally recognized in tropical countries; more often views of "limitless" resources are maintained even in the face of declining annual national catches and scientific evidence to the contrary.

The widespread failure to address economic and social conflicts within the fishing industry, and even to organize fishing to provide a stable supply of fish, most often stems from the failure to fully understand the consequences of three interacting features of fisheries:

- *fisheries resources although often bountiful, are always finite;* they do not respond, past a certain level, to further increase of fishing effort by a corresponding increase in yield;
- *entry into fishing is usually open, with the fish belonging to whomever catches them*; fishery resources are "common property" and fishing, unlike farming, is an "open-access" activity;
- *demand for fish, for positive economic returns on boats and other capital investments and (in most third-world countries at least) for jobs in the fishing sector are steadily increasing;* if left on its own, this demand will always produce levels of fishing effort far beyond that needed to exploit a stock optimally.

These three features are the essential reasons why, for example, the North Atlantic fisheries are overexploited and overcapitalized, with about US$1,000 million of potential resource rent dissipated annually. In Southeast Asia, they are the cause for declining catch and fishermen incomes in such countries as Thailand and the Philippines. The above-mentioned key features of fisheries are also the cause for recurring, often violent, conflicts between fishermen. For example, conflicts between Indonesian small-scale fishermen and trawl operators became so intense that the government in 1981 banned trawling in Indonesian waters altogether.

Recent interdisciplinary studies conducted in various parts of the world strongly support the suggestion that small-scale fisheries throughout most of the third world are economically more efficient than large-scale fisheries, besides usually exploiting resources in a way that guarantees their renewal. However, insufficient comprehensive interdisciplinary research has been carried out on small-scale fisheries. For example, a number of comprehensive studies exist on the (large-scale) demersal trawl fisheries of Thailand and the

(large-scale) fishery for Peruvian anchovies, both by local (Thai and Peruvian) and by foreign researchers, but few exist on the small-scale sector of these two countries, although they employ far more people (in the case of Thailand) or provide the bulk of the fish for human consumption (in the case of Peru).

There are a number of obvious sociological and other reasons why research on small-scale fisheries is usually neglected. One of them is the simple fact that it is usually far more difficult to study small-scale than commercial fishermen. In the tropics, small-scale fishermen, operating a variety of gears which often change between seasons and are often modified as new construction materials become available, usually land their catches at the most unpredictable hours (to nonfishermen at least!), in faraway, inacessible places. Catches may in part be earmarked for consumption by their own families, with the rest sold in small batches to processors or middlemen with whom the fishermen are linked through complex ties of mutual dependence.

Obtaining reliable estimates of total catch, its composition and of other important statistics in these fisheries therefore is extremely difficult. Yet, making appropriate decisions concerning allocation of total available catches amongst small-scale and commercial fisheries, especially when they compete, requires that such data be available and analyzed.

The gathering and analysis of catch and biological data for use in managing fisheries, including that required for the more straight-forward practice of stock assessment, is necessary because it is only through analysis of the performance of a fishery, of its catches and their trends that rational decisions can be taken. For example, when analyzed such data, coupled with data on fleet economic performance, can help determine whether fleet expansion should be encouraged (the rarer case), or discouraged, or whether attention should be given to the development and deployment of new gears or to gear restrictions. One important role for an international center such as ICLARM, devoted to research to improve decisionmaking, should thus be to reduce the costs involved in routine stock assessment, and to make such assessments feasible where previously, as in the case of tropical small-scale fisheries, they were thought to be impractical. This involves concentrating on the development of appropriate methodologies, the area to which ICLARM has devoted its stock assessment research in the last decade.

Fisheries economics research, long seen by many as only complementary to management schemes that were structured around the biology of fish stocks, is also extremely important in tropical fisheries, since fisheries economists, rather than fisheries biologists, are the ones most qualified to assess and compare the direct and indirect costs and benefits of various management schemes. In small-scale fisheries, economists also can help by quantifying the costs and benefits of alternative employment schemes (including aquaculture), evaluating management options, and assessing the indirect costs incurred by developing economies when large segments of their population are kept outside the mainstream of society. Here again, methodologies need to be developed, tested, modified and disseminated.

Another important area, where resource economics can usefully intervene as far as fisheries in third-world countries are concerned, is the marketing aspect. Examples of relevant issues here are the cost/benefits of production for export *vs* domestic consumption, the competition of developed *vs* third-world countries on the international fish markets and related issues. Finally, the analysis of resource economics increasingly will be needed to help formulate strategy and tactics of negotiations involving access by foreign nations to their exclusive economic zones (EEZ), as regulated by the new Law of the Sea.

Active programs of management of living aquatic resources in third-world countries are only now being considered by governments because seemingly irreparable damage to coastal ecosystems, of which such resources are a part, is occurring at an alarming rate. Traditional resource management measures by coastal communities in conserving their resources/ecosystems have been abandoned as a result of economic, political and population pressures, especially since World War II, and can no longer be counted upon to assure these resources are available for future generations. New approaches are desperately needed.

Existing management schemes in most nations, including those for fisheries, are unisectoral in approach and mainly directed towards conservation of the resources through various laws and regulations governing their use. However, these laws and regulations in most cases have not been effectively implemented or enforced and illegal exploitation, such as the use of explosives and destructive gears for fish and coralline resources, continues unabated. In fact, it is extremely difficult to find a good example among third-world countries of living aquatic resources that are effectively and scientifically managed.

The complexity and diversity in coastal resource use in the tropics call for integrated coastal resources management strategies involving various relevant economic sectors, the regulation of which requires the understanding and support of those affected. Despite their frequent inability to make hard decisions towards resource management, most governments today have become more aware recently of the need for rational, sustainable utilization of their nation's living resources. The problem is that these policymakers are confronted with national economic development priorities that may conflict with long-term resource management, and the absence of or insufficient relevant databases for policy decisions and management options.

One good example of this problem is the large-scale development of mangrove swamps for fish and shrimp ponds. While ecologists have strongly voiced the need to conserve mangrove swamps to help sustain the nursery grounds of certain species of shrimp and fish, they have failed to provide substantiated quantitative data on the potential loss of shrimp or fish stocks in the inshore waters, and of other relevant activities such as nipa palm production, if the mangroves were cut. Consequently, voices in favor of longer-term management have been drowned out by those favoring short-term expediency; the race to develop coastal shrimp farms thus continues

unabated. This is not to mention potential future market constraints for all the shrimp hat will be produced.

The fact mentioned earlier that $1,000 million per year of potential resource rent is dissipated by overfishing the North Atlantic, means that forces other than biological and economic considerations (in the fisheries sector at least) are influencing the policymakers involved. The challenge facing those who would seek to recover the lost rent in this and many other fisheries is to formulate alternative management plans that take into consideration the many other factors involved, and that account for those factors quantitatively.

Sound management of aquatic living resources should be based on scientific databases containing basic resource information which is analyzed and synthesized for formulating management strategies. It is essential, if the management plan is to be workable, to adopt a holistic, integrated approach in resource management plan formulation. This approach must also be interdisciplinary in perspective. Not only regulatory measures are needed to form the basis for environment protection and resource conservation; possible enhancement measures, such as artificial reefs, that potentially rehabilitate resources and restore the environment should receive equal attention.

ICLARM's activities in this field include a decade of development of appropriate methodologies for the assessment of tropical, multispecies fisheries stocks, as well as a number of economic and sociological studies, which continue to contribute significantly to management approaches for multispecies fisheries. The recent embarkation on a four-year ASEAN/US Coastal Resources Management Project executed by ICLARM and national groups in the six ASEAN nations is providing further opportunities to broaden the focus of the Center's program and acquire expertise in the development of methodologies for integrated coastal resources management planning.

Focus

While ICLARM's mandate, as its name implies, covers the management of living aquatic resources, it is certainly logical and essential now to establish linkages with land-based activities that have an impact upon the nearshore aquatic environment. ICLARM needs to be certain, however, that its activities do not extend too far from the Center's aquatic mandate, and moreover that the Center's efforts remain primarily in the arena of research and methodology development. As in the Center's Aquaculture Program, activities of the Resource Assessment and Management Program are expected to become more refined and interdisciplinary during the coming Five-Year Plan period (Fig. 9).

ICLARM's mandate is to devote the bulk of its resource assessment and management attention to problems of small-scale fisheries. It is not possible to view small-scale fisheries in isolation, however, from other users of the same resources. The degree of competition between small-scale fishermen

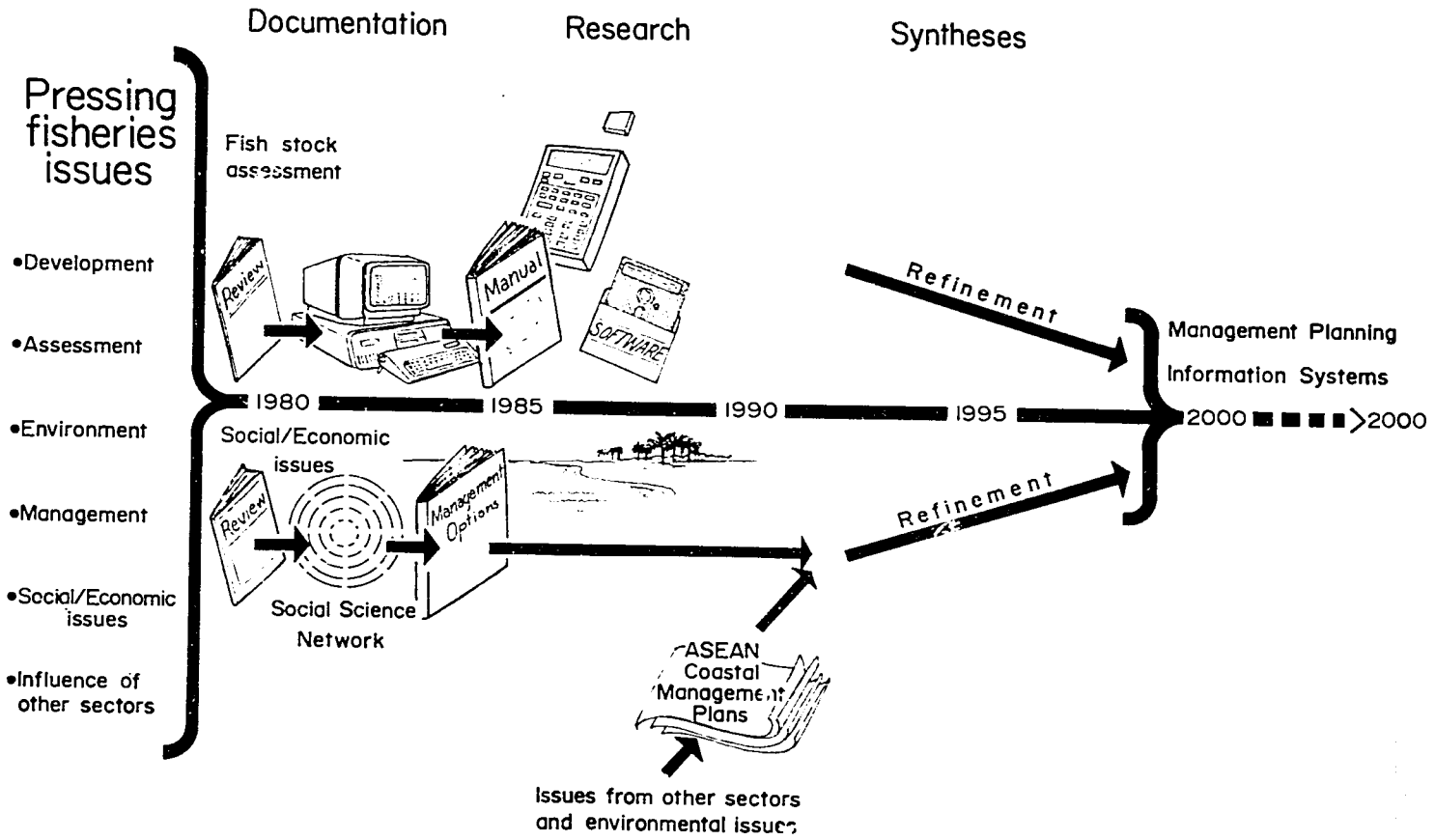


Fig. 9. ICLARM's selection of research topics from the array of pressing issues in the late 1970s. Assessment of stocks and social/economic issues were first addressed. Later, the ASEAN/US Coastal Resources Management Project brought environmental issues into focus and future plans are the integration of these interrelated activities into Planning Information Systems directly usable by resource managers.

and larger vessels has increased dramatically during the past few decades, not only for shared stocks but also in terms of market competition. For example, ICLARM's research program has expanded in recent years to include analysis of the Peruvian anchoveta fishery, the world's largest in good years, which contains both large-scale and small-scale components. Planned work in the Gulf of Mexico in cooperation with Mexican institutions will examine by-catch disposition because here too competition for these species exists between small- and larger-scale vessels. In many Asian locations, competition has become unresolved open conflict because effective management institutions have not developed.

It is one thing to demonstrate the existence of overfishing and competition between various vessel types both small and large; ICLARM and its research partners have done this effectively for the past decade. It is quite another task to conduct research on management institutions and plans that will be effective in resolving overfishing and problems of conflict. Yet this is clearly the direction in which ICLARM's Resource Assessment and Management Program must move in the coming decade.

One of the reasons that aquatic resource management is not routine is that the means to integrate synoptically and analyze diverse kinds of biological, socioeconomic and environmental data have been lacking. There is a need to develop an approach or system which can be used to provide information for aquatic/land resource planning and management for whole countries, regions or for smaller ecological units; that is, a "what if?" system for planners. This approach would take ICLARM a step beyond documenting the need for fisheries management, for example, which it has been doing with some success over the past decade to addressing with its national partners questions of alternative management approaches.

The means to facilitate at least preliminary evaluations of this nature are available: specialized computer software which enable storage, manipulation and analysis of large quantities of data of diverse kinds having a common geographical base. These are known as Geographical Information Systems (GIS) which provide automatic reporting in the form of tabular data, graphics and, more significantly, geographical coordinate maps. These systems have been widely used for land resource assessment as well as storing of countrywide resource and environmental inventories.

The use of GIS has recently been extended to aquaculture planning and now needs to be adapted for living aquatic resource planning and management. ICLARM proposes to initiate the development of a broad information system linking aquatic and land-based activities for comprehensive resource planning and management. Such an information system would build upon GIS methods for storage of resource data, in association with environment and social science information that can be retrieved and analyzed for a particular ecological unit or geographical location. The system would include the use of advanced scientific technology for resource assessment (e.g., application of remote sensing) to strengthen and expedite the collection of living aquatic resource data. The system would also attempt in the future to ascribe economic values to each resource and

information on environmental impacts pertaining to their utilization as caused by economic development.

ICLARM, with its long and successful track record of research in stock assessment methodology and application, social science issues and research methodology, and aquaculture, together with new activities in information research and coastal zone management, is uniquely placed to spearhead development of such a system for third-world countries.

The current implementation by ICLARM and cooperating institutions of coastal zone research and fisheries management activities provides the Center the opportunity to consolidate its existing research programs and to focus more on management research with respect to living aquatic resources. At this stage the precise role of ICLARM in developing the proposed information system cannot be definitely projected. Workshops with invited scientists in various relevant fields are needed at an early date to help ICLARM identify its future role in aquatic resource management beyond the current parallel, but separate activities in resource assessment, economics of small-scale fisheries, and coastal zone management.

Objectives and Priorities

A number of activities based on the issues reviewed above are ongoing or planned. Table 3 provides details of the current areas of focus. Further details of ongoing activities can be found in the ICLARM Report 1986. Several new activities are proposed:

- Development and implementation of multispecies models as tools for integrating knowledge on fisheries resources systems
- Development of an interactive database on tropical fisheries resource management
- Economics as if people mattered and application to the management of small-scale fisheries
- Coastal zone management planning
- A review of the future of tropical aquatic resources
- Aquatic Resources Planning and Management Systems

ICLARM's current research in this field (Table 3) has followed the major theme of "management-oriented research" to draw attention to the present gap between research and management discussed above.

An additional objective of the Program has been to promote increased confidence and self-dependence amongst scientists who are nationals of third-world countries. The principal vehicle for achieving this objective is the international Network of Tropical Fisheries Scientists (NTFS) and complementary training activities. The network now serves as a major vehicle for communication among over 800 members in 73 countries, primarily through the network's newsletter *Fishbyte*. ICLARM also serves as a major source of information, reprints and database searches for NTFS members. Training programs in stock assessment techniques have been promoted in a variety of ways including short courses and longer-term in-

Table 3. Summary of the current activities of ICLARM's Resource Assessment and Management Program with the following program themes identified: (CBSAM = Computer-Based Stock Assessment Methodologies; ID = Information Dissemination; IDMA = Inter-Disciplinary Management Approach; TMD = Training and Manpower Development; and PI = Project Implementation).

Project Title	Theme(s)	Cooperating Institutions	Duration	Donor(s)
(Ongoing)				
A. Tropical Fish Stock Assessment Project	CBSAM	in-house research with informal linkages with various institutions	continuous from 1979	core
B. Network of Tropical Fisheries Scientists (NTFS)	CBSAM/ID	individual membership; libraries of various institutions are recipients of newsletter	continuous from 1982	FAO; DANIDA; NORAD
C. Management-Oriented Fisheries Research Project	CBSAM/TMD	UNAM; Dept. of Fisheries, Brunei	1988-1989 (planned)	to be identified
D. ASEAN-Coastal Resources Management	IDMA/TMD/ID	BRUNEI-Dept. of Fisheries; INDONESIA--Indonesian Inst. of Science; Directorate General of Fisheries, Center for Oceanological Research & Development; Univ. of Indonesia; Bogor Univ. of Agriculture; Research Institute for Marine Fisheries; MALAYSIA--Ministry of Science Technology and Environment; Fisheries Department; Univ. Kebangsaan Malaysia; Univ. of Kalaya; Forest Research Institute; Univ. Pertanian Malaysia; PHILIPPINES--Natl. Science & Tech. Authority; Phil. Council for Agr. Res. & Dev. (PCARRD); Univ. of the Phil.; Marine Science Inst./Inst. of Social Work & Community Devt./Univ. of the Phil. in the Visayas; BFAR; SINGAPORE--Science Council of Singapore; Natl. Univ. of Singapore; Primary Prodn Dept.; THAILAND--Office of the National Environment Board, Ministry of Science, Tech. and Energy; Tourism Authority; Fisheries Dept.; Forestry Dept.; Land Development Dept.; Kasetsart Univ.; Chulalongkorn Univ.; Mahidol Univ.; Mineral Resources Dept.; Thailand Development Research Institute	1986-1989 (Phase 1)	USAID
E. Management Options for Small-Scale Fisheries	IDMA/TMD	Bay of Bengal Programme; Ford Foundation; Food and Agricultural Organization (FAO); Ministry Fish. & Livestock, Bangladesh and others	1986-1990	Ford Foundation

Project Title	Theme(s)	Cooperating Institutions	Duration	Donor(s)
F. Assessment and Mgmt. of Small Pelagic Stocks in the Philippines	IDMA	BFAR	1986-1988	World Bank
G. ICLARM Software Project Compleat ELEFAN	CBSAM/ID	in-house research with informal linkages with various institutions	continuous from 1987	core
(Proposed) H. Multispecies Modelling	CBSAM	in-house research with informal linkages with various institutions– [IMARPE, Peru; UNAM, Mexico; ASEAN-USAID-CRMP institutions]	1988-1992	to be identified
I. Interactive Database for Tropical Fisheries Resource Management	ID	to be complemented by members of NTFS; possibly FAO, UNESCO/IOC	1988-1992	initially to be core-funded after which donors will be identified
J. A Review of the Future of Tropical Aquatic Living Resources	ID	a compendium of studies to be produced by all ICLARM Staff w/ external contributions from other scientists	1988-1990	initially to be core-funded after which donors will be identified
K. Socio-Economic Studies on Policy Making	IDMA/PI	same as (E) plus others to be identified	(pending)	to be identified
J. Integrated Training Courses in Aquatic Resources Management	IDMA/PI	same as (D) plus others to be identified	(pending)	to be identified

Further details on these activities can be found in the ICLARM Report 1986: Tenth Anniversary.

house work experience programs at ICLARM in Manila for individual scientists with more experience.

The activities proposed over the next five years and beyond follow the same basic theme of management-oriented research with an interdisciplinary flavor, but will lead to a more coordinated and interdisciplinary approach to this field. Details follow.

Development and implementation of multispecies models

The fisheries resources exploited in tropical third-world countries are usually *multispecific,* and may include several dozens, or even hundreds of species. Such multispecies systems usually consist of a large biomass of small prey species (which may include valuable shrimp) and a smaller biomass of larger predators. These systems are commonly analyzed on a per species basis, and usually treated in assessment as if consisting of a single species. Improved models which do not require large amounts of biological parameters have recently become available and need to be further modified and more widely disseminated.

It is proposed to implement such cost-effective models in various locations over the next five years; selection criteria are:

- availability of research group(s) interested in a joint activity with ICLARM on this topic;
- availability of suitable data sets.

Sites under active consideration with potential cooperating organizations include the Peruvian upwelling ecosystem, the Southern Gulf of Mexico and various areas in Southeast Asia (e.g., Southern Samar Sea, Philippines, Brunei Shelf, western Indonesian waters).

These research activities would complement three international research programs of major interest to the global scientific community and presently implemented within the "Ocean Science in Relation to Living Resources" program of IOC/FAO. These three programs are the Tropical Demersal Recruitment Program, the International Shrimp Recruitment Program and the Sardine/Anchovy Recruitment Program.

The research effort itself, to be completed within a period of five years, would be conducted by a small group of ICLARM scientists within the Resource Assessment and Management Program, working in close cooperation with national groups.

Interactive database on tropical fisheries resources management

The information gap discussed above in conjunction with tropical fisheries probably cannot be bridged using classical means, such as maintaining extensive libraries, encouraging interlibrary loans and electronic

data exchange. Rather, it can be expected that shortage of funds for such classical activities will become increasingly problematical, and hence increase the isolation of scientists working on tropical resources from the mainstream of their science and from reference materials.

The ICLARM Program proposes to alleviate this problem by developing a self-sufficient database implemented on standard microcomputers (and at first limited to tropical capture fisheries) which would provide key facts and information extracted from the literature. It would largely replace stock assessment text books. The database would constitute an "expert system" (an artificial intelligence type information system in which commands or queries can be made in simple English).

These facts and information will include species identification keys, morphometric data, a summary of growth and mortality information for each species and a summary of biological data on each species. Initially, data on about 200 major species will be provided on diskettes, with the ultimate goal of covering 2,500 species.

ICLARM's main partners in this venture will be the 800 members of the Network of Tropical Fisheries Scientists, whose data and information needs in the initial phase of this project will provide the orientation for the form and contents of the database. A larger audience will be approached eventually, and this might involve cooperation with other organizations, such as FAO and/or UNESCO/IOC.

Economics as if people mattered and its application to the management of small-scale fisheries

At successive levels of effort, resources abundance as well as genetic and faunal diversity are very much reduced. System oscillations and major ecosystem changes are reduced also and these may lead to extinction of local fish populations or of endemic species. Thus, numerous species of large rays have totally disappeared from overexploited trawling grounds in Southeast Asia, as they have from the Irish Sea. Furthermore at this stage, fishermen, at least in most third-world countries, will be driven by their need for daily subsistence to destructive fishing practices, such as use of dynamite and poison and in the process destroy the very system upon which their long-term survival relies. When desperate, poverty-stricken fishermen pour bleach over coral reefs to kill and collect the few fish that previous dynamiting has left behind, conservation and rational resources exploitation have similar goals.

The problems besetting small-scale fishermen throughout the tropics might indicate that third-world governments are not concerned about the poverty of their citizenry. This is obviously not true in most cases; the problem is one of knowing what can be done about it. Almost every day, choices are made concerning investments, development schemes and other economic activities which can contribute directly or indirectly to widening the gap between rich and poor. Such actions include subsidized loans being made available for building large trawlers that will operate in waters exploited by

small-scale fishermen, or when mangrove stands are razed to implement an export-oriented shrimp aquaculture scheme.

ICLARM should continue to address these issues as it has for the past decade and complete the analyses of the planners and consultants who propose such practices by pointing out their hidden (and not so hidden) social costs. This activity will be conducted using quantitative information and tools and would include areas neglected by planners and consultants, such as the cost to society of "policing" poor people; the costs of not educating their children; the costs of not providing adequate preventive health care; and the cost of excessive population growth.

More specifically, ICLARM's activities in this small-scale fisheries area over the next five-year period will consist of the following:

- continued case studies, as currently underway in the inland fishery of Bangladesh and in other selected areas of the Bay of Bengal (this work thus nicely complements the Southeast Asian focus of the Asian Fisheries Social Science Research Network, see pp. 67-77);
- preparation of a Manual on Data and Information Needs for Small-Scale Fisheries Management, intended to provide guidelines for information acquisition, is underway in cooperation with FAO Fisheries Department;
- continued training courses and workshops on Management of Marine Fisheries in cooperation with ICLARM's fisheries scientists, with emphasis on research methodologies; and
- a major new activity consisting of an Interdisciplinary Evaluation of Artificial Reefs. This research activity seeks to clarify the potential of these structures, which are expanding extremely rapidly throughout Asia, to deal with not only stock enhancement but also issues of competition between trawlers (which would be excluded from nearshore areas by these reefs) and nontrawl units. The structures thus have major biological and income distribution implications.
- exploration of program expansion possibilities in Latin America.

Coastal zone management and planning

Coastal areas of tropical countries are characterized by highly productive ecosystems which support a broad range of economic activities. Possibly no other region in the world is more dependent on the utilization of such coastal resources than the Association of Southeast Asian Nations (ASEAN) region comprising Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore and Thailand.

With the increasing populations and rapid economic growth in these countries, coastal resources have contributed significantly to economic development. However, because these resources have been exploited through extraction, environmental degradation as well as conflicts in resource utilization due to sectoral miscoordination have resulted. Lack of an adequate

information base on these resources has been a further complication. Exploitation of such resources must be based on their sustainable utilization in order to meet present and future development opportunities and for this a long-term management perspective is needed. It is against this background that the integrated Coastal Resources Management Project (CRMP) was formulated. It was initiated in 1986 and is now ICLARM's largest single activity.

The goal of the project is to increase existing capabilities within the ASEAN region to develop and implement coastal resources management strategies that are comprehensive, multidisciplinary and environmentally sustainable.

The project is funded by the United States Agency for International Development (USAID) for an initial period of four years (1986-1989) and is being executed by ICLARM. As executing agency, ICLARM provides technical and administrative support to national teams as well as facilitates overall project implementation. The CRMP's Project Steering Committee composed of representatives from each of the ASEAN nations is responsible for establishing overall project policy direction and oversees and evaluates project activities and performance.

The CRMP has two major components. The first is the development of site-specific coastal resources management plans in the respective ASEAN countries. Elements within this component include resource assessment, cooperative research and planning activities. The sites for in-country research activities are shown in Fig. 10.

The second component is information dissemination and manpower development through:

- publications
  - a quarterly regional newsletter, *Tropical Coastal Area Management,* covering issues and recent information on trends in coastal resources utilization and related activities, including progress on project implementation;
  - technical reports generated from in-country pilot site activities, reviews, monographs, training manuals, workshops and conference proceedings;
  - educational materials addressing the region's coastal environmental issues in the form of booklets and leaflets produced in various languages and audio-visual materials;
- training activities
  - short-term training courses in: principles of coastal resources management; remote sensing applications in coastal resource assessment and management; integrated coastal resources management methodologies; including economic and social analysis; information research and management;
  - postgraduate training in coastal resources management;
  - on-the-job training (three and six months in ASEAN institutions and 10 weeks in US institutions);
- technical workshops and policy seminars.

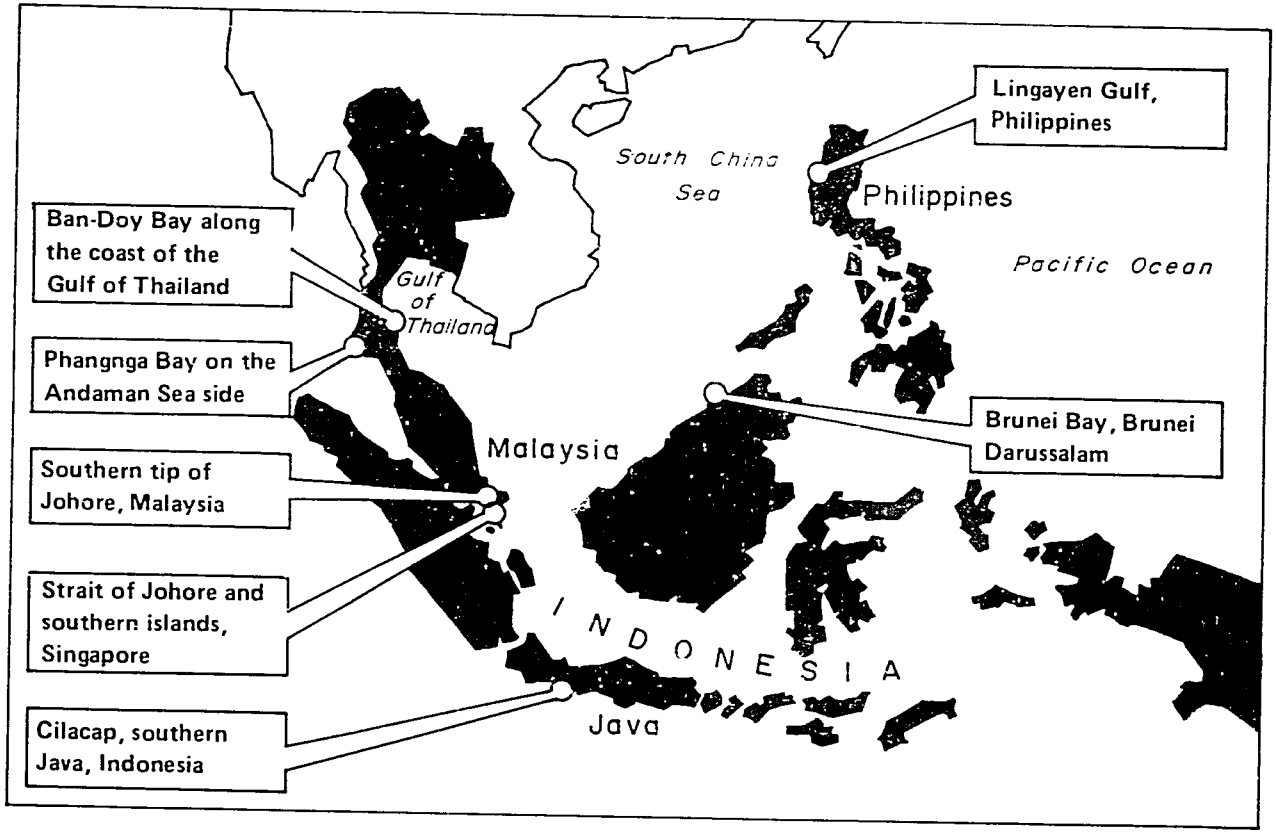


Fig. 10. In-country project sites of the ASEAN/US Coastal Resources Management Project.

A number of national institutions are involved in these resource assessment, research and planning activities leading to development of the site-specific management plans. These national institutions are coordinated through the following agencies:

- Department of Fisheries, Brunei Darussalam
- National Institute of Oceanology, Indonesia
- Ministry of Science, Technology and the Environment, Malaysia
- Philippine Council for Agriculture and Resources Research and Development, Philippines
- Science Council of Singapore, Singapore
- National Environment Board, Thailand

National activities are coordinated by the respective coordinating agencies in each country while the Project Steering Committee is responsible for establishing overall project policy direction and oversees and evaluates project activities and performance. ICLARM, as CRMP's executing agency, provides the technical and administrative support and facilitates overall project implementation.

Since the implementation of the project in 1986, various activities have been initiated. Coastal profiles from each participating country are being prepared providing valuable background information of the pilot sites, identifying management issues, information gaps and research needs. Over 60 principal investigators from the six nations together with the 140 associate scientists, research assistants and technicians are now actively involved in the generation of database necessary for the formulation of coastal area management plans. Fifty-eight participants from the six ASEAN nations have successfully completed three short-term training courses organized by ICLARM in collaboration with national institutions. Four scientists from Indonesia, Malaysia, the Philippines and Thailand are now undertaking various masteral degree training in the US and two Malaysians are currently on on-the-job training with NOAA, USA.

The project newsletter has been widely distributed to about 1,400 scientists from 90 nations. It has become an important information source on coastal area management in tropical third-world nations. Training manuals and educational materials are being prepared.

The project seems well on its way to achieving its broad objectives.

This program is a major one for ICLARM in a new area of endeavor - coastal zone management. Results to date have been excellent, though preliminary. The site-specific plans, if proven successful, will serve as excellent models for application in other areas and countries in the tropics. The Center's hope is that the initial four-year phase of this project ending at the end of 1989 will be extended by ASEAN and USAID to permit actual implementation and monitoring of the management plans developed. While the actual plan implementation will be fully executed by national governments, ICLARM expects that the management monitoring component, in particular, would be a most useful and appropriate contribution of the Center.

This major activity will provide ICLARM with extremely valuable experience in the coastal zone management field. At this time it is premature to say exactly what the Center's long-term future involvement will take, but certainly key elements will be in the areas of interdisciplinary research, training and development of educational materials, all of which are part of ICLARM's mandate.

For purposes of this Five-Year Plan of ICLARM, therefore, it is assumed that funding levels for the ICLARM component of this project (that is, excluding the national components, the funds for which simply flow through ICLARM) will continue at current levels until 1992, the end of the ICLARM Five-Year Plan Period. This will require approval of a second phase by USAID, after completion of the first phase at the end of 1989. Core funding from other sources will be solicited to enable ICLARM to retain its new capability beyond 1989 in case the second phase of the ASEAN/US project will not materialize.

A review of the future of tropical aquatic living resources

Careful reading of published works including projections into the future of major trends in population, agricultural production, energy needs and supply usually reveals that the available information on the fishery and aquaculture sectors and on the coastal zone in tropical countries are woefully inadequate for any useful projection. ICLARM has the flexibility and the contacts within the scientific community that would be needed to conduct research and publish a comprehensive document which would remedy this situation.

The product envisaged is a set of topical reviews by leading experts in their fields, arranged by issues and regions, which could serve as a reference for national planning agencies, international institutions, government and private donor organizations, NGOs, private investors, banks and other entities. Global issues would include:

- world population growth and its impact on fish demand;
- world fish markets and the role of third-world countries;
- fishery and aquaculture development and resource conservation;
- the role of tropical fisheries and aquaculture research;
- aquaculture and other uses of resources such as land, water and fertilizers;
- coastal zone management in tropical third-world countries;
- information and training needs for improved fish supply, etc.;
- constraints to effective management.

The expected product should, more than any of the Center's previous written output make obvious the interdisciplinary research orientation of ICLARM, and the fact that it can play a role that no other organization can assume. The advice of the Worldwatch Institute in Washington, D.C. will be sought so that ICLARM can benefit from that group's highly successful *State*

of the World series. The document will also serve as a major planning document for ICLARM's future work in Resource Assessment and Management.

Aquatic resources planning and management system

A long-term goal of the Program is the preparation, distribution and use of computerized planning and management information systems for aquatic resource managers. Most of the projects described above are elements of such systems. Since aquatic resource managers must take into account the conflicting interests of various coastal and shore-based business and industry sectors, it would be presumptuous of ICLARM to attempt to set up information systems that did not include input from these sectors. Also, there are various organizations working on other elements of such information systems within the aquatic sector.

The near-term plan is to identify the more serious research groups in both the aquatic and coastal/onshore sectors of interest and to hold at least two workshops within the next five years towards coordinating activities and deciding how each group, including ICLARM, could best complement the others in progressing towards holistic planning and management information systems that can be generated using microcomputers. ICLARM's future role and the pace of project development will be determined through the workshops.

Program Development

The time chart presented here as Table 4 illustrates the chronological development of the RAMP activities. As might be seen, most projects cover the whole five-year period considered here, reflecting their continuous nature, and the fact that 1987 happens to be a year during which several new long-term projects were conceived which will start in 1988.

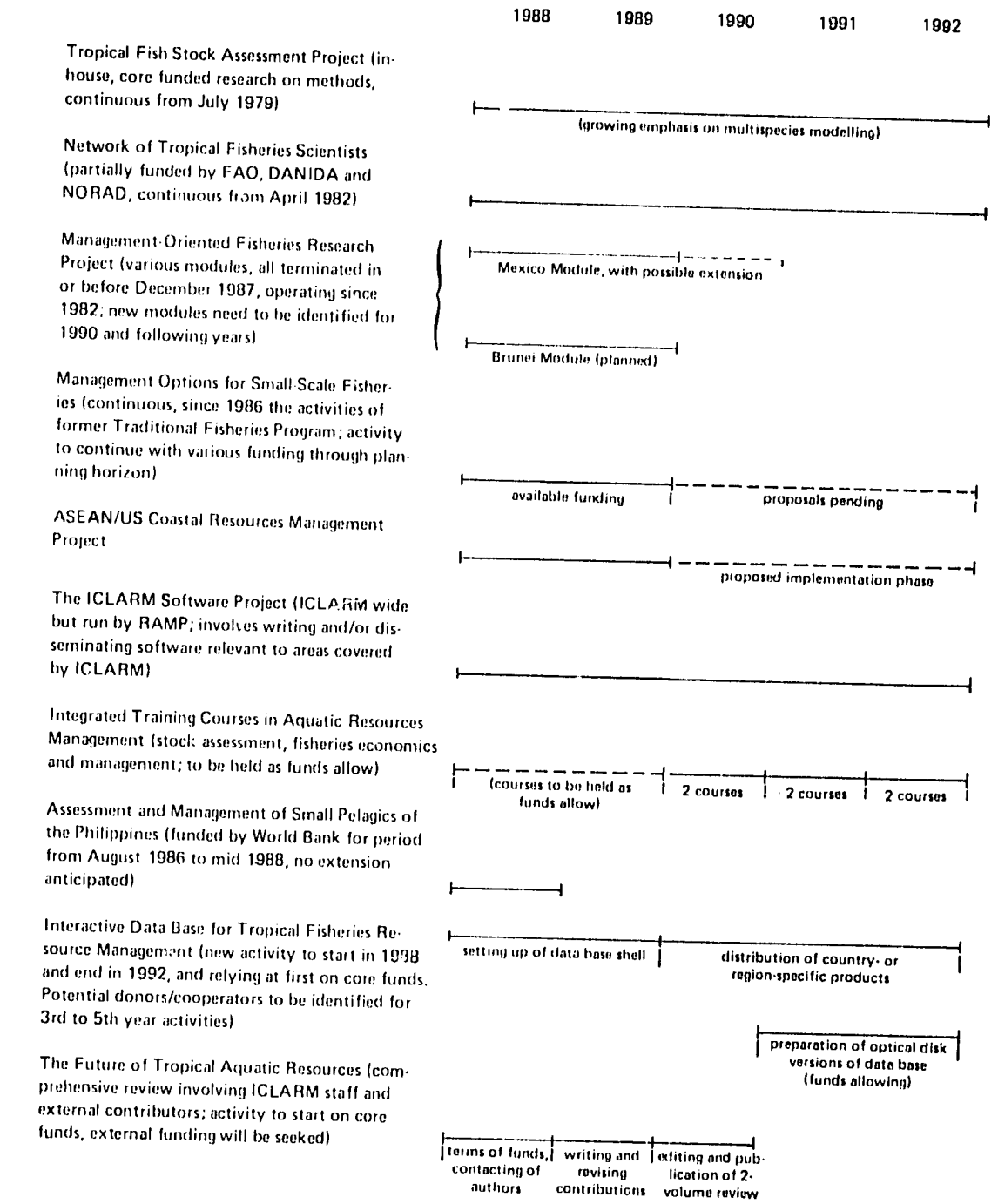
Requirements

Facilities: As the RAMP will continue to work primarily on the development of research methods, it will continue to remain independent of facilities such as research vessels and/or laboratories. However, the increased emphasis on computer-based methods, and on programs that use high-resolution graphics implies the acquisition in 1988 and the following years of various software and hardware to complement present assets.

Staff: As shown in Table 4, the time chart of activities implies for the RAMP core staff 1 Director, 1 Associate Scientist working on resource economics, 1 Sociologist/Economist (Associate Scientist level) to work on fisheries policy, 2 scientists to work on coastal zone management issues, and

Table 4. Activities of the Resource Assessment and Management Program, 1988-1992.

RAMP activities, 1988-1992 (excluding ASEAN/US CRMP)



1 Associate Scientist to work with the Program Director on fish population dynamics and fishery management. Also two additional research assistants will be needed.

The Resource Assessment and Management Program, unlike the Aquaculture Program which appears to have potential for partial CGIAR support, will be dependent upon financial support from members of the ICLARM Support Group. ICLARM is diversifying its contacts with international bodies, such as IUCN, UNEP and FAO as well as with other natural resource management centers, in hopes of identifying new sources of financial support for this program and others of the Center.

Budget details can be found in the ICLARM Five-Year Plan (1988-1992), Part 2. Projected Budgets.

SOCIAL SCIENCES

Since its inception ten years ago, ICLARM has been engaging with cooperating groups in social science research on fisheries and aquaculture issues. ICLARM has long recognized the importance of the social sciences and their potential contributions to issues of fisheries and coastal zone management and to aquaculture development. As fisheries resources have become increasingly overfished and as coastal resources especially have become scenes of intense competition amongst various user groups, issues of resource management, including the required institutional development and allocation of the available catch and other benefits, have become increasingly important.

The importance of these issues and those related to the nontechnical aspects of aquaculture development have become generally recognized, yet the number of social scientists available to address these and related issues has remained small. While the usefulness of the early social science work of ICLARM has been widely acknowledged, it became quite clear in the early 1980s that the Center's task needed to shift from the research per se to include that of helping develop a group of practicing social scientists at the national level who could begin addressing these critical issues. The Asian Fisheries Social Science Research Network was an outgrowth of this concern, which was shared by IDRC of Canada and the Ford Foundation, both of which have become major financial supporters of the Network since it formally began in 1983.

While other social science work outside Network member institutions and countries continues to be pursued under the Aquaculture and the Resource Assessment and Management Programs, this work will increasingly involve coordination and collaboration with this Network.

Rationale

The Asian Fisheries Social Science Research Network (AFSSRN) is an attempt to remove two serious constraints on social science research related to fisheries and aquaculture in Asia: 1) the serious shortage of experienced social science professionals and 2) the weak institutional support for long-term fisheries social science research. The results of these constraints have been a dependence upon countries outside the region for education, consultation and research in social sciences. The overriding objective of the AFSSRN, therefore, is to build national research capacity to address important economic and social issues in the management and development of the living aquatic resources in Asian countries. It is a program of institutional and professional development which seeks to provide continuity to and improve the quality of fisheries social science research and to assure

that future professional social science needs can be largely met within the region.

Current Network membership consists of eight institutions in Southeast Asia (see Fig. 11) and includes both university and government research groups.

The importance of the Network program rests in the great economic and social importance of fisheries and aquaculture to the countries and the people in Asia. Fish supplies most of the animal protein to the people of the region and provides an income to more than twenty million people in Southeast Asia alone. The regional fisheries resources are large, but the nearshore fisheries of the region are threatened by overexploitation. This has increased the expectations for aquaculture, which are very high indeed. To achieve these development expectations and to achieve a rational management of the fisheries resources it is essential that policymakers, planners, managers and other decisionmakers have available to them adequate information on the economic and social consequences of their decisions. This can only be provided by research done by competent social scientists committed to the solution of problems of the region. However, the number of professionals currently involved in the effort is not nearly adequate to the task and their distribution within the region is uneven. Moreover, the current scope of the Network is not broad enough to be able to address the variety of issues that arise in all Asian countries.

The Network has two broad program areas:

(1) The development of medium- to long-term programs of social science research on management and development issues of national and regional importance related to fisheries and aquaculture resources.

The AFSSRN assists researchers from the social sciences in affiliated universities and government research institutions to develop and implement programs of research. It provides grants for high priority projects, partly as a means of ensuring continuity in the research programs at the early stages of implementation. Network research teams can draw on experienced scientists from ICLARM, other Network institutions and elsewhere for technical and professional inputs where needed. The Network organizes special workshops to develop and evaluate appropriate methodologies for economic, social and multidisciplinary research on fisheries and aquaculture in the Asian region.

(2) The development of national programs of professional training in fisheries and aquaculture economics.

The Network has, heretofore, linked eight institutions in four countries of Southeast Asia and the number of institutions will be increased during the next phase of development. The interest in and awareness of the importance of this kind of research is growing throughout the world and the Network will grow both within and out of Southeast Asia in order to support the development of effective fisheries social science research programs. Expansion to South Asia in Bangladesh, Sri Lanka and South India will take place when

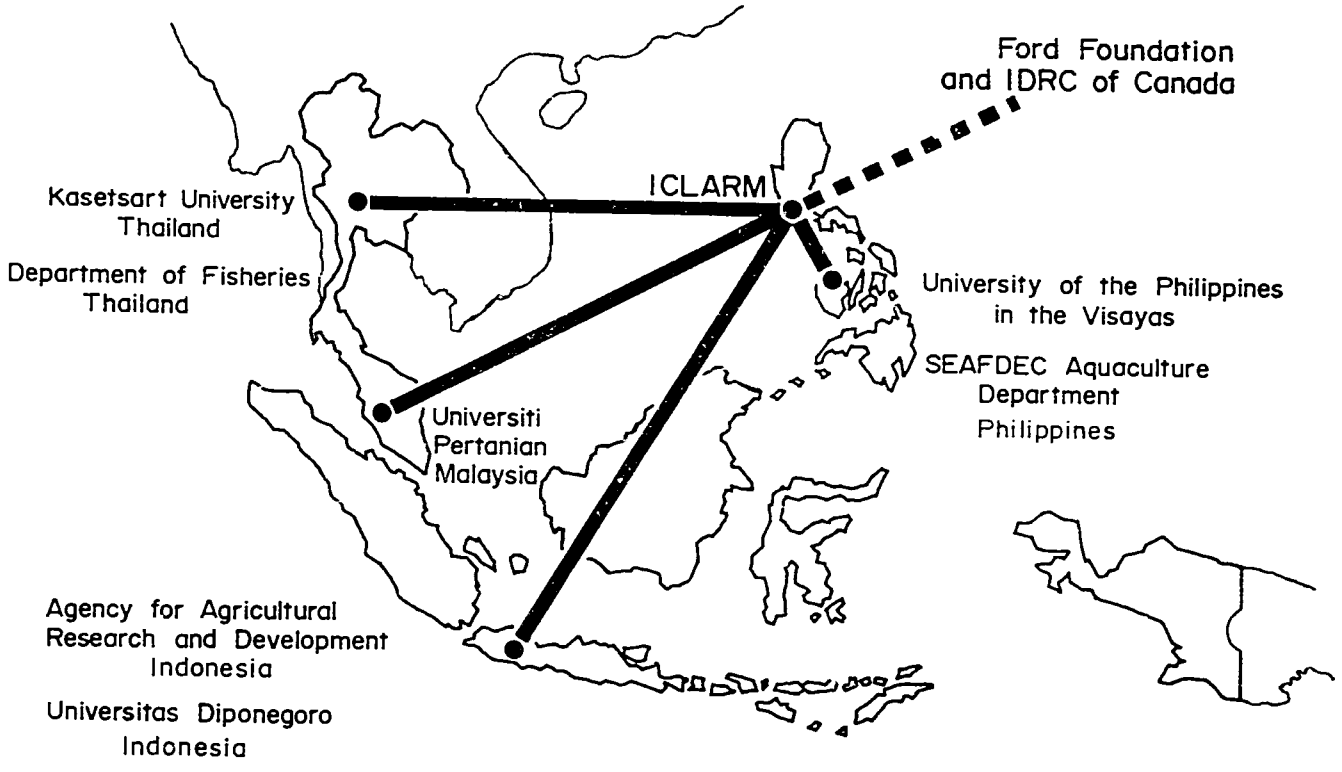


Fig. 11. Member institutions of the Asian Fisheries Social Science Research Network as of late 1987. Further linkages are being promoted at the national level, in order to broaden the participation of social scientists in research on issues of resource management and aquaculture development.

adequate financial resources are available. Consideration will also be given to Network expansion to the People's Republic of China at one or two major research centers. Within the countries already in the Network, it is planned that the geographic and issue orientation will be broadened through the admission of additional collaborating institutions. National networks will be built around the member institutions. Later, the Network, or others like it will include Latin America and Africa.

The Network aims to assist a university in each major fishing nation in Asia to become a national leader in this specialized field of applied social science and to assist other universities and institutions to develop special competence to deal with issues of national importance. Particular attention is given to the development of training material related to the unique conditions under which aquaculture and marine fisheries operate in the region. The Network provides affiliated universities with professional and technical assistance in designing fisheries and aquaculture economics courses and programs of study, assistance with teaching and research materials and literature, and identifying opportunities for staff training and professional exchange in association with IDRC of Canada, one of the key supporters of the AFSSRN.

As these two program areas develop, the Network will encourage: (1) the establishment of strong professional working relationships (linkages) between the fisheries social scientists and agencies responsible for fishery resource use management, planning and development; (2) the increasing collaboration of social scientists with fisheries and aquaculture scientists in research; and (3) the formation of a regional professional association to carry on the work of the Network.

Objectives and Priorities

The Network seeks to maintain a balance in its research efforts in capture fisheries and aquaculture, and within these areas to concentrate particularly on the problems relating to small-scale producers. The issues facing these sectors and the lack of attention paid to social science aspects have been described in the introductory sections of this Five-Year Plan. A listing of Network research projects to date can be found in Table 5.

Objectives

Network research is planned to contribute both to the management decisionmaking process and to research and management methods. It is important that the research contribute immediately to policy and program formulation but equally important that the practical methods of management decision analysis be developed for future use. The research projects

Table 5. Completed and ongoing research projects of the Asian Fisheries Social Science Research Network, as of December 1987.

Title	Researcher and Institution	Duration
Market Potential for Freshwater Fish	Kusairi Mohd. Noh: Faculty of Resource Economics and Agribusiness, Universiti Pertanian Malaysia (UPM), Serdang, Selangor, Malaysia	March-October 1986
Marketing Analysis of the Fish Fry and Fingerling Industry in Malaysia	Mohd. Ariff Hussein: Faculty of Resource Economics and Agribusiness, Universiti Pertanian Malaysia (UPM), Serdang, Selangor, Malaysia	October 1986-1987
A Firm Management Analysis of Integrated Farms with Freshwater Fish, Prawn and Other Agricultural Activities	K. Kuperan: Faculty of Resource Economics and Agribusiness, Universiti Pertanian Malaysia (UPM), Serdang, Selangor, Malaysia	August 1987-March 1988
Review of Malaysian Fisheries Management Policies	Kusairi Mohd. Noh: Faculty of Resource Economics and Agribusiness, Universiti Pertanian Malaysia (UPM), Serdang, Selangor, Malaysia	August 1987-March 1988
Economic Analysis of Cockle Culture in Thailand	Ruangrai Tokrisna: Faculty of Economics and Business Administration, Kasetsart Universit· , Bangkok, Thailand	August 1985-September 1986
Economic Evaluation of Sea Bass Culture in Selected Coastal Areas in Thailand	Marut Muangkoe: Faculty of Economics and Business Administration, Kasetsart University, Bangkok, Thailand	August 1985-September 1987
Economic Analysis of Green Mussel Culture Systems in Thailand	Sanit Kao-ian: Faculty of Economics and Business Administration, Kasetsart University, Bangkok, Thailand	August 1985-September 1987
Economic Analysis of Various Oyster Culture Practices in Thailand	Somkit Tugsinavisuitti: Faculty of Economics and Business Administration, Kasetsart University, Bangkok, Thailand	August 1985-September 1987
Price Analysis of Selected Marine Fish	Ruangrai Tokrisna: Faculty of Economics and Business Administration, Kasetsart University, Bangkok, Thailand	August 1987-March 1988
Economic Viability of Freshwater Prawn (*M. rosenbergii*) Culture in Thailand	Ruangrai Tokrisna: Faculty of Economics and Business Administration, Kasetsart University, Bangkok, Thailand	August 1987-March 1988
Freshwater Aquaculture in Northeastern Thailand: The Development and Constraints	Piti Kantangkul: Faculty of Economics and Business Administration, Kasetsart University, Bangkok, Thailand	October 1987-March 1988
Evaluation of the Socio-economics and Diffusion Process of "Hulbot-Hulbot" Fishing in Iloilo, Philippines	Benedict Posadas: College of Arts and Sciences, University of the Philippines in the Visayas, Iloilo, Philippines	April 1986-February 1987
Patterns and Processes of Decision-Making Among Small-Scale Fishermen in Selected Areas of Iloilo, Philippines	Ida Siason: College of Arts and Sciences, University of the Philippines in the Visayas, Iloilo City, Philippines	December 1985-January 1987
A Socio-Economic Analysis of the Seaweeds Industry in Selected Areas of the Philippines	Benedict Posadas: College of Arts and Sciences, University of the Philippines in the Visayas, Iloilo City, Philippines	August 1987-March 1988
Economics of Aquaculture: Case of Shrimp Cultivation in Central Java, Indonesia	Mudiantono: Faculty of Economics, Diponegoro University, Kotak Pos 270, Semarang, Indonesia	November 1985-August 1986

Continued

Table 5. Continued

Title	Researcher and Institution	Duration
Analysis of Catfish Production and Marketing in Central Java Province, Indonesia	Basuki Suwardo: Faculty of Economics, Diponegoro University, Kotak Pos 270, Semarang, Indonesia	August 1986-July 1987
The Economic Assessment of Household Fishponds in Central Java, Indonesia	Mudiantono: Faculty of Economics, Diponegoro University, Kotak Pos 270, Semarang, Indonesia	August 1987-March 1988
An Evaluation of the Methods and Level of Management of Aquaculture Systems and Enterprises in Java	Mudiantono: Faculty of Economics, Diponegoro University, Kotak Pos 270, Semarang, Indonesia	September 1987-March 1988
Analysis of Fish Consumption Patterns in Selected Urban and Rural Areas of Central Java	Syafrudin B. Suharto: Faculty of Economics, Diponegoro University, Kotak Pos 270, Semarang, Indonesia	August 1987-March 1988
A Review of Fisheries Management Measures and Estimates of Fisheries Potential in Use for the North Coast of Java	Wiratno: Faculty of Economics, Diponegoro University, Kotak Pos 270, Semarang, Indonesia	September 1987-March 1988
Assessment of the Credit and Financial Programs for the Fishery Sector, Philippines	Generoso Octavio: Center for Policy and Development Studies, University of the Philippines at Los Baños (UPLB) College, Laguna, Philippines	August 1985-August 1986
Market Structure Analysis of Fish Distribution Channels Supplying Metro Manila	Enriqueta Torres: Center for Policy and Development Studies, University of the Philippines at Los Baños (UPLB) College, Laguna, Philippines	February 1986-November 1987
Impact of Fishing Boat Motorization on Income Distribution in Indonesia	Faisal Kasryno: Center for Agro Economic Research, Jl. Ir. H. Juanda 20, Bogor, Indonesia	April 1986-December 1987
Comparative Economic Analysis of Different Prawn Nursery Production Systems in the Philippines	Danilo Israel: Aquaculture Department, Southeast Asian Fisheries Development Center (AQD-SEAFDEC), Tigbauan Iloilo, Iloilo City, Philippines	July 1985-August 1987
Economics of Prawn Hatchery and Integrated Hatchery-Floating Nursery Operations in the Philippines	Danilo Israel: Aquaculture Department, Southeast Asian Fisheries Development Center (AQD-SEAFDEC), Tigbauan Iloilo, Iloilo City, Philippines	July 1985-August 1987
Costs and Returns Analysis of Newly Developed Aquaculture Production Systems in the Philippines	Danilo Israel: Aquaculture Department, Southeast Asian Fisheries Development Center (AQD-SEAFDEC), Tigbauan Iloilo, Iloilo City, Philippines	July 1985-August 1987
Socio-economic Analysis of the National Bangus Breeding Program (NBBP)	Noel Lopez: Aquaculture Department, Southeast Asian Fisheries Development Center (AQD-SEAFDEC) and Bureau of Fisheries and Aquatic Resources (BFAR), Quezon Avenue, Quezon City, Philippines	August 1987-March 1988

prosecuted within the Network may have either one or both objectives. Education and training activities are also planned to continue.

Priorities

The priorities indicated below are Network-wide. Emphasis may differ slightly among countries but the main thrust of programs will be the same in all.

a) Capture fisheries

In addition to the use of conventional fisheries models to address management issues in capture fisheries some projects will attempt to formulate the management problem using more advanced methods of modelling and simulation. The methodologically oriented research will be formulated to deal effectively with the dynamics of the management decision processes.

The capture fisheries to be studied are two main contributors to regional fisheries production - small pelagic and demersal fisheries - in both of which ICLARM has broad experience through the Resource Assessment and Management Program. This work forms a foundation upon which management models can be jointly developed by the social and fisheries scientists.

b) Aquaculture

The small-scale fish farmers - those with small backyard ponds, most of those with fish as one farm enterprise among others, the typical rice-fish farmer, as well as the brackishwater fish growers with a few hectares - control the use of large amounts of land and water resources along with other important inputs into the fish farming process. Efficiency, or lack thereof, in the use of these resources has important consequences for the agriculture systems and the coastal environments within which aquaculture is found and equally important consequences for the incomes of the farmers. The emphasis on production technology in the past has resulted in the neglect of the management decisionmaking process and the provision of proper support for it. The Network emphasizes, in its research, the broader agro-ecosystems and policy issues of managing aquaculture development and matters that contribute to more effective management of integrated and other small-scale fish farming enterprises.

c) Education and training

Central to the Network research program is an expanded team of well educated and trained research workers. To provide the kinds of research that the future requires will necessitate the training to the doctoral level of

at least fifteen more members of the present Network teams. As the Network expands this number will obviously expand. The MS program in Fisheries and Aquaculture Economics at the Universiti Pertanian Malaysia will continue to be a major program for training team members, and it is expected that at least thirty degrees will be awarded team members by that Institution in the next five years.

During the next five years it is also expected that Kasetsart University will be providing fisheries economics education to the Masters level that will contribute greatly to the manpower requirements of the national fisheries management and development program of Thailand. It is expected that by 1994 the Universiti Pertanian Malaysia will be prepared to offer the PhD degree in economics with specialization in fisheries. By 1994 it is also planned that the Universitas Diponegoro will also be prepared to offer an MS degree in fisheries economics.

Network training programs will concentrate on advancing the methodological skills of the team members and on maintaining them at a high level of proficiency. In a field that is new, and advancing very rapidly, but unevenly, this effort is to assure that the Network is in the vanguard of applied fisheries economics and social research. This program will be based upon short courses of two-weeks duration offered by social, fisheries and aquaculture scientists from ICLARM and universities throughout the world. In the next three years eight courses will be offered, of which four will be directed to aquaculture research and four to fisheries management.

A strong program to integrate other social sciences into the Network along with economics has already begun in the Philippines. This integration has also begun in Indonesia and will be strongly promoted during the next five years.

Work Program

Research

The Network research activities will fall within three program areas of which the first two will be emphasized. These are: 1) Capture fisheries systems and their management, 2) Aquaculture systems and enterprise management and 3) Market systems analyses. Participating institutions will each have research programs that are similar to some or all of these three program areas but each institution has defined its programs somewhat differently to suit national needs and the special skills and interests of the team.

The discipline mix in some cases may include biology, economics, geography, anthropology and sociology. The past Network experience provides a foundation for the effective integration of input from a number of disciplines in a single research effort. This research is somewhat more difficult, given the nature of the production process and fisheries property rights, or lack thereof, than research with similar objectives in agriculture or

other land-based systems. The concepts and practice of modelling and simulation will be introduced into the Network research programs to assure that an adequate analytic framework is prepared to address questions concerning the dynamics of fisheries systems. Simulation can play a particularly important role in analyzing systems and provides a framework in which optimization need not be the driving force or the central objective. Optimization models, in contrast, tend to place an unnecessary constraint on both researchers and policy decisionmakers.

Capture fisheries. The Network research program on capture fisheries systems and their management will direct its effort to an assessment of the costs and benefits of managing the nearshore resources. The research will be conducted at a number of levels of complexity. At the most basic level the research will focus upon estimating the level of effort reduction necessary to improve or maintain production of selected coastal systems and the benefits that will result from these changes. Estimates of the costs and the community social impact will also be made in these cases. Attention will be given to both pelagic and demersal resources, the focus to be determined by the significance of the resource in the community or district under consideration. At a greater level of complexity, the research will attempt to formulate models of management systems that can support decisionmaking by policymakers and resource managers. A subset of the research activity will be directed to exploring the potential of simulation methods in dealing with the nearshore and other fisheries management problems of the region.

The interdisciplinary research mentioned above is only a part of a broader mix of disciplines that are necessary to address questions concerning the impact of management on the community, broadly construed. A significant part of the Network research effort will attempt to address the social and political impacts of management at the community level. This work will provide a broader basis for policy and management decisionmaking.

Aquaculture. The focus of Network research in aquaculture will shift substantially beginning in 1988. The enterprise management of farming systems, integrated and otherwise, will constitute a major thrust of the research. This represents a substantial change in approach from earlier work which concentrated on costs and earnings.

The Network will focus on the dynamics of the farming process. To provide a framework for dynamic analysis a subset of the research effort will be devoted to exploring the simulation of aquaculture systems as a basis for more effective management and planning.

An important new approach to Network research in aquaculture will be the effort to link the research activity to other ongoing development as well as research programs. The objectives of the link are two: 1) to obtain data, over time, on the operations of the development program and of the enterprises that are part of it and 2) to provide timely analysis for the support of the development project and for extension systems in support of the enterprises in it. Another important benefit of this approach to research

is that it will force attention to the analysis of the dynamics of management and development in a systems context.

Network aquaculture research will shift some of its resources to the development of dynamic analytic and management models of aquaculture enterprises and of farming systems. Using these models as a guide, teams will experiment with the creation of fish farm simulators, for integrated and other farms as well. The program of the Network seeks to provide a research foundation for the more effective management of fish farms.

As in the case of marine fisheries management research of the Network, aquaculture research will also address the larger questions of community impact. This, in fact, is an integral part of what has been termed aquaculture systems analysis. There is a clearer framework, which derives from agriculture, for this kind of analysis than exists for marine fisheries and coastal communities. This stems to some extent from the fact that the production processes in land-based systems are generally less erratic than those based upon the sea.

Marketing. Marketing and pricing issues are sometimes central to fisheries aquaculture development and management. The Network will address these issues as they arise. The research will be on the markets as a system.

Requirements

The current program

The program, as it is now structured, with the research and training commitments outlined above, and with a coordinator and one assistant, requires US$270,000 a year or $1,350,000 for five years to operate effectively.

A modest, but important, program addition would involve seeking associations with universities in other parts of the world to obtain access to short-term research and educational skills in support of professional development within the Network. The participation of other institutions in Network training and research planning at a modest level would require approximately US$50,000 annually to be used for about three man-months of professional support at various venues. This would raise the annual financial requirements to US$320,000 or to US$1,600,000 for a five-year period.

Limited program expansion

A limited program of expansion of the Network is necessary to more adequately address the broad range of issues confronting countries now in the Network and their near neighbors. In Indonesia it is important to be able to conduct research of importance to different regions of this very large and diverse country. Current institutional representation is all in Java. Members in North Sumatra and the Moluccas would provide greater geographic scope

for research and also provide the basis for addressing problems in different kinds of fisheries. The varied capture fisheries and rapidly expanding aquaculture sector of Thailand, including expansion to the northeast region and the south, would provide important scope and local knowledge to the Network research program The Philippines, also a large country, requires AFSSRN research bases outside of Iloilo where both members have their venue, to help alleviate the geographic narrowness of current research. In Malaysia, the Network has been constrained to address only Peninsular problems and as institutions in Sabah and Sarawak evolve they should be considered for membership as well.

The program of expansion outlined above should be regarded as a natural evolution based upon the developing strengths of the current members and taking place over a period of five years. Further, this expansion will be supported by the Network in the form of national networking arrangements with the consequent strengthening of institutional linkages within countries.

The added annual program cost of a Network expansion to twice the present membership over a five-year period would be US$150,000 a year at the end of five years. Of this, $100,000 would be devoted to research and the remainder to Network development and management. The coordination staff based at ICLARM would add one mid-level professional with expertise in modelling, simulation and computer matters. The total annual program cost at the end of the expansion period would be US$470,000 which is 74% greater than the cost of the current program. A summary budget, based on these assumed costs, is included in the document, ICLARM Five-Year Plan, Part 2. Projected Budgets.

EDUCATION AND TRAINING PROGRAM

The value of and need for appropriate training and educational activities have always been recognized by ICLARM. The Center has endeavored to provide training opportunities where possible and to examine ways to complement education processes.

ICLARM distinguishes between training and education in the sense that the former represents short courses and internships of the type that can readily be offered by ICLARM while the latter is primarily the function of formal educational institutions. For various reasons, including financial constraints, the Education and Training Program has never been formally staffed.

With regard to training, ICLARM offers opportunities for visiting scientists and students to spend short periods at the Center to work with senior staff and to become familiar with methodologies and approaches developed and/or used by ICLARM staff.

ICLARM's educational activities include supervision of M.S. and Ph.D students, scholarships, teaching, curriculum development and educational books.

Details of activities and plans for the future follow.

Training

ICLARM's training activities are integral parts of its research programs, since much of the training is done through research under staff supervision and through networks with staff guidance. Information about these activities is detailed separately here, principally because they are perceived as separate entities from research by some groups.

There is tremendous need for training opportunities for researchers and aquatic resource managers, but this training must be relevant for tropical third-world settings. Much training available to date for such individuals has been offered in temperate locations and in many cases has been based upon methods and case studies largely inappropriate to the tropics. ICLARM envisions future training activities that would include specialized nondegree courses and regular assistance to other institutions through the Center's various networks.

Present and planned training activities within the research program areas follow.

Resource assessment and management

Many visiting scientists and students have spent time working one-on-one with senior scientists in this program, after which they have returned to

their home base and pursued cooperative research with the Center. Other training activities have been in the context of answering enquiries from and producing information for members of the Network of Tropical Fisheries Scientists (NTFS) and in teaching at stock assessment courses organized by FAO and others.

For the period 1988-1992, training will continue to be embedded in the program's activities and central themes. Pre- and postdoctoral students will be involved more than hitherto in the program's research activities, particularly where lack of funds prevent a full staff member from being hired. Also, the activities of the NTFS will be intensified with regard to upgrading members' skills.

Program staff will attempt to replace their prior extensive involvement as lecturers in stock assessment courses given by other organizations (particularly FAO) by the development of courses organized by ICLARM and funded by external donors. Participants would be selected by ICLARM from NTFS members and various other applicants, in line with ICLARM's priorities. It is hoped that two such courses per year, both interdisciplinary in content, will be offered in the last three years of the period covered by this Five-Year Plan.

Aquaculture

Training in aquaculture has been mostly through staff development in projects as well as lecturing at various short courses.

Training of researchers will also be one explicit mandate for the three aquaculture facilities to be operated by ICLARM by the end of this Five-Year Plan period. The first of these - the Coastal Aquaculture Center in the Solomon Islands - will be ready to host its first trainees in 1988. Training will be given in cultivation techniques for specific organisms, including processing, handling and preparation methods, particularly to fisheries extension workers from within the South Pacific region, but also to relatively unskilled persons who are actively involved in the cultivation of those marine organisms. The Center may also prepare instructional materials on aquaculture topics.

By the early 1990s when all three aquaculture units of ICLARM have been established, the Center's Aquaculture Program will begin assuming a much more prominent role in the training of aquaculture researchers.

The new Network of Tropical Aquaculture Scientists will include a training component as has the NTFS described above.

Social sciences

Training has been given to project staff in the various cooperative research projects with social science components, and these staff have helped develop new methodologies through their experience. Most training is being

channelled through the Asian Fisheries Social Science Research Network, in the form of workshops and short courses which will continue. Degree course work is discussed below in the Education section.

Information

On-the-job training has been a function of the ICLARM library over the past few years at the request of such agencies as IDRC, FAO and UNESCO. There are always one or two trainees from local colleges in the library; they undertake part-time training over a 2-3 month period.

A proposal for support of the library and information services, made to the Philippine government, calls for ICLARM to provide more regular training in various forms (seminars, workshops, primers, internships and individual coaching) aimed at sharing its expertise in librarianship and information services as well as teaching users how to make maximum use of information resources.

Future plans

Over the coming five years, ICLARM envisages training programs that cut across program lines and draw upon the professional expertise of all ICLARM staff. The Center does not plan to hire a Training Director *per se* because these activities are built-in responsibilities of the senior staff of the Aquaculture and the Resource Assessment and Management Programs. It is proposed that the Center's Deputy Director General position (currently vacant) assume the responsibility of developing ICLARM's activities in this area. Another primary function of this person will be the development of educational materials in collaboration with other ICLARM scientists (see Education section below).

To a certain extent, training activities can be self-supporting as evidenced by the number of already-funded training requests for stock assessment study visits that ICLARM receives. ICLARM's formal training courses would initially focus on two areas where the Center's research contributions have been clearly recognized and where its present lack of physical research facilities would not be a constraint; these are in (1) living aquatic resources management and (2) information science. The Center has pioneered the development of microcomputer software for fisheries stock assessment and is now extending this work into fisheries economics and management. For example, funds are being actively sought for two one-month fisheries stock assessment and management training courses for researchers and mid-level managers planned for 1988. The total number of courses, excluding those to be developed for the various aquaculture units (see p. 38-42), will not exceed four per year in 1988-1990 and then six per year in 1991-1992.

Education

ICLARM is primarily a research organization. While training is an integral part of the research programs, educational activities have not been a major function of the Center.

Educational needs in third-world countries are many. The following list prepared at the Asian Fisheries Society Workshop on Fisheries Education and Training in Developing Countries in Asia, Iwate, Japan, 16-18 May 1987, provides an up-to-date summary of these needs, which are probably broadly applicable in other regions also:

- Development of a policy which incorporates fisheries education and training with fisheries manpower development strategies.
- A comprehensive and regular review of fishery education programs in line with development trends of the fisheries industries.
- Upgrading of existing fisheries training capability in Asia.
- Promotion or strengthening of a network of fisheries educational institutions with areas of excellence in fisheries science in Asia.
- Stronger linkages among fishery professionals in government, universities and private institutions involved in training, research and development.
- Taking steps to improve the image of the fisheries profession and the professional status of fisheries personnel.

ICLARM, which is not a formal educational institution, is clearly not an appropriate organization to take a lead role in addressing all these issues. However, because the Center has a great deal of expertise in tropical fisheries science, it presently plays a subsidiary role in support of educational institutions through:

- *Supervision of graduate students* carrying out M.S. and Ph.D. projects. To date these have included persons at universities in the Philippines, Malaysia, the Netherlands and the Federal Republic of Germany.
- *Scholarships for degree courses* in fisheries and aquaculture economics through the Asian Fisheries Social Science Research Network, coordinated by ICLARM; also selected ASEAN-country researchers are undertaking overseas M.S. and Ph.D. courses during the ASEAN/US Coastal Resources Management Project, executed by ICLARM.
- *Teaching* at the graduate and undergraduate level. This activity is largely confined to the Philippines for logistic reasons.
- *Curriculum development.* The Asian Fisheries Social Science Research Network, coordinated by ICLARM, is contributing in a major way to teaching programs of its member institutions. The marine science curriculum at Chulalongkorn University in Thailand was developed with the advice of an ICLARM staff member. Informal curriculum assistance has been provided to many other institutions in other areas of ICLARM expertise.

- *Publication of educational materials.* A number of ICLARM's publications have become textbooks at universities, while many more appear on "reading lists." These books are generally quite specific in subject matter and have become textbooks by default - no broader or expressly educationally-oriented material is available.

ICLARM has put forward to donors several unsuccessful proposals related to the preparation of university-level textbooks. It seems that donors are not yet willing to make significant commitments in this area, despite the generally acknowledged lack of appropriate books. However, in 1987 ICLARM began its own Education Series of publications with a general booklet on coral reefs (from the ASEAN/US Coastal Resources Management Project). Other booklets are planned, but funds are not presently available for large textbook undertakings.

Over the next five years ICLARM plans to increase the impact of some of its present education activities. By the early 1990s all three of ICLARM's aquaculture research units will be in operation and the number of opportunities for postgraduate theses and dissertations to be supervised by ICLARM scientists will increase correspondingly. With more scientific staff in these research units and in headquarters, there will be a corresponding increase in the amount of undergraduate teaching, given existing and planned future linkages between ICLARM and educational institutions.

For example, in the South Pacific region, there is a shortage of scientists and one of the most effective methods for attaining research objectives while at the same time providing research instruction is to employ young graduates as Research Assistants on the understanding that a part of their research will form the body of a higher degree thesis. This provides an opportunity for gainful employment while at the same time fulfilling higher degree aspirations. It is envisaged that the Coastal Aquaculture Center in the Solomon Islands will offer training in research methods to candidates for higher degrees. The development of an academic relationship with a regional university is also under consideration.

Dissemination of educational materials will increase (i) through output of the ASEAN/US project, in which 800 free copies each of a variety of coastal resource management materials will be distributed free over the next three years; (ii) through ICLARM's continuing publication program of its technical series, in which 300 copies of each item are distributed worldwide free of charge; and (iii) by further pursuing the development and production of tropical fisheries science textbooks.

To plan and coordinate all these activities, especially textbook development, as well as to integrate them into the Center's research and training programs, it is proposed that the Center's Deputy Director General (position currently vacant) take responsibility for ICLARM's education activities. In addition to administrative responsibilities, the primary function of this person will be the development of educational materials in collaboration with other scientists, both within ICLARM and outside.

A full plan for development of these materials is yet to be formed, but will be an explicit task of the Center during the coming years once the key

staff position has been filled. The existing linkage of the Center with the Asian Fisheries Society (AFS), for which ICLARM currently provides the secretariat, and its 1,000 professional members will provide an avenue for contributions from the regions's top scientists and educators. Discussions between ICLARM and the Asian Fisheries Society are currently being held to identify more clearly specific areas of collaboration. The increased involvement of these AFS members with ICLARM would help assure that the curriculum materials developed are relevant for tropical needs and institutions, yet reflect the tremendous diversity of tropical aquatic ecosystems (e.g., coral reefs, estuaries, mangrove swampland, river systems, inland reservoirs). A summary budget for the program for 1988-1992 is included in the complementary document, ICLARM Five-Year Plan, Part 2. Projected Budgets.

INFORMATION PROGRAM

Background

The value of information in aquatic sciences was well recognized by the founders of ICLARM, who prescribed a library of international standards for the Center as well as its own publishing unit.

Information retrieval and dissemination have become cornerstones of ICLARM's activities and since 1984 these functions have been combined in a Selective Fisheries Information Service, which has been funded by IDRC of Canada. It is widely used by researchers all over the world. ICLARM's information resources are unique in Asia, with computerized, easily searchable databases, not only of library holdings but also of compact-disk and online overseas aquatic databases, together with the substantial contributions of ICLARM's own seven technical series and four regular newsletters/magazines.

The evolution of ICLARM's information resources into an information service is continuing, with critical analyses of the literature and databases; investigations into the shortcomings of scientific communication in aquatic sciences; and research that may lead to improving both the information resource and access to it. Thus, the present Information Program has the dual roles of service and research.

Rationale

For aquatic science, as for many other fields of science, information is difficult to get in tropical and third-world countries. Researchers in particular suffer from lack of access to current ideas, current literature and even standard textbooks whether in fisheries, aquaculture or related coastal zone or rural research. Compounding this, too often, research activities fail to produce usable research results and publications. In general, the flows of information are south-north in direction rather than around the tropics.

There are also financial aspects to the acquisition dimension of this problem. Researchers in the tropics often cannot attend meetings with their peers in other countries, particularly those in other regions; library budgets (where there is a library) are meager, while the costs of western journals and books and use of computerized database services are exorbitant by third-world standards. The high cost of journals leads further to the ironic situation that third-world researchers who publish in western journals cannot afford to buy back their own research results.

The progress of fisheries science in the third-world has been fragmentary partly as a result of the above mentioned problems. However, apart from such general statements, there is very little that can be said authoritatively about the status of fisheries science because there are no

quantitative data. Without such data it is impossible to set realistic goals to improve the situation. For example, we know little about the scientists themselves as a group, their numbers, their educational background or their productivity. How well do they access and use fisheries literature? We know even less about the use and usefulness of their work. Measuring citations to published papers is one technique to establish impact but as yet there is no database in this field from which to make the calculations. Thus, there are presently no data to indicate how well scientific results are being used by other scientists either within a country or regionally/internationally.

Assuming that published papers achieving some impact in the fisheries scientific community add to our knowledge of the resources or their use in fisheries or aquaculture, then these papers can be considered to be impacting, possibly in the same relative proportions, on the development of fisheries management mechanisms and institutions or on aquaculture development.

In order to make proper judgements about the effects of future programs aimed at improving scientific education or productivity in fisheries science, such baseline information about the present scientific community is indispensable.

Fisheries information research is needed to make the necessary quantitative data available. Not only fisheries administrators and the researchers themselves would benefit; there are uses of the data for educators, librarians and publishers also.

Armed with quantitative measures of these characteristics, numerous parameters can be extracted. For example, a donor given a proposal for an information retrieval project can use the publishing productivity of the average scientist to estimate how much literature is likely to emanate from a given country or subregion per year, and relate this to the estimates in the proposal. Of course, the proposal writer can benefit from the same data. Publishers can determine whether the market is large enough for a projected fisheries publication or new journal in a specific field. Authors can see which are the dominant publication channels. Educators (and donors) can asess the need for new courses/degrees within the region. Administrators can use the data on numbers of research/training institutions and the relationship between institution size and productivity.

Research of this nature is basic and long-term; it is research that national institutions would be unlikely to carry out, yet has clear usefulness to them and others. In short, it represents the kind of research that ICLARM was specifically designed to carry out.

Objectives

In response to these and other interrelated problems, ICLARM has taken the initiative in several areas to assist in the improvement of the workings, use and contributions of tropical aquatic science information systems.

ICLARM's Information Program has two thrusts:

- Information Services
- Research

A. *Information Services*

The long-term objective of the Information Services portion of the program is the improvement of information availability and access.

To this end several interrelated projects and inhouse activities are ongoing or planned for the next five years.

These are:

1. Publication and distribution program
2. Maintenance of ICLARM's (public) library
3. Selective Fisheries Information Service (SFIS) Phase II:Project ADD
4. SFIS African module
5. Information Sourcebook on Tropical Fisheries Science
6. Computerization of library holdings and dissemination
7. INFOTERRA (Nairobi) Information Service
8. Needs, constraints and solutions to information access
9. Translations
10. Communications

1. Publication and Distribution Program

ICLARM's publication program continues to grow as staff size and number of concurrent projects grow. Since 1980, five technical series have been published - Studies & Reviews, Conference Proceedings, Technical Reports, Bibliographies and Translations - as well as Annual Reports and the quarterly ICLARM Newsletter, renamed in 1986 as Naga, the ICLARM Quarterly, which is free to readers in the third world. A second newsletter, "Fishbyte", for members of the Network of Tropical Fisheries Scientists was added in 1982 and a third, "Tropical Coastal Area Management", in 1986. "Clamlines", newsletter of ICLARM's International Giant Clam Mariculture Project, also began at the end of 1986. In 1987, two new technical series began - Education and Software. A fifth newsletter, "Aquabyte", for members of the Network of Tropical Aquaculture Scientists, is also beginning in 1988. ICLARM also handles the editorial and publishing functions of the Asian Fisheries Society, for which it provides the Secretariat. The Society's new journal, Asian Fisheries Science, begins in 1988. The planned increases in staff/activities of the other ICLARM program areas suggest that to meet publishing demand, improved facilities, such as a scanner to input text quickly, a reduction/enlargement camera and high-quality printer, as well as extra staff (editorial and drafting) will be needed. Computer networking to transfer files between editing and typesetting will also be advantageous.

All technical series titles are distributed free or in exchange to some 300 institutions. The remainder are sold at the lowest possible price. Newsletters are almost all distributed free.

A larger number of publications entails extra costs associated with handling and storage. ICLARM's modest stockroom is already overflowing and larger facilities will be needed during the coming five years. Handling and packing will become more time consuming also, not to mention order fulfilment and maintaining stocks at various distributorships, with an increasing stock list.

2. Maintenance of ICLARM's (public) library

The library at ICLARM headquarters in Manila has been open to the public since it began in 1978. The annual number of external users has grown rapidly over the years and could double by 1992 (Fig. 12) to nearly 2,500 on present trends. Should ICLARM move as planned to a site near the University of the Philippines, the increase will undoubtedly be greater and a "safer" figure might be 5,000 annual visitors for planning purposes. In both scenarios there is a critical need for more reading room. Numbers of books, reprints and serial titles will almost double during the five years under review. However, we should look beyond five years to 10 or even 20 years in planning the next expansion of library area. Clearly more personnel will be needed to handle enquiries from users and to maintain the collection. In the near future a photocopying machine and operator will be needed in the library to handle copying requests, currently serviced by ICLARM's machine two floors above. In view of the growing use of videocasettes for educational purposes, the library is beginning to collect relevant videos but cannot offer library users a viewing area. Video playing equipment will be needed either in the library or adjacent training area. Electronic mail connections on an experimental basis to the library from overseas groups have proven useful and could well become more a necessity than a luxury in the future, both for interlibrary loans/copying and for the information service.

3. Selective Fisheries Information Service (SFIS) Phase II: Project ADD

ICLARM carried out a very successful project entitled Selective Fisheries Information Service over three years, April 1984 - March 1987. The Service was directed to researchers in tropical third-world countries and consisted of a computer literature search, some photocopied key articles and advice from ICLARM's professional staff. Over 600 enquiries were handled and feedback from postcard questionnaires was highly positive. The service was supported by IDRC of Canada.

A proposal for a renewal of the Service has been approved by IDRC, using experience from SFIS to include two new features. First, it was found

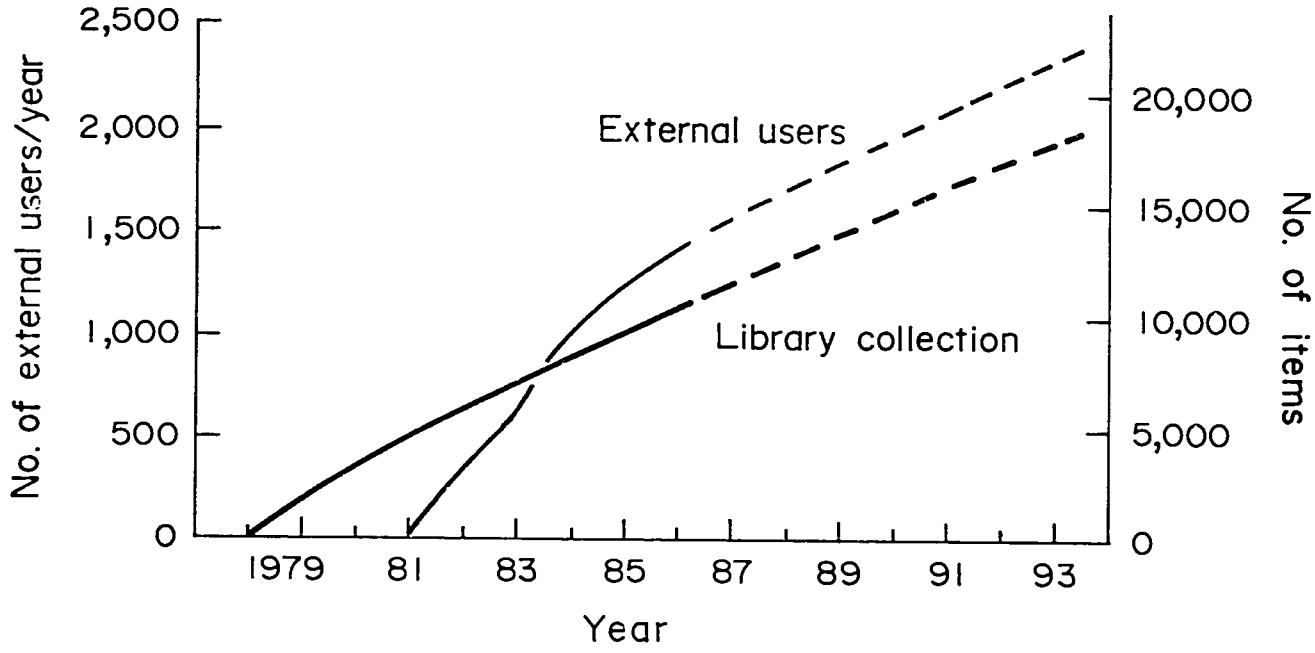


Fig. 12. Past and projected future numbers of (i) external users of the ICLARM library and (ii) books, monographs and serial titles in the library collection.

that researchers often had difficulty obtaining hard copies of references received through SFIS; for Phase II a larger document delivery budget is proposed. Second, it was discovered that results of computer literature searches were usually deficient in their coverage of subject matter and that researchers relying on them might miss much important literature. Several "mini-reviews" on selected topics were made, which were critical analyses of the content of computer searches and bibliographies using bibliometric/scientometric methods; to the analyses were added lists of prominent researchers/institutions, titles of useful new monographs and journals, together with some advice on reading material and contacts for new researchers entering the field. In support, enquirers were offered free copies of the computer search and other references used in the analyses.

The new two-year (initially) project proposes to undertake 50 "mini-reviews" for selected users of SFIS Phase II as well as provide increased document delivery to all users. Hence the subtitle of the project is "Project ADD," where ADD means "Analysis and Document Delivery".

4. SFIS African Module

During the SFIS project, IDRC requested that the information needs of African fisheries researchers be determined. A survey of 10 countries was conducted by ICLARM in 1986. It was found that African researchers have virtually no sources of current information other than through whatever personal contacts they may make. Most libraries are defunct and librarians in any case non-existent.

It is proposed to take advantage of ICLARM's new office in Malaŵi to share its information resources and to act as a focal point for SFIS enquiries in Africa.

The idea is to provide an information officer to the ICLARM office to enhance the information gathering and dissemination activities of the project leader by (i) announcing new material to researchers, extension workers and fishfarmers; (ii) offering free copies of publications by ICLARM, AIT, FAO, and IDRC and reprints incoming to the project library; (iii) distributing news articles about various aquaculture activities; (iv) advertising SFIS and referring research enquiries to SFIS in Manila; and (v) lending copies of accumulating African material to SFIS for microfiche preparation, thus forming a unique Asian source of African literature.

Some of these steps (i - iii) can be conveniently made through a regular letter to interested parties - a quarterly African letter, a small newsletter - to be distributed in bulk to the various African institutions and to African addressees of ICLARM's Naga as an insert. Such an African letter would also become the only informal "publishing" outlet for African aquaculture researchers, as none other exists at present.

5. Information sourcebook on tropical fisheries science

As part of its campaign to improve access to fisheries information, ICLARM has devoted its newsletter (Naga) to the subject on three occasions. A major finding from these newsletter issues was the diversity of information sources, their overlaps, and the many "undiscovered" or underutilized sources and services. A compilation of some articles from previous ICLARM newsletters and other sources together with new articles to be commissioned is planned. The result is expected to be a sourcebook which will prove invaluable for researchers and technicians.

6. Computerization of library holdings and dissemination

The library is developing several computerized databases:

- library holdings of monographs, etc.
- references to articles, mainly from journals, for publishing in the Information Department of Naga, the ICLARM Quarterly
- special bibliographies

It is hoped to enter all monograph, etc., titles into the computer to enable users to have instant access to the full library collection. Work has begun but additional help will be needed to input old as well as new titles. When the task is completed (i.e., all items back to 1978 are input) it is proposed to publish a fully indexed catalog to enable other libraries to compare and check their holdings.

The database of journal references published in Naga represents a unique current awareness source on tropical fisheries. It is based on an ongoing selection of journal articles, reports and monographs from all the material received by the library. Currently the entries over the past nine years since the newsletter began (1978) are being entered into the database and it is proposed to publish a 10-year compilation of these valuable references, together with indexes and lists of authors and addresses; the indexed authors' list will be a directory of researchers who have been working on tropical fisheries over the past decade.

Another publication planned is a list of serial holdings. Such lists are invaluable to libraries around the world.

To produce these publications, probably in 1989, assistance will be needed to accelerate inputting as well as a budgetary allocation for publication and distribution.

7. INFOTERRA Information Service

In 1987 a contract was signed with INFOTERRA, a service of the United Nations Environment Programme, for ICLARM to answer fisheries and resource management enquiries sent to INFOTERRA on their behalf. ICLARM is to be paid pro rata to a maximum of $5,000/year representing

around 100 enquiries. It is expected that this arrangement will continue through the next five years.

8. Needs, constraints and solutions to information access

As demonstrated in the case of Africa (see no. 4 above), an investigation of needs of a certain group may point to a unique solution in providing better access to information an fisheries. A proposal has been submitted to the Philippine Ministry of Agriculture and Fisheries entitled "Library based training and information service in fisheries and aquaculture". The grant initially would provide two years of support to ICLARM's library and ongoing training (see no. 2 above) and information dissemination activities. In addition a survey would be made of the needs of researchers in Philippine university, college, public and other institutional libraries. This survey should assist in determining the information needs of researchers in third-world countries in general, as well as of the Philippines in particular.

A second project is planned in the People's Republic of China to determine and respond to needs of fisheries researchers, through the Chinese Academy of Fishery Sciences (CAFS). Key elements are expected to be translations and information retrieval techniques. Initial contacts with Chinese officials indicate that a project of this nature will be welcome there. A broad Memorandum of Agreement between ICLARM and CAFS was signed in December 1987. Activities under the arrangement begin in 1988.

A third activity is the development of information exchange and support for the Bangladesh Agricultural Research Council (BARC). A broad Memorandum of Agreement between ICLARM and BARC was signed in late 1987 and activities begin in 1988 subject to funding.

9. Translations

ICLARM has always been mindful of the need to make information available across language barriers but has to date made modest inroads only, witnessed by eight published translations. Several ICLARM publications and articles from Naga have been translated into languages other than English by various agencies. However, as ICLARM's activities expand within Asia and into Africa and Latin America, it is clear that a systematic effort will be needed by ICLARM to cater for French, Spanish and Chinese researchers in their own languages. Such an effort will be expensive, require external support and will need to be based on a prior study of needs in the various countries involved.

10. Communications

ICLARM's regular communication channel to "staff, friends, colleagues and donors" is the occasional *ICLARM Newsbriefs,* while highlights of projects appear in *Naga;* an annual report is widely distributed. Publication advertisements, book fair attendance and press releases have been on an *ad hoc* basis. Following the recent establishment of the CGIAR's Public Awareness Committee of which ICLARM is a member, we have been prompted to begin to develop a long-term publicity action plan. The plan would be incorporated into the activities of a proposed "association of communication services", including both CG and non-CG centers.

B. *Information Research*

While the Information Services portion of the Information Program seeks to improve access to information, the long-term objective of the Research portion is to improve the quality and quantity of the information resource itself. Following are ongoing and planned projects:

1. Inhouse information research
2. Tropical fisheries citation analysis
3. Characteristics of the Asian aquatic science research community and literature.

1. Inhouse information research

A number of small projects, all directed to a better understanding of information resources and their use, are in progress or planned. The use of libraries by researchers is being studied in an effort to rationalize collections; pinpoint any problems in basic library use; plan resource sharing, etc. A study of ICLARM's library has been made and further studies in other libraries in the Philippines and selected third-world countries are planned.

A second project concerns use of reprints from scientific journals. Authors of articles in all issues of two journals have been sent questionnaires relating to the usefulness of reprints and from over 200 respondents data are now being analyzed. The analyses should suggest ways of improving reprint use or other mechanisms of information transfer.

ICLARM's experience in using a wide variety of information resources and in critical analysis of their usefulness has led to many ideas of use to researchers before and during the undertaking of a thesis or other project. It is planned to collate these ideas into a published guide entitled "Use of Information in Research Design and Reporting" for use of aquatic science researchers initially. A broader agricultural research guide may be published later, in cooperation with other international centers in the CGIAR system.

Finally, citation analysis of ICLARM publications will be carried out as a case study of the impact of fisheries literature; the study could become a

model for other institutions. Through this study, ICLARM will learn for the first time to what extent its publications have been used by other researchers in various countries.

Further projects in the conceptual stage concern measuring the "current awareness" of researchers through their article references.

2. Tropical fisheries citation analysis

Institutional studies of the citations of their publications (as proposed above for ICLARM) only scratch the surface of the fisheries field as a whole.

An analysis is proposed of authorship and citation of all papers dealing with tropical fisheries and aquaculture over a certain period to reveal the patterns of publishing and usage of published material in this field. Apart from highlighting important research areas and papers, it is expected that the analysis will quantify the importance of "grey" literature in fisheries generally and point to ways to optimize both publishing and use of fisheries literature in the tropics. The project could become a model for similar studies in other fields in the tropics, since the problem of grey literature is by no means confined to fisheries. Initially, a two-year module within Asia is proposed to begin in 1989, with African and Latin American modules to follow.

3. Characteristics of the Asian aquatic science research community and literature

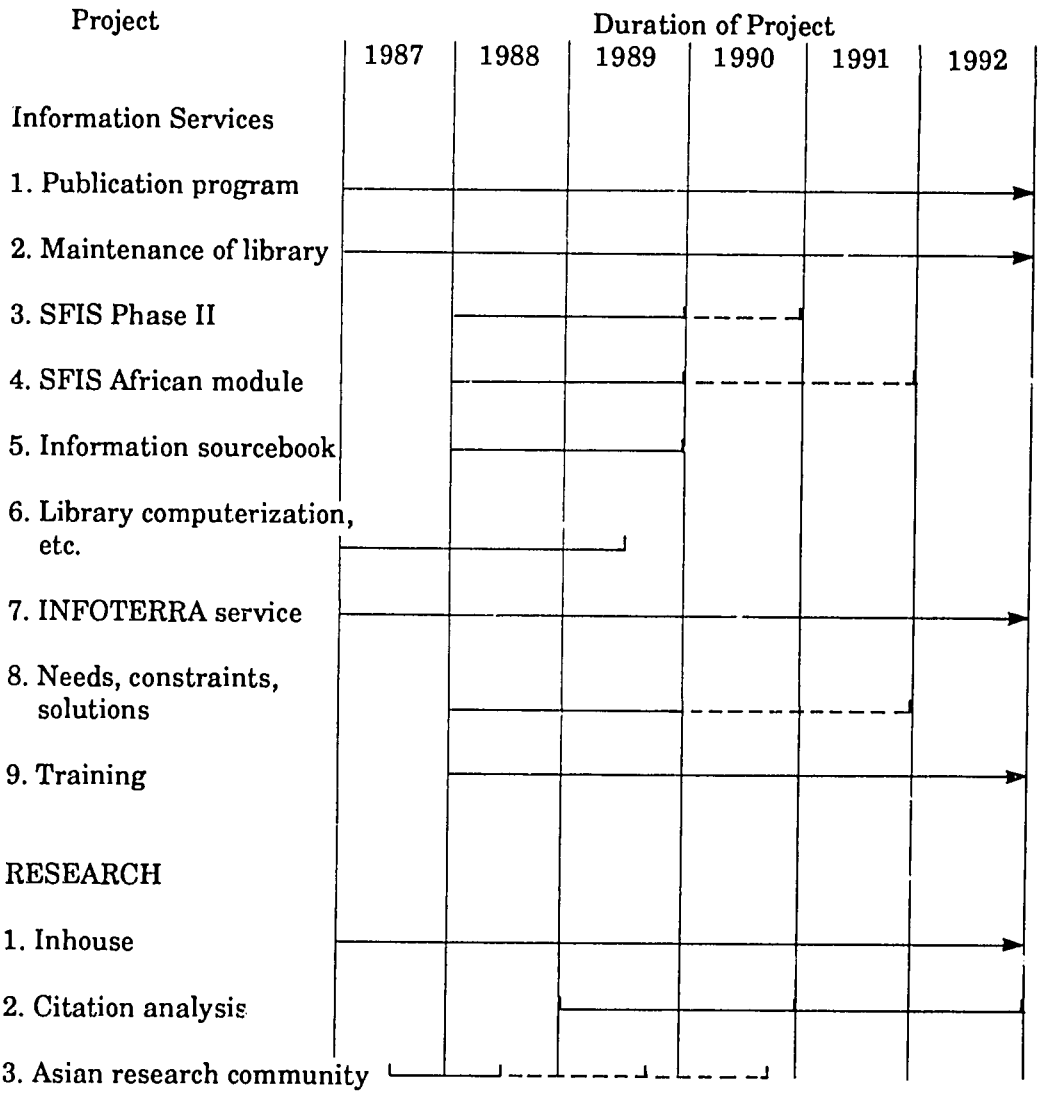
This project is currently being undertaken by a research officer of the Asian Fisheries Society and is supervised by ICLARM. The primary objective of the study is to determine the publishing and academic characteristics of Asian fisheries scientists and through analysis of these, to present a quantitative assessment of Asian fisheries science. The results of the study are intended to form a basic tool for researchers, educators, administrators and publishers.

It is expected that the results of the project, to be completed by mid-1988, will lead to further studies that seek to explain some findings of the project and to provide suggestions for improving, for example, communications between certain groups. Such studies will continue to be under ICLARM's supervision.

The Information Program also conducts a significant amount of training, which is recorded in the Education and Training Section.

Work Program

The time frame for these projects is in part speculative, as it depends on funding. The schedule below is in two parts, for informative service and research activities, respectively. Dotted lines indicate possible extensions to projects or follow-on projects.



A summary budget for the Program for 1988-1992 is included in the complementary document, ICLARM Five-Year Plan, Part 2. Projected Budgets.

STAFFING AND BUDGET

Background

ICLARM, being similar to the international agricultural centers that are part of the CGIAR system, has adopted similar financial management terminology. Like the CGIAR Centers, ICLARM lacks endowment funds. The Center makes distinctions among funding for unrestricted core, restricted core and special projects. It is important to point out that the cooperative approach to research that typifies ICLARM's program means that a portion of the restricted and special project funds provided to ICLARM simply pass through the Center to its cooperators. The most prominent example of this is the ongoing ASEAN/US Coastal Resources Management Project where approximately 80% of the total US$5 million budget over four years (1986-1989) passes through ICLARM to ASEAN institutions. The number of special projects outside core program themes has been minimal during most of the ICLARM's life but increased quite dramatically in 1986 as ICLARM fought for survival. The Five-Year Plan envisions a reversal of this trend and renewed prominence of unrestricted and restricted core support and activities.

After its 1977 incorporation in the Philippines, the Center received unrestricted core support first from the Rockefeller Foundation, then later from the United States Agency for International Development (USAID), the Australian International Development Assistance Bureau (AIDAB), the Royal Norwegian Agency for International Development (NORAD), and most recently from the Danish International Development Agency (DANIDA) and the German Agency for Technical Cooperation (GTZ). Restricted core support developed slowly, with the first grants made by the United Nations University and the Australian International Development Assistance Bureau in 1980, the German Agency for Technical Cooperation in 1981, and more recently the Ford Foundation, IDRC of Canada, UNDP, the Ministère de la Recherche et de l'Enseignement Superieur, France and the World Bank. In its early years, ICLARM was thus dependent upon a relatively small group of core supporters (see Fig. 13), but this number has grown steadily since 1980.

Despite this diversified support, in 1985, ICLARM's revenue profile changed significantly. As the Rockefeller Foundation shifted its program away from Asia and concluded its unrestricted core support for ICLARM at the end of 1984, the annual level of unrestricted grants to the Center declined by 57%. For the first time in ICLARM's history, in 1985 the level of restricted and special project grants exceeded that of unrestricted grants (Fig. 14). Total revenue dropped 25% from US$1.76 million in 1983 to US$1.32 million in 1985.

The substantial reduction in unrestricted core support, which had supported headquarters' scientific and information staff and facilities and permitted research initiatives, forced ICLARM to restrict its research

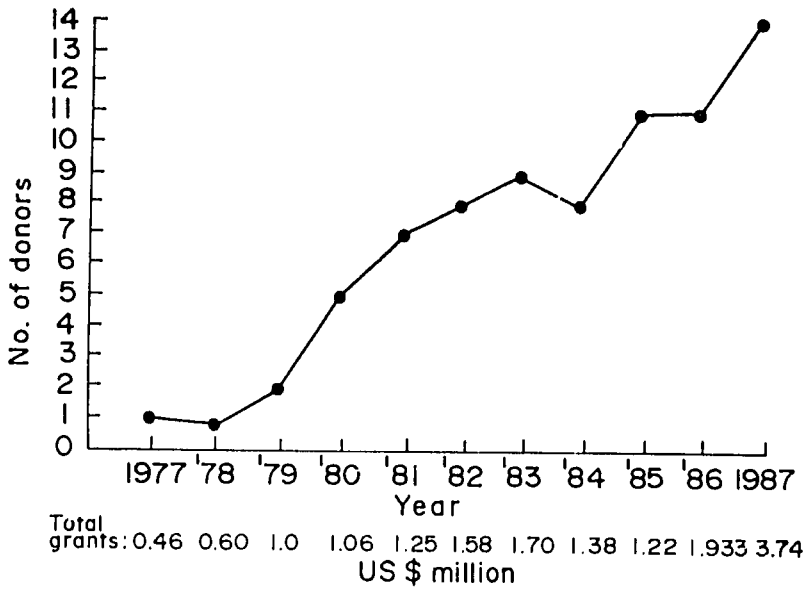


Fig. 13. Donor numbers and total grants. Above figures and number of donors include all categories of support (unrestricted and restricted core, special projects).

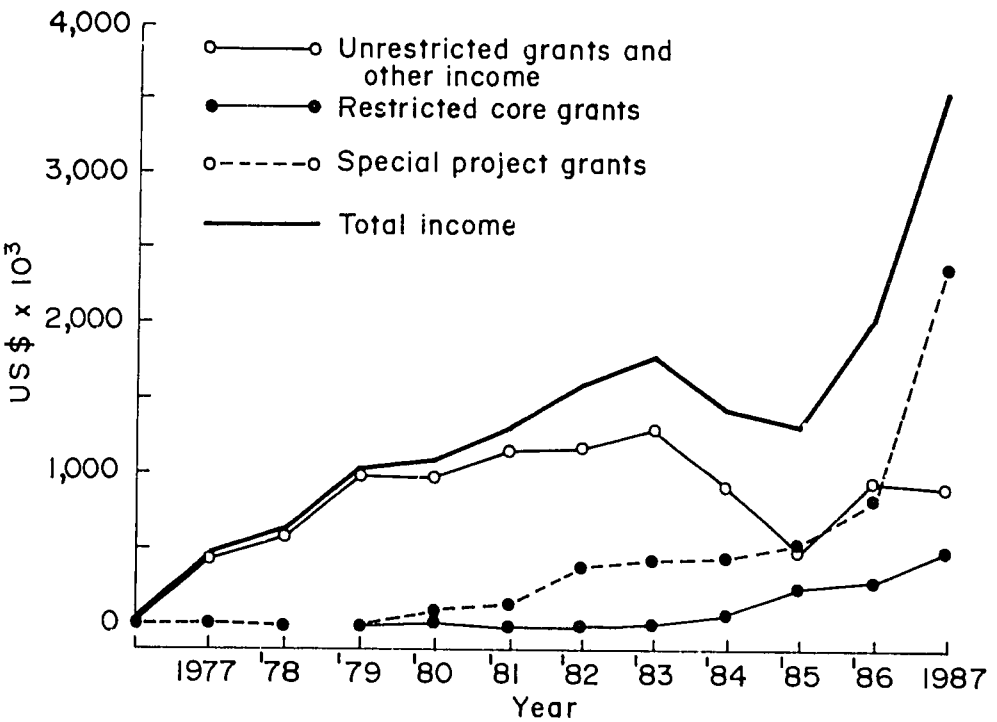


Fig. 14. ICLARM income profile, 1981-1986. Of the total US$1.47 million restricted grants in 1986, US$651,467 (44%) may be classified as restricted core and US$820,374 (55%) as special projects.

program activities. The 1985 financial strategy adopted by ICLARM was to conserve whatever resources were available in order to keep key headquarters staff positions filled for as long as possible. Thus, ICLARM cancelled or indefinitely deferred several in-house projects, publications and other program activities for which restricted funding could not be found and from which staff time had to be diverted. A significant portion of staff time was channeled, by necessity, into income-generating consultancies, the preparation of project proposals and involvement in funded projects. Every effort was made to increase and standardize the overheads charged by ICLARM for restricted project activities to reflect real costs of project implementation.

Since 1985, ICLARM has made considerable progress to increase and further diversify its support (see Appendix A), though the Center remains too heavily dependent on short-term restricted core and special project funds (Fig. 14). Of total income in 1987 of almost $3.2 million, approximately 27% was unrestricted core in nature, 43% was restricted core, and 30% was special project. At the end of 1987, ICLARM received the welcome news of a new unrestricted core grant from the World Bank, which established a new fund specifically to assist centers outside the CGIAR which engage in natural resource management issues.

ICLARM had sixteen supporters in 1987, and this number is expected to grow through the activities of the ICLARM Support Group which was formed at the end of 1986. Current Chairman is Mr. Timothy Rothermel, Chief of Global and Interregional Programs of UNDP. The Support Group meets annually, usually during the mid-year meeting of the CGIAR.

Five-Year Staffing and Budget

ICLARM's future over the coming five years is a mixture of excellent research and training opportunities, tempered by financial constraints. The Center's Aquaculture Program is poised for new advances in genetics and farming systems research, if the necessary funds proposed for the modest research facilities and associated networks can be raised. The Resource Assessment and Management Program is expanding into research, planning and training on coastal zone management, but the number of staff to lead the other key activities of the program in methodology development remains too small. ICLARM's social science activities, including research networks, have much promise but are also financially constrained. The Center's rented headquarters facility in Manila is again becoming inadequate for the scientific, information and support staff; a more permanent home for the organization is needed.

In sum, the annual budget of ICLARM is expected approximately to double over the next five years. Details of the projected budget for ICLARM over the 1988-1992 period can be found in Part 2 of this Five-Year Plan (Projected Budgets).

Staffing is shown in Table 6. Details of 1988 staff are given in Appendix B.

Table 6. Current and projected professional and mid-level professional staff.

Professional Staff

	Current Staff	1988	1989	1990	1991	1992
1. ADMINISTRATION						
Director General	Smith	1	1	1	1	1
Deputy Director General	—	1	1	1	1	1
Manager, Administration and Finance	Rodriguez	1	1	1	1	1
2. AQUACULTURE PROGRAM						
a. HEADQUARTERS						
Program Director	Pullin	1	1	1	1	1
Sr. Scientist, Economics	—	0	1	1	1	1
Post-Doc. Fellow, Genetics	Eknath	1	1	1	1	1
b. AQUACULTURE GENETICS UNIT						
Director/Sr. Scientist	—	0	1	1	1	1
Associate Scientists	—	0	1	2	2	2
c. INTEGRATED FARMING UNIT						
Director/Sr. Scientist	—	0	1	1	1	1
Associate Scientists	—	0	1	2	2	2
d. COASTAL AQUACULTURE CENTER						
Hatchery Manager	Usher	1	1	1	1	1
Senior Scientist	—	0	1	1	1	1
Associate Scientists	—	1	1	2	2	3
e. AFRICAN INTEGRATED FARMING						
Project Leader	Balarin	1	1	1	1	1
Associate Scientist	—	0	1	1	1	1
f. ASIAN RICE-FISH FARMING						
Project Leader	Dela Cruz	1	1	0	0	0
Associate Expert	Van Dam	1	1	0	0	0
3. SOUTH PACIFIC OFFICE						
Director/Sr. Scientist	Munro	1	1	1	1	1
4. RESOURCE ASSESSMENT AND MANAGEMENT PROGRAM						
Program Director	Pauly	1	1	1	1	1
Sr. Scientist, Coastal Zone	Chua	1	1	1	1	1
Associate Scientist, Coastal Zone	White	1	1	1	1	1
Associate Scientist, Resource Economics	Aguero	1	1	1	1	1
Associate Scientist, Sociology	—	0	1	1	1	1
Associate Scientist, CAM	—	1	1	1	1	1
5. SOCIAL SCIENCES						
Sr. Scientist/Network Coordinator	Lampe	1	1	1	1	1
6. EDUCATION AND TRAINING						
Director (concurrently Deputy DG)						
7. INFORMATION						
Program Director	Maclean	1	1	1	1	1
Editor	—	—	—	1	1	1
TOTAL PROFESSIONAL STAFF	15	18	26	28	28	29

Mid-level Professional Staff

	Current Staff	1988	1989	1990	1991	1992
1. ADMINISTRATION						
Chief Accountant	Apostol	1	1	1	1	1
Administrative Assistant	Veneracion	1	1	1	1	1
Asst. Manager, Finance	—	0	1	1	1	1
Project Administrator	—	1	1	1	1	1
Senior Secretary	Bernardo	1	1	1	1	1
2. AQUACULTURE						
a. HEADQUARTERS						
Program Asst., Economics	Bimbao	1	1	1	1	1
Program Asst., Biology	—	1	1	1	1	1
b. AQUACULTURE GENETICS UNIT						
Administrative Assistant	—	0	0	1	1	1
Senior Technicians (2)	—	0	0	1	2	2
c. INTEGRATED FARMING UNIT						
Administrative Assistant	—	0	0	1	1	1
Research Associates (2)	—	0	0	1	2	1
d. COASTAL AQUACULTURE CENTER						
Research Associate	Govan	1	1	1	1	1
3. RESOURCE ASSESSMENT AND MANAGEMENT PROGRAM						
Program Assistant	Cruz	1	1	1	1	1
Project Specialist, Coastal Zone	Paw	1	1	1	1	1
Project Specialist, Coastal Zone	Guarin	1	1	1	1	1
4. SOCIAL SCIENCES						
Research Associate	—	0	1	1	1	1
5. INFORMATION						
Research Associate, Information	—	1	1	1	1	1
Chief Librarian	Temprosa	1	1	1	1	1
Managing Editor	Dizon	1	1	1	1	1
TOTAL MID-LEVEL PROFESSIONAL STAFF	10	13	15	19	21	20

EXPECTED IMPACT AND PROGRESS

ICLARM's immediate future remains a mixture of opportunities and financial constraints. These constraints obviously make planning problematic. However, the more positive view has been taken in this document that the ICLARM programs, if presented in a reasonably comprehensive and forward-looking fashion, will attract the necessary long-term support. This has been the primary purpose of the preceding sections of this Five-Year Plan.

A key question to be asked in this context is what will be the likely impact of the ICLARM program.

Aquaculture

It is important to realize that two of the three major aquaculture activities proposed, that is, the genetics and integrated farming systems research units and aquaculture affiliated networks, will not be underway at the earliest until halfway through the coming plan period (1988-1992).

The likely impact of any food production research and training program is difficult to forecast with precision, especially when, as in the case of aquaculture development, it includes the need to address fundamental questions regarding the scope for growth of the systems under study. However, ICLARM is confident that its aquaculture program will lead in the long term to highly significant increases in cultured fish production, income improvement and nutritional benefits for the third-world countries of Africa, Asia and the Pacific. The potential benefits for Latin America and the Caribbean are less clear, but may still be significant for communities remote from marine fisheries.

The continuing activities of headquarters and the networks will undoubtedly assist hundreds of researchers in third-world countries to improve their research methods and their sources of information. Indeed, this will continue to be a primary goal of ICLARM. The long-term impact of this on the currently very weak research base for tropical aquaculture will be enormous.

The genetics program will provide a focal point for tilapia and carp researchers worldwide, who will both supply and receive information, training and improved breeds of fish. The first improved tilapia strains are expected to be available for release within five years. Within 10-15 years, tilapia production in Asia is expected to increase about five-fold as a direct consequence of the development of improved breeds and the adoption of suitable farming systems. For the Philippines alone, this would mean an annual production of 200,000 t/year, probably surpassing current milkfish production, and thus making tilapia the most popular cultured species in the

country. Taiwan has already undergone such a transition. However, genetic deterioration has begun to set in and research is clearly needed to sustain this initial progress.

The integrated farming program will bridge the traditional gap between aquaculture and agriculture. The program's 'whole farm' approach in research and training will greatly improve the cooperation between researchers and extension officers in these complementary sectors. The impact of the program will depend on national institutions, with which ICLARM will link through networks, and the effectiveness of their extension programs. Demonstrations of high yields on experimental stations of an international center such as ICLARM's integrated farming systems unit are not enough to ensure widespread implementation of results. For example, manured pond aquaculture and rice-fish integrated farming have hardly developed at all in the Philippines, despite highly encouraging demonstrations in that country. It is not yet fully understood whether the constraint lies in extension of the technology or in other economic, social or institutional factors. These constraints are currently being investigated by ICLARM and cooperating groups in Asia.

It can be said, nevertheless, that the program will produce vital information and well-trained professionals for the future development of integrated agriculture-aquaculture farming systems in Asia and Africa and possibly other regions and that the fish production from such systems will be a major source of profit and nutritional benefit for small-scale farmers.

The development expected can be described in terms of the evolution of farming systems worldwide. The most primitive levels of settled agriculture (non-integrated and crop-dominant, with few livestock) are still prevalent in tropical third-world countries. The implementation of crop-livestock-fish integrated farming could raise millions of third-world-country small-scale farmers to a higher level of farming systems development -- fully integrated, with livestock using crop by-products, ponds receiving crop and livestock by-products and other interactions, thereby making use of all available resources for maximum benefit.

The integration of a fish subsystem can provide much-needed diversification and increased profitability for rice-dominated systems. For Africa, the prospects are less certain, but it is probable that a fish subsystem could also greatly improve settled agriculture there (maize-based and other systems) given adequate water and suitable climate conditions.

Measurement of progress for the Coastal Aquaculture Center in the Solomon Islands will be a long-term activity because the major giant clam species on which research is being conducted takes seven years to reach maturity. Because the work in this Center is to be fairly applied research, success will be measured initially by the receptivity of South Pacific island nations to undertake culture of these reef species and the degree to which the income earned from such culture activities accrues to island communities rather than to outsiders. Progress will also be measured in terms of success in hatchery production and establishment of initial growout systems.

Resource Assessment and Management

The expected impact of the activities planned in the next five-year period for the Resource Assessment and Management Program is considerable, but of a nature different from that of the Aquaculture Program. This is mainly because ICLARM's research and training activities in resource assessment and management are designed to alleviate stated, and presently unmet, needs of the communities of fisheries scientists in tropical third-world countries, and of various agencies involved in resource assessment and management, rather than needs of the fisheries sector per se. The pilot studies, such as those to be conducted in coastal zone management, are expected to explicitly address questions of implementation and impact in their second phase, to begin 1990.

The impact of the Resource Assessment and Management Program has been well demonstrated over the past five years in the adoption of stock assessment methodologies developed at ICLARM, in at least 30 countries. These methods have made stock assessment possible in many situations where it was previously impossible or very difficult. The Program has kept in the forefront of development with methods adapted for programmable calculators and most recently for microcomputers. Thus, future impact in this field will be a measure of the spread of these refinements, all of which make stock assessment easier and cheaper and biologists more confident in providing advice.

Impact of the Coastal Resources Management Program is expected to be in the form of implementable coastal management plans in the ASEAN nations. The project itself expects to execute a subsequent implementation phase and thus ensure the impact of these plans.

In the longer run, the refined stock assessment methodology will merge with information systems (including Geographic Information Systems) expected to become a major component of the Coastal Resources Management Project. Social science elements will also be included to create holistic management planning information systems. The mid-term impact, then, is expected to be the adoption by third-world countries of such systems. Ultimately, impact will be seen in the implementation of these aquatic resource management plans.

Social Sciences

With the development of more effective linkages to the fisheries policy establishment within Southeast Asia, it is expected that the results of research of the Asian Fisheries Social Science Research Network will effectively influence management policy and program formulation. These links will be forged through collaboration in research and research planning and through more effective national networking than has heretofore been practiced. A much greater use of national workshops and seminars will be made in the coming years to assure that research results reach

decisionmakers and that research programs are planned with the cognizance of these decisionmakers. Continued training in research methods will be a feature of the Network.

As mentioned above, social science elements will be integrated with biological information in creating holistic management planning systems. This is a longer-term goal where impact will be measured by the adoption of such systems in third-world countries.

In addition, the Network research will increasingly form the basis for educational programs in fisheries economics in Asia at the undergraduate as well as the graduate level.

Progress will be measured by: 1) identifiable use of results in policy and management decisionmaking; 2) identifiable use of results and methods in extension schemes for aquaculture and fisheries. In addition, the more conventional secondary measures of impact will also be used, such as: 1) publications produced, 2) publications distributed, 3) publications requested and 4) refereed journal article publications.

Asian fisheries scientists have established very high levels of professionalism in research and support of development. Within this group, the number of economists and other social scientists is relatively small and their impact has been relatively limited. During the next five years the Network will promote a greater participation of social scientists in Asian fisheries affairs through a stronger contribution to the Asian Fisheries Society and its journal, Asian Fisheries Science, based upon a strong management-oriented research program.

Education and Training

All of ICLARM's major programs in aquaculture, resource assessment and management and social sciences have built-in training activities, such as short courses and internships. These activities will continue, indeed intensify, during the coming five-year period. The success of these activities will be measured by fairly traditional approaches, including: (1) number of trainees and interns, (2) participant and staff evaluations of courses offered and (3) degree and content of post-course followup. This last point is a key element in ICLARM activities that attempt to strongly link research, training and information.

ICLARM's Education activities will concentrate upon preparation of educational materials suitable for the teaching of tropical fisheries, aquaculture and coastal zone management. Progress will depend not only on identifying appropriate individuals both within and outside ICLARM to contribute to this effort, but also upon an initial assessment of educational needs. Since the assessment will take several years, ICLARM contributions to this area during the coming Five-Year Plan period are expected to be modest, picking up in the 1990s. However, the impact in that decade is likely to be very great, as ICLARM educational materials are adopted for use by educational institutions throughout the tropics. Evaluation of the impact of

this ICLARM activity will depend primarily upon the rates at which the proposed educational materials are produced and put into effective use. As noted below, the impact of the center's existing technical publications is already considerable.

Information

ICLARM's information activities to date, publications and information services, have already achieved demonstrable impact. Comments received from a 1986 survey questionnaire on Naga, the ICLARM Quarterly, show some of the enthusiasm for this unique publication:

- Naga is very hepful in the third-world countries. Surely it will help to change our economy (Bangladesh)
- A wonderful name, a wonderful newsletter (Brazil)
- Very beneficial quarterly to our organization (Fiji)
- Naga is very informative and helpful to the research workers (India)
- This magazine is very important to us (Indonesia)
- An excellent publication (FAO)
- The Information Department is the best of its kind. I save lots of time by reading it only - not others (Papua New Guinea)
- Naga is very informative, unique magazine (Philippines)
- It is a good publication which we all appreciate (Yemen)
- Please continue with your good work (Zambia)

Naga has a free circulation of around 4,000, but according to an ICLARM survey is read by at least 15,000 persons.

ICLARM's technical publications are distributed free to fisheries departments and libraries throughout the third world and in exchange for many of the important journals in the ICLARM library. Also they are sent for review to leading journals and are well received. For example:

- A Hatchery Manual for the Common, Chinese and Indian Major Carps, 1985.
  "This book is undoubtedly a valuable addition to the available literature" (Aquaculture). Printed - 2,000 copies. Status - sold out.
- Fish Population Dynamics in Tropical Waters: A Manual for Use with Programmable Calculators. 1984.
  "The first comprehensive attempt to use models in a way that is easy to use" (Fisheries Research). Printed - 2,000 copies. Status - 380 left.
- The Biology and Culture of Tilapias 1982; reprinted 1983, 1984.
  "I would strongly recommend this book for all students, researchers and culturists of tilapias" (Aquaculture). Printed (total) - 4,000. Status - 80 left.
- Integrated Agriculture-Aquaculture Farming Systems. 1980; reprinted 1984, 1986.
  "It is difficult to do justice to this ICLARM publication, so much of which is highly quotable" (Fish Farming International). Printed (total) - 3,000. Status - 110 left.

All the above books are being used as text books in one or more institutions. Countries in which we are aware of ICLARM books being so used include Malaysia, Nigeria, the Philippines, Thailand and the USA; they are used as texts also in FAO and US Peace Corps training courses. In all there are over 50 technical publications enjoying wide readership. Further, while we have not yet made a formal analysis, it is clear that nearly all these publications are very well cited by other authors. The publications are certainly being well *used*.

With regard to information services, the major activity has been a three-year (1984-87) IDRC-supported project which provided a question/answer service to over 700 enquirers. Again, there were hundreds of complementary messages received through postcard questionnaires, such as:

> "Excellent service, especially for young biologists" Dr. F. Pineda Polo, Colombia.
>
> "The information obtained has greatly improved the quality of our projects" C.L. Kalonga, Tanzania, East Africa.
>
> "The retrieved materials helped in locating new literature previously unknown. Very useful service". K. Viswanath, India.
>
> "The information I received proved to be very useful. Thanks for the quick response". Dr. G.E.M. Ogutu, Nairobi, Kenya.

It is expected that this project will again be funded for 1988 and 1989 at least. Improvements are planned so the impact is expected to be at least as great as in the past. Further, the proposed "African module" adjunct to the project should impact greatly on aquaculture researchers in that continent because it will be backed up by ICLARM aquaculture staff within Africa.

Through its Information Program, ICLARM helped to initiate the Asian Fisheries Society and has provided the secretariat since 1984. Membership of the Society has grown to 1,000 scientists, technicians and students, who are beginning to benefit from free and inexpensive literature, while research grants and a Society Journal (edited and published through ICLARM) will soon be established. The Society's impact is very positive and is drawing support from a number of donors.

All of the above activities and others will continue in the coming Five-Year Plan period and are expected to have similar impact.

CONCLUSION

Tying Together the Major Themes

The thrust of ICLARM's research has gradually shifted over the past decade from documenting fisheries and aquaculture problems, to evaluating alternative solutions and carrying out related research. For example, the Center moved closer to the management end of the spectrum in 1986 with the beginning of the ASEAN/US Coastal Resources Management Project, coordinated by ICLARM. Nevertheless, development of research methodology has been and will remain a strong theme in ICLARM's resource assessment and social science research.

At the same time, the Center is finding that its research results and considered advice, both most often developed in cooperation with national institutions, are often slow to find adoption. At the time of ICLARM's founding, the expectation was that the results of the Center's activities would find their way fairly rapidly into the mainstream of fisheries policy. In the third world, the links between research and impact have been found not to work that way. In many countries, national fisheries research activities, with which ICLARM's network programs are intricately linked, appear to be an end in themselves with little impact on government policy. National scientific progress is fragmentary as a result of poor access to information and lack of communication amongst scientists.

These problems are created in part by financial problems. Policymakers do not look hard at national fisheries researchers for advice. Policymakers are, expectedly, even more distant from conclusions offered by an international center. Put another way, an excellent publication record, such as ICLARM has, is not enough.

To overcome this barrier, common to many countries in the tropics, the options for ICLARM were either to itself prepare and distribute extension material or to move further towards resource management issues and physical centers for aquaculture research. Given ICLARM's mandate, the latter course has been chosen and while some extension literature is being prepared in specific projects, the center's primary thrust in the coming years will be to bridge the gap between research and management.

It is recognized that policymakers are influenced not only by fisheries-related matters, including biological, social and economic considerations, but also by similar considerations in other, interacting sectors, from agriculture to industry.

Research is needed to develop the methodology that will provide fisheries and aquaculture policymakers with quantitative information on all relevant issues in such a way that the maximum number of options can be explored and evaluated: an information system to answer "what if?" questions across the broad range of issues involved. It is this proposed system that will be the key element tying together ICLARM's diverse activities.

Beyond the development of such a system there are a host of research issues regarding implementation of management decisions, some of which ICLARM already addresses; others will develop with the proposed information system.

Importantly, this thrust will make further use of ICLARM's interdisciplinary approach and serve to unify the current directions of research in the different program areas and networks. Thus the aquaculture systems developed will require parallel development of effective management schemes just as in capture fisheries. Both will become elements in the proposed planning and management information system.

External Considerations

Uncertainty has been a fact of life at ICLARM for several years now and this situation is unlikely to change in the very near future. While the Center has begun to achieve an element of cohesion in support through the formation of the Support Group under UNDP leadership, much remains to be done. While each major program of ICLARM has secure elements within it due to longstanding interest of specific donors, other elements are newer or more high-risk in nature, thus not yet attracting the level of donor support required.

The decision of the TAC and CGIAR with respect to possible long-term support for selected aquaculture themes will be a critical element in attracting the support necessary for the two aquaculture units (genetics and integrated farming systems) proposed. Though relatively modest in nature when compared to other international agricultural centers (several of which work on topics of much less importance economically or nutritionally than fisheries and aquaculture), each of these units and associated networks will require funding quite considerably above current levels of support for ICLARM's aquaculture program. This is appropriate for an activity which is emerging from its documentation phase to a research phase. If the CGIAR postpones its decision to provide aquaculture support, or rejects the idea altogether, ICLARM will have to raise the required funds elsewhere.

Other core activities of ICLARM in Resource Assessment and Management and Social Sciences, not to mention the Coastal Aquaculture Center which may not in any case be considered for support by the CGIAR at this time, will also require longer-term financial support than that presently available. Planning and successful fundraising in these areas will require stronger linkages with related international bodies, both intergovernmental and nongovernmental, than ICLARM currently has. Preliminary discussions with donors and other international research centers, particularly those with a natural resource or resource management mandate all of which including ICLARM are currently outside the CGIAR, have already begun to explore other consortium possibilities.

During the past three years, the severe funding shortage of ICLARM has led the Center into several areas of work that would not normally be part of

the core program. This has included an excessive amount of short-term consulting work, particularly for development banks, and several projects where a research role was not paramount. Such activities need to be curtailed.

Staff secondments from other agencies need to be more fully explored as an alternative to core financial support. Only two such assignments (one each from UK and the Netherlands) have been arranged to date; additional possibilities, consistent with the ICLARM staffing plan, both in area and levels of expertise, need to be examined. The Five-Year Plan and its outline of staffing requirements should permit this.

The ICLARM Five-Year Plan, especially the aquaculture section, highlights for donors the geographic focus of the Center's program. While the program will be expanding cautiously in Africa and Latin America, the primary focus will remain Asia and the Pacific, where by far the greatest numbers of poor and protein-malnourished people live. During the next five years, linkages will develop with Africa and Latin America, primarily in the context of ICLARM's attempts to foster South-South exchange through its various networks.

Attracting the levels and duration of support outlined in this Five-Year Plan will permit ICLARM to concentrate upon the more basic research issues which it was created to address. Certainly, there is no shortage of tasks to be undertaken in the area of more applied research, but it is ICLARM's view, consistent with that of other international agricultural centers, that this work should primarily be the responsibility of national institutions. Interaction between ICLARM and these national institutions should come mainly through research networking, training and information exchange, approaches in which the Center already excels.

Finally, ICLARM's extremely active publication and information program, expanded as proposed in this Five-Year Plan to include translations and educational materials, should continue as a key element of the core program, not collapse into a minor program support activity as some have suggested.

Funding Considerations

ICLARM, with ten years of research, training and information experience, is recognized globally as being in a leadership position on many aquatic resource management issues. The number of donors supporting the institution has more than doubled in the past three years, and opportunities for collaborative work far exceed the Center's abilities to respond. Both reflect confidence in ICLARM's program.

Continued growth in number of donors, and in the size of the grants of each, is thought by the Center's staff and Board to be achievable now that the Center's Support Group has been formally initiated at the end of 1986. Already, new core grants, though initially small, materialized in 1987 from several new donors, including the governments of France, Federal Republic of

Germany and Denmark. At the end of 1987, ICLARM was informed of a new grant from the World Bank ($800,000 in 1988) awarded to the Center from a newly established fund to assist worthy institutions outside the CGIAR system.

In 1987, the ICLARM Board of Trustees approved a core budget for ICLARM of US$2.30 million, excluding special projects which amounted to another US$0.97 million. During the years of the Five-Year Plan (1988-1992) ICLARM expects that the annual budget of the Center will grow from US$3.67 million to US$7.12 million, an increase of 94%. Budget details can be found in Part 2 (Projected Budgets) of the ICLARM Five-Year Plan (1988-1992).

To achieve this planned budget increase, ICLARM staff, Trustees and Support Group members will need to work in unison to persuade additional donors to support the organization and existing donors not only to increase their support but also to shift much of it from short-term special project support to longer-term unrestricted or restricted core support. The staff and Trustees of ICLARM are confident that this can be achieved, the only variable being the time that it will take.

The Five-Year Plan of activities outlined in the previous sections should be viewed as a serious challenge to those involved with ICLARM. For too long, the Center has been forced to struggle along on minimum funding and with a very small professional staff. It is the intention of the senior staff and the Board of Trustees to persuade donors that the work of ICLARM is worthy of the levels of support outlined in this document and for the very exciting activities envisaged.

APPENDIX A. CONTRIBUTIONS TO ICLARM (1977-1987) BY DONOR AND BY YEAR (US$)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987[1]	Total
A. UNRESTRICTED GRANTS												
Rockefeller Foundation	453,748	600,000	700,000	750,000	812,000	850,000	850,000	720,000				5,735,748
United States Agency for Intl. Dev.			300,000	200,000	300,000	320,000	320,000		300,000	523,662	449,338	2,713,000
Australian Intl. Dev. Assistance Bureau						20,986	29,750	83,257	46,350	105,315	107,152	392,810
San Miguel Corporation								714	1,047			1,761
Planters Products Inc									1,047			1,047
Norwegian Ministry of Dev. Cooperation										52,009		52,009
Danish Intl. Development Agency											63,591	63,591
Subtotal	453,748	600,000	1,000,000	950,000	1,112,000	1,190,986	1,199,750	803,971	348,444	680,986	620,081	8,959,966
B. RESTRICTED CORE GRANTS[2]												
Rockefeller Foundation				22,795				50,000	50,000	8,470		131,265
Food and Agriculture Organization							6,703	5,000	5,000	5,172	7,429	29,304
Ford Foundation									165,138	51,186	138,553	354,877
New Zealand Embassy									12,582			12,582
Australian Intl. Dev. Assistance Bureau									53,397			53,397
United States Agency for Intl. Dev.										85,987	129,834	215,821
German Agency for Tech. Cooperation (GTZ)										52,008	51,377	103,385
United Nations Development Programme										42,000	10,700	52,700
International Development Research Centre										12,775	88,890	101,665
Overseas Development Administration										19,718	6,582	26,300
Skaggs Foundation											10,000	10,000
Norwegian Ministry of Dev. Cooperation											13,427	13,427
Australia and Pacific Science Foundation											24,228	24,228
Asian Development Bank											5,300	5,300
Subtotal	0	0	0	22,795	0	0	6,703	55,000	286,117	277,316	486,320	1,134,251

C. SPECIAL PROJECT GRANTS[2]

Rockefeller Foundation	3,000				32,947							35,947
United Nations University				20,000	20 000							40,000
New Jersey Marine Sciences Consortium				10,000	6,000	31,283	10,000					57,283
Australian Intl. Dev. Assistance Bureau				57,845								57,845
United States Agency for Intl. Dev.					6,245							1,349,331
German Agency for Tech. Cooperation (GTZ)					55,234	269,597	231,165	191,588	292,366	346,767	996,319	1,575,915
United Nations Development Programme					15,292	23,638	33,379			260,355	275,610	123,203
Philippine Council for Agriculture and Resources Research and Development										18,000	32,894	
Kuwait Institute for Scientific Research					2,850	10,426						13,276
International Development Research Centre						51,856	54,447	67,721	30,883			204,907
Intl. Bank for Reconstruction & Development							117,109	200,754	225,906	118,387	14,683	676,839
Ford Foundation										89,637	221,069	310,706
Der Bundesminister für Wirtschaftliche Zusammenarbeit (BMZ)											69,853	69,853
Food and Agriculture Organization										8,114	47,416	55,530
Asian Development Bank											15,128	15,128
Peru—Programa Cooperativo Peruano											69,524	69,524
											30,201	30,201
Subtotal	3,000	0	0	87,845	138,568	386,800	446,100	460,063	549,155	841,260	1,772,697	4,685,488
D. OTHER INCOME												
Overheads & Staff Time from Special Projects							46,975	53,254	31,475	145,678	104,918	382,300
Overheads from Restricted Core	6,110	2,522								177,151	71,809	248,960
Consultancies				5,552	18,472	12,072	28,767	47,132	62 927	54,918	19,911	258,383
Project Produce			7,578	40,886	27,946	94						76,504
Training Fees								5,896	2,400		1,090	9,386
Publication Sales				1,496	6,215	17,342	26,275	28,248	26,464	18,380	19,075	143,495
Interests/Dividends/Miscellaneous	2,026	5,904	9,489	26,107	55,936	4,432	9,609	14,490	17,887	37,671	35,451	219,062
Subtotal	8,136	8,426	17,067	74,041	108,569	33,940	111,686	149,020	141,153	433,798	252,254	1,338,090
GRAND TOTAL	464,884	608,426	1,017,067	1,134,681	1,359,137	1,611,726	1,764,239	1,468,054	1,324,869	2,233,360	3,131,352	16,117,795

[1] Based on unaudited year-end results.

[2] Restricted core and special project grants are recognized as income when used in the specified projects. (Regardless of amount and time funds are received.)

APPENDIX B. CURRENT ICLARM STAFF (February 1988)

Director General
Ian R. Smith, Ph.D.

Resource Assessment and Management Program

Daniel Pauly, Ph.D.	Director
Ms. Anabelle Cruz, B.S.	Program Assistant
Ms. Ma. Lourdes Palomares M.S.	Research Assistant
Ms. Mina Soriano, M.O.S.	Programmer
Felimon Gayanilo, Jr.,B.S.	Programmer
Ms. Norma Parial	Secretary

ASEAN INTEGRATED COASTAL RESOURCES MANAGEMENT PROJECT

Chua Thia-Eng, Ph.D.	Project Manager
Alan White, Ph.D.	Technical Advisor
James Paw, M.Aq.	Project Specialist
Ms. Flordeliz Guarin, M.S.	Project Specialist
Ms. Socorro Guerrero, A.B.	Project Assistant/Secretary
Ms. Angelina Agulto, A.B.	Project Assistant
Ms Marie Sol Sadorra, A.B.	Project Editor
Ms. Germilina Dizon, B.S.	Project Accountant

PHILIPPINE SMALL PELAGICS MANAGEMENT PROJECT

Paul Dalzell, B.Sc.	Project Leader
Ruben Ganaden Ll.B.	Project Officer
Ms. Perlita Corpuz, M.A.	Project Economist
Josefina Cañezo, B.S.	Secretary

MANAGEMENT OPTIONS FOR TROPICAL SMALL-SCALE FISHERIES

Max Aguero, Ph.D.	Associate Scientist
Mr. Exequiel Gonzalez, B.S.	Project Specialist

Aquaculture Program

Roger S.V. Pullin, Ph.D.	Director
Barry Costa-Pierce, Ph.D.	Associate Scientist (Indonesia)
John Balarin, M.Sc.	Project Leader (Africa)
Catalino dela Cruz, Ph.D.	Project Leader, Rice-Fish Integrated Farming Project
Anne van Dam, M.Sc.	Associate Expert, Rice-Fish Integrated Farming Project
Graham Usher, M.Sc.	Research Associate, Coastal Aquaculture Center
Hugh Govan, B.Sc.	Research Assistant, Coastal Aquaculture Center
Ms. Mary Ann Bimbao, M.S.	Program Assistant
Ms. Josephine Capili, B.S.	Research Assistant
Ms. Felicidad Estrada, B.S.	Secretary

Information Program

Jay L. Maclean, M.Sc.	Director
Ms. Leni-Lou Estudillo, B.S.	Secretary

PUBLICATIONS

Ms. Leticia Dizon, A.B.	Managing Editor
Ms. Marie Assunta Carigma, B.S.	Editorial Assistant
Ms. Priscilla Calalang, B.S.	Typesetter
Ms. Eloisa Espiritu, B.S.	Typesetter
Mr. Ovidio Espiritu, Jr., B.S.	Draftsman
Mr. Ramon Estarez	Information Aide

LIBRARY AND INFORMATION SERVICES

Ms. Rosalinda Temprosa, B.S.	Chief Librarian
Ms. Norma Jhocson, B.S.	Associate Librarian
Ms. Erlinda Gonzalez, B.S.	Assistant Librarian
Ms. Nelia Balagapo, B.S.	Assistant Librarian
Mr. Reynaldo Damalerio	Information Aide

Social Sciences

Prof. Harlan C. Lampe	Coordinator, Asian Fisheries Social Science Research Network
Ms. Marissa Manela	Project Assistant

South Pacific Office

John L. Munro, Ph.D.	Director, South Pacific

Administration and Finance

Basilio, M. Rodriguez, Jr. M.B.A.	Director
Ms. Marieta Veneracion	Administrative Assistant
Ms. Remedios Apostol, C.P.A.	Chief Accountant
Ms. Arlene Balane, B.S.	Accountant
Ms. Gemma Calderon, B.S.	Accounting Clerk
Ms. Ma. Concepcion Bernardo, B.S.	Senior Secretary to the Director General
Ms. Nenita Sunglao, B.S.	Secretary
Ms. Ma. Concesa Calderon, B.S.	Clerk-Typist
Ms. Belen Dagmil	Receptionist
Mr. Benjamin Bayron	Driver
Mr. Dominador Gomez	Driver