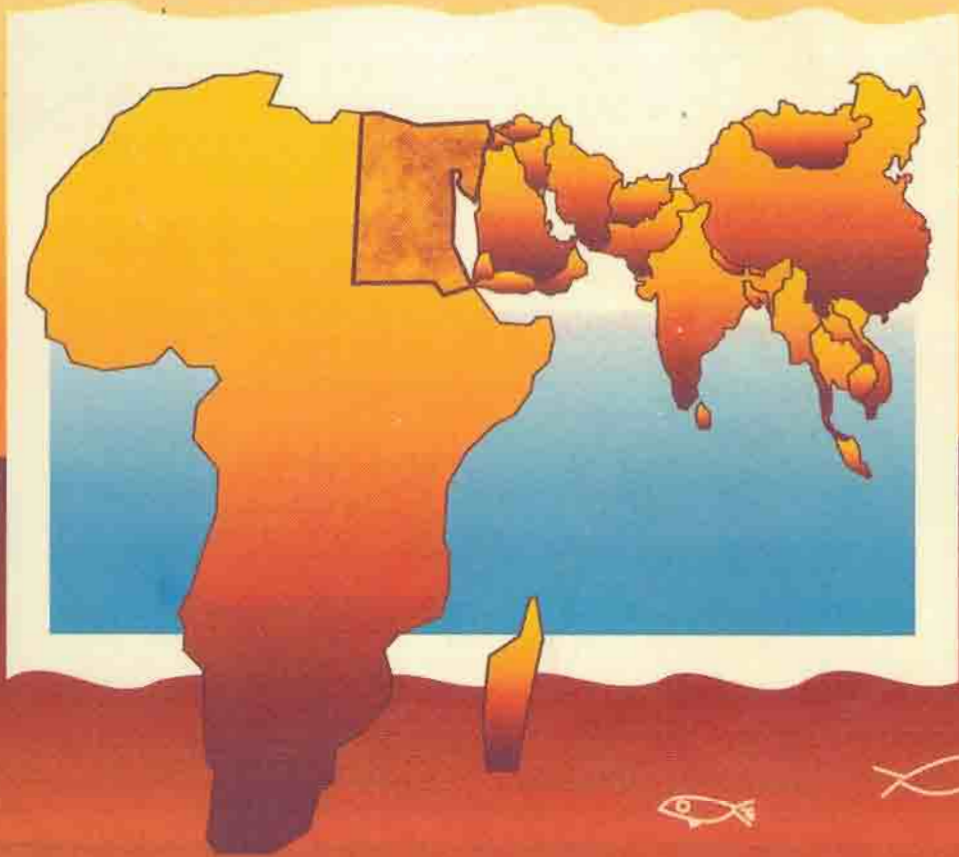




Fisheries and Aquaculture Research Planning Needs for Africa and West Asia

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Edited by
JOHN H. ANNALA



ICLARM

International Center for Living Aquatic
Resources Management

**Fisheries and Aquaculture
Research Planning Needs
for Africa and West Asia**

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PREFACE

This volume reports on the proceedings of a workshop organized by the International Center for Living Aquatic Resources Management (ICLARM) and held in Cairo from 23 to 27 September 1995. The impetus for the workshop arose from the generous offer made by the Government of the Arab Republic of Egypt to ICLARM late in 1994 that included the use of the Central Laboratory for Aquaculture Research at Abbassa. ICLARM is planning to conduct additional research into living aquatic resources management in Africa and West Asia and to use the Abbassa facility as a regional hub. The main purpose of the workshop was to identify research needs and issues to help in developing a draft research agenda for the Africa and West Asia region.

In drawing together the workshop, we have been mindful of the need to combine expert advice on fisheries, aquaculture and aquatic resource conservation from those with insights into African, West Asian and global needs. We are also mindful of ICLARM's mission as an international research center within the Consultative Group on International Agricultural Research (CGIAR) - namely, to improve the production and management of aquatic resource systems for the benefit of low-income producers and consumers in the developing world.

The outcomes of the workshop are used to develop ICLARM's research program for the Africa and West Asia region. On the day after the workshop, members of ICLARM's management team present in Cairo met to prepare a summary of the priority research issues resulting from the workshop. They presented their report to the Program Committee of ICLARM's Board of Trustees at its meeting over the next two days. This recommended research agenda was evaluated, using a priority setting process to rank the research issues.

As we go to press, refurbishments at the Abbassa site are well advanced and the selected research issues are being developed to project stage.

J.H. ANNALA

ACKNOWLEDGEMENTS

The costs of both the workshop, including the publication of this volume, and the travel incurred by invited participants, including those from the International Center for Living Aquatic Resources Management (ICLARM), were met through generous financial support provided by the Government of Denmark through its Danish International Development Assistance, better known as DANIDA, and the Consultative Group on International Agricultural Research (CGIAR) Secretariat. ICLARM gratefully acknowledges this support which enabled it to conduct the workshop.

ICLARM is also grateful for the generous offer from the Government of the Arab Republic of Egypt for the use of the Central Laboratory for Aquaculture Research (CLAR) facility. We also received considerable assistance at all stages of the workshop's preparation and conduct, particularly through the good offices of Dr. Youssuf Wally, Deputy Prime Minister of Egypt and Minister for Agriculture, Animal Resources, Fisheries and Land Reclamation.

Individuals who were invited to participate in the workshop were selected on the basis of their expertise, current research fields and knowledge of specific geographical regions. In making the selections, ICLARM was very conscious of the fact that the people whom it invited were probably the busiest and most in demand on a variety of fronts. We are very grateful to them for agreeing to participate in the interest of helping ICLARM to develop its draft research agenda for Africa and West Asia. We also thank Dr. Robert E. Kearney for the excellent manner in which he chaired the workshop and the convenors and rapporteurs of the working groups for their contributions.

ICLARM also gratefully acknowledges the support of the Government of Japan for the enhancement of the physical facilities of CLAR at Abbassa, in the near future.

INTRODUCTION

J.H. ANNALA

ICLARM sought a comprehensive range of expertise and knowledge for the workshop rather than representations of official country and organization views and consulted widely to prepare a list of invited, expert participants to the workshop. Invitations were sent to individuals and research organizations in 23 countries in Africa and West Asia, three regional government bodies, all donor-members to the Consultative Group on International Agricultural Research (CGIAR) and other donor organizations, all CGIAR centers, international organizations with interests in fisheries, a number of international aquatic resource experts and key ICLARM staff.

A total of 55 participants attended the workshop. They came from 11 African and West Asian countries, one regional African body (Common Market for Eastern and Southern Africa), two international bodies with interests in fisheries (Food and Agriculture Organization and United Nations Development Programme), four donor organizations, three CGIAR centers (International Irrigation Management Institute, International Service for National Agricultural Research, International Center for Agricultural Research in the Dry Areas), fisheries experts from three countries, and ICLARM.

Six resource systems and research-related activities were identified for discussion at the workshop:

- coral reef resource systems;

- coastal aquatic resource systems;
- inland aquatic resource systems;
- African great lake and reservoir resource systems;
- social sciences and co-management; and
- partnerships between the national aquatic research systems (NARS) and ICLARM in Africa and West Asia.

The following three sets of documents were used as inputs to the Cairo workshop:

1. Participants were asked to provide ICLARM with a brief description of major fisheries, aquaculture and aquatic resource research issues and needs for the Africa and West Asia region. These descriptions were summarized and tabled at the workshop.

2. Selected participants, including ICLARM staff, prepared brief background documents on a specific resource system or research-related activity. These documents contained background information on the resource system or research-related activity and a discussion of the relevant research issues and needs. These papers were also presented at the workshop.

3. A preliminary set of researchable issues was developed by ICLARM to provide a basis for discussion at the workshop. These issues were developed in an objective fashion at an internal planning workshop held in Manila on 10 and 11 August 1995 by following a structured evaluation process. Particular attention was given to how the pre-

liminary issues identified fitted ICLARM's priorities as defined in its 1992 Strategic Plan in combination with how the location and facilities at Abbassa could be utilized. These preliminary research ideas were included in the background documents prepared by ICLARM staff and later summarized for presentation at the workshop.

The first day of the workshop consisted of a tour of the Central Laboratory for Aquaculture Research. The second day was devoted to reading background material and presentation of the opening remarks, and introductory and background information. The third and fourth days were devoted to the presentation of background documents by the invited speakers in each of the six resource systems and research-related areas described above. Extended abstracts of these and other selected background documents tabled at the workshop but not presented are included in these proceedings.

On the morning of the last day, six working groups, corresponding to each of the resource systems and research-related activities, met to develop a draft research agenda for each of the six topic areas. Each working group had a chair and a rapporteur and was provided with a set of suggested operational guidelines for developing the draft. The guidelines included a request to develop a list with a maximum of nine researchable issues and to assign high, medium or low priority, with up to three issues in each priority group. The working groups were asked to refer to the three sets of background documents described above in developing the draft agendas. They reported back to a plenary session on the afternoon of the last day. The lists of research issues developed by the working groups are included in these proceedings.

REPORTS OF THE WORKING GROUPS

To assist ICLARM in developing a draft research agenda for Africa and West Asia to be carried out from the Central Laboratory for Aquaculture Research (CLAR), six working groups were convened on the last day of the workshop. Each working group dealt with a separate research or research-related area as follows:

- coral reef resource systems;
- coastal aquatic resource systems;
- inland aquatic resource systems;
- African great lake and reservoir resource systems;
- social sciences and co-management; and
- partnerships between the national aquatic research systems (NARS) and ICLARM in Africa and West Asia.

The main objective of each working group was to develop a list of a maximum of nine major researchable issues by taking a regional perspective. The nine issues were grouped according to priority, high, medium and low. However, some of the working groups chose not to group the issues into the three requested categories.

Coral Reef Resource Systems

The working group identified nine major researchable issues in approximate order of priority as:

1. evaluation of the status of coral reef resource systems of East Africa,

the Indian Ocean islands and the Red Sea;

2. investigation of the role of marine protected areas in the management of coral reef fisheries;

3. development of cost-effective data acquisition systems for small-scale fisheries;

4. stock assessment of multispecies artisanal fisheries;

5. valuation of coastal resources;

6. development of management strategies for coral reef fisheries;

7. development of systems for village-based aquaculture and stock enhancement;

8. evaluation of the effects of exploitation on the community structure of coral reefs; and

9. management of integrated coastal areas.

Coastal Aquatic Resource Systems

The working group identified ten major researchable issues and grouped them into high, medium and low priorities as:

High

1. development of techniques to improve surveys of resource potential;

2. development of integrated coastal zone management techniques; and

3. improved use of coastal resources.

Medium

1. multispecies modelling of demersal assemblages;
2. identification and analysis of processes and factors affecting recruitment; and
3. development of fisheries data acquisition systems.

Low

1. development of means of information exchange;
2. assessment of feasibility of the aquaculture of bivalves and crustaceans;
3. investigation of the biology of important species; and
4. investigation of the potential of sea ranching and stock enhancement.

Inland Aquatic Resource Systems

The working group identified nine major researchable issues and grouped them into high, medium and low priorities as:

High

1. farm pond systems;
2. rice-fish systems; and
3. aquatic biodiversity and genetic characterization.

Medium

1. small water body systems;
2. policy issues and governance of resource systems; and
3. genetic enhancement.

Low

1. watershed management;
2. pond trophic dynamics; and
3. environmental safeguards.

African Great Lake and Reservoir Resource Systems

The working group identified eight major researchable issues in priority order as:

1. regional support for African lake fisheries research;
2. research into cost-effective, innovative and multidisciplinary methods for monitoring and assessment of catch, effort and socioeconomic information providing species, temporal and spatial dimensions;
3. research into quantitative methods of evaluating the current status of fisheries, potential yields, and environmental and social impacts to provide decision support for fisheries management;
4. research into fundamental processes comprising the natural production base of lake fisheries using a systems approach;
5. integrated lakeshore management;
6. field identification guides;
7. development of products, markets and fishing gear; and
8. mesocosm experiments to evaluate the impacts of fish introduction in human-made lakes.

Social Sciences and Co-Management

The working group identified eight major researchable issues and grouped them into high and medium priorities as:

High

1. adoption of aquaculture technology;

2. economic and social analysis of fishers and fishfarmers; and
3. priority setting, research impact assessment and NARS strengthening.

Medium

1. policy analysis;
2. market, marketing and price analysis;
3. institutional and organizational issues in fisheries management;
4. property rights issues for lakes, inland waters and small water bodies; and
5. ecological economics of aquatic resources.

NARS Partnerships

The working group identified ten major researchable issues and grouped them into high, medium and low priorities as:

High

1. information - library and literature services;
2. on-line communication and exchange;
3. networks;
4. training - on-site courses that are informal and formal; and
5. multilinguality.

Medium

1. collaboration of international agricultural research centers with NARS, NARS with NARS, NARS with nongovernment organizations (NGOs);
2. coordination with donors;
3. transfer of technology (linkages); and
4. inventory of research information.

Low

1. visits/workshops/conferences.

SUMMARY OF WORKSHOP SESSIONS

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During the introductory presentations on the opening day of this workshop (24 September), the purpose of the meeting was defined by Drs. Meryl Williams, Director General of the International Center for Living Aquatic Resources Management (ICLARM) and John Annala, Workshop Coordinator. It was agreed that the workshop had two primary responsibilities: firstly, to suggest a research agenda for fisheries for Africa and West Asia for which regional cooperation would be beneficial; and secondly, to assign priorities to the components of this agenda.

Dr. Williams advised us of the "window of opportunity" which existed at the present time. This opportunity has been created by the offer of the Egyptian Government to make available its Abbassa facility for regional fisheries activities and the interest shown by a number of donors to support this offer.

Development of an appropriate research agenda has been identified as a prerequisite for proceeding. It was made apparent to those attending the workshop that there is currently a chance to do something in fisheries for this region which would not be possible without major support from donors, and that

the current offer may represent the only real opportunity for quite some time.

ICLARM is not only mindful of the current opportunity but also well aware that in accepting any offer to increase its activities in Africa and West Asia it **must** not detract from its current work program which continues to successfully address ICLARM's stated priorities. It is apparent that the current Egyptian offer would not have been made if it was not acknowledged that ICLARM has performed with distinction in meeting its mandate in fisheries, concentrating to date primarily on the Asia-Pacific region.

ICLARM has been progressively increasing its activities in Africa and West Asia but this increase has been greatly restricted by a lack of budgetary support. ICLARM has not had the opportunity to establish a major presence in this region in the 20 years of its existence and it may be some time before it receives another opportunity as good as the current one.

In describing ICLARM's functions, Dr. Williams detailed the ten points which govern the way in which ICLARM operates. She stressed that these operations must remain closely aligned to ICLARM's Strategic Plan noting that the plan is a living document and must

evolve with the times. It appears to me that if ICLARM is to undertake a major increase in its activities in this region, then its Strategic Plan will need significant alteration to truly reflect this changing priority.

Dr. John Annala summarized the relevant demographic statistics for this region and stressed that Africa has the world's most rapidly increasing population. Certainly there is at least some poverty in most countries of the region and much poverty in many. Undoubtedly there is a need for help with fisheries issues and clearly a role for a body such as ICLARM. There is considerable local expertise in the countries of the region (the quality of the representatives attending the workshop is testimony), but it is widely accepted that it is nowhere near enough. It is also accepted that there is considerable benefit to be gained from cooperation in forging partnerships for fisheries research.

ICLARM has convened this workshop to take advantage of the combined expertise of the region to provide inputs for the Consultative Group on International Agricultural Research (CGIAR) on three primary questions:

1. What does cooperation on fisheries-related research have to offer the future of Africa and West Asia and what priorities can be approached on a regional basis?

2. Is it worthwhile for CGIAR to increase its commitment to fisheries in this region?

3. If so, how can the current offer from the Government of Egypt help?

These three questions can be transformed into alternative questions which can be more directly dealt with by this workshop as:

1. What fisheries research priorities for the region should be approached from a regional perspective?

2. What priorities should CGIAR, through ICLARM, support?

3. What priorities could help with the involvement of the Abbassa facility and the increased support from donors that might be associated with it?

Over the last two days, our discussions have been divided into six sections, but as time passed it became increasingly apparent that there is a considerable overlap between the subjects covered in these sessions. This overlap highlights the need for an integrated research program.

Section 1 - Coral Reef Resource Systems

Dr. John Munro correctly highlighted the great importance of coral reefs to coastal tropical fisheries. He also stressed that they should not be considered in isolation and are only part of the total coastal aquatic resource systems to be further covered in the next session. Dr. Munro stressed the fragility of coral reefs and both he and Ms. Nyawira Muthiga stressed the enormous contribution of coral reefs to biodiversity in coastal areas.

Remarkably little is known about coral reefs in this region even though they are obviously of great biological and resource importance. There is unquestionably a need for more research. Many opportunities for research exist but I was swayed by the argument that the use of protected areas warranted special consideration.

As Dr. Munro advised us, area closures are one of the oldest forms of fisheries management and have been common in many parts of the world, certainly in the Pacific Islands, for many hundreds of years. As Ms. Muthiga pointed out, in recent years numerous areas of the African coast have been declared as

protected for reasons other than fisheries management, most notably as national parks or restricted closures to secure large resort developments or protect access of the wealthy. Throughout the world, there is increasing involvement of interests other than fisheries in declaring reserves. Fisheries researchers and managers then need to remain diligent to ensure that they do not lose control of the process.

In many areas where reserves have been declared, local fishers have been displaced without compensation and there is no assurance that fishing in adjacent areas will improve as a result of these closures.

Fisheries agencies have seldom accepted responsibility for aquatic organisms other than fish and other edible components of the ecosystem; we have tended to only be concerned with organisms such as corals and seagrasses because they are fisheries habitats and not because they are valuable in their own right. As a result, where habitats have been damaged, a case is being made that fisheries agencies have not been duly concerned about the conservation of biodiversity and the maintenance of total ecosystem balance. Conservation agencies then tend to take over the resource management agenda.

I would like to remind ICLARM that it is by definition a living aquatic resources management agency and not just a fisheries agency. Unless it plays a significant role in biodiversity and other conservation issues for organisms other than those which are directly harvested, it may well not serve the region to the level that could be expected. Does the Strategic Plan require adjustment?

Section 2 - Coastal Aquatic Resource Systems

The enormous range of research needs was well detailed by Dr. Thomas Ajayi. I accepted his argument that all of the issues he listed were worthy of attention; the problem of the enormity of the task was aptly described.

Accepting the extreme difficulty of selecting a few issues from this section for specific attention, three topics appear to me to be particularly worthy:

1. Dr. R.K. Ruwa was convincing on the need for an integrated approach to coastal zone management in most countries and of the benefits that could be gained from regional consideration of this issue. It is obviously a broad subject but one where the benefits from success in one country should be able to be transferred to others through regional cooperation.

2. Dr. Saul Salla stressed that small pelagic fish species need to play an increasing role in the fisheries of the region. Very large quantities of these species that are available would only be caught by larger vessels and to this extent may deprive the poorest of the poor. However, these species represent considerable potential for increasing the food available to poor nations, provided that cost-effective catching and processing technology can be developed. This technological development, together with increased understanding of the upwelling systems which support these resources, are obvious research priorities.

3. There is an excellent opportunity for ICLARM to build on its acknowledged leadership in providing innovative

approaches to the assessment of fisheries resources in a manner that could be understood and used in developing countries. ICLARM has proven its ability to keep computerized analytical technology within the perspective of developing countries.

It was acknowledged that resource assessment involves a degree of sophisticated analytical and computer skills and that developed and developing countries alike struggle to understand the dynamics of their fisheries resources. The need for ICLARM to provide intellectual leadership in this field and ensure that the countries of the region have access to the best available techniques was highlighted.

Section 3 - Inland Aquatic Resource Systems

The integrated resource management (IRM) system developed by ICLARM was well described by Drs. Roger Pullin and Randall Brummett. I was impressed that this project truly operates at the grass-roots level and integrates fisheries and agriculture, thereby drawing many fisheries researchers into broader natural resource management spheres. There would appear to be great scope for extending this work to more countries, thus having an appreciable impact on feeding the poorest of the poor. My only reservations probably reflect my bias as a fisheries scientist for I do wonder about the degree to which the project is focused more on increasing agricultural than fisheries production. There would appear to be scope for ICLARM to draw other CGIAR agencies into this area.

Dr. Abdel Rahman El Gamal outlined aquaculture development in Egypt which tends to be at the other end of the scale of aquaculture from that

outlined by Dr. Brummett. Egyptian aquaculture production now approximates 60,000 t per annum and is truly a demonstration of the success of fisheries research and development.

Dr. Olajide Ayinla stressed the strategic nature of aquaculture and the importance of assessing its environmental impact. He pointed out that if aquaculture is to help breach the widening gap between the demand and supply of fish, then cheaper diets which utilize local produce and waste will need to be developed.

Discussion in this session drew out the need to have social scientists more involved in assessing the real values of aquaculture for this region. I believe there is an urgent need to truly assess the best use of water which is such a scarce commodity. Should it be best used for aquaculture or agriculture or a combination of the two? Should countries such as Egypt reconsider their policy on agriculture prioritizing water? It appears to me that many of the analyses that are required can be easily carried out and that ICLARM is well qualified to do these analyses and provide the appropriate information to governments.

Section 4 - African Great Lakes and Reservoir Resource Systems

The large lakes and reservoirs of subSaharan Africa contribute approximately 50% of the fisheries production from the region but as for coastal fisheries there are serious inadequacies in the data available. Dr. Tony Pitcher pointed out the great uncertainty that exists in attempting to predict the availability of fish resources and also highlighted the need

for a multidisciplinary (social, economic, biological and mathematical) approach to addressing the problems. There are considerable differences between the numerous lake systems but for the larger lakes some of the problems, such as those associated with mixed trophic levels, are similar to those facing coastal fisheries.

With several countries bordering many of the lakes, there is a great need for international cooperation. There would appear to be a ready-made niche for an organization such as ICLARM.

The need for cooperation and regional approaches was further underlined by Dr. Cecil Machena. He reminded us that classical approaches to fisheries management have tended not to work in situations such as the great lakes of Africa. He gave us the example of the increases in fishing effort which follow the influx of people to the edge of lakes in times of drought; traditional western fisheries management strategies seldom accommodate such effort increases. Dr. Machena is correct in suggesting that, while we need spirited, new approaches, we also need to take more heed of traditional management systems. More consultation with small-scale fishers and among the numerous fisheries management regimes should help.

There is certainly not enough fisheries research carried out on the African lakes at the present time. It seems unlikely that national governments will give increased priority to fisheries when such issues as defense and education still dominate. There is a great need to help fisheries officers sell the importance of fisheries to their governments. In so doing, the important role that fish resources play in related activities, particularly tourism, will be emphasized. Lakewide management plans which

accommodate all users of the resources but at the same time highlight the role of fisheries are likewise necessary.

Section 5 - Social Sciences and Co-Management

Dr. Robert Pomeroy stressed the multidisciplinary nature of fisheries problems and the intricate dynamics of resource valuation and management. Integrative inland and coastal systems are required to meet diverse needs of the people of the region.

The need for interagency cooperation was stressed. Tools such as aquatic reserves or protected areas impact other sectors of the community and necessitate the involvement of other development or management agencies, for example, agriculture, tourism or conservation departments. ICLARM is one of the few fisheries agencies to employ people to actively work on social sciences; most fisheries agencies merely give lip service to this need. Dr. Pomeroy correctly pointed out that few of the national fisheries agencies have the mix of social and biological sciences necessary to manage the fisheries of their country. A role for ICLARM here is obvious.

Dr. Kofi Afful reminded us that in most countries it is prohibitively expensive to enforce fisheries management legislation. He also stressed the need to assess the changes in the total resource base, including people, associated with the development or decline of fisheries.

Two particularly interesting examples of social change were brought up:

1. Our attention was drawn to the increased involvement of women in marketing fish in some areas to the point that they were becoming so successful as to begin to dominate the men involved in the industry. I was

reminded of Dr. Pitcher's statement that in other areas the success of a fishing industry had been judged by the number of wives fishermen could afford to have. In Dr. Afful's study, perhaps we have detected the world's first case of the success of a fisheries venture judged this time by the number of husbands a fishwoman could afford to have.

2. The cost of canoes in some areas has increased by 300% in the last ten years. Appropriate timber is no longer available because of excessive tree felling and land clearing. While new boat designs and construction technology are obviously required, these will not hide the serious dislocation of people and resources currently occurring. Dr. Afful concluded by noting that most African countries do not see fisheries as particularly important and certainly not as an area where there could be major developments to generate new taxes and revenues. A real issue is how to get governments to recognize the importance of fisheries and support fisheries research agencies.

Dr. Theophilus Brainerd provided an excellent listing of the many researchable issues; as for the list provided by Dr. Thomas Ajayi, the enormity of the problems is evident. While it was most difficult to single out one item for particular attention, Dr. Brainerd gave the impression that he felt that the problem of how to restrict entry to African fisheries was perhaps the most pressing. This issue occurs in all sectors of fisheries and, throughout the world, solutions have proved elusive. In Africa, where starvation is a real issue and droughts cause unexpected shifts of population, restricting access to fisheries resources can be impossible. Overfishing of resources by those most dependent on them is the disastrous,

and inevitable, consequence. Dr. Pitcher had reminded us of Dr. Daniel Pauly's work on this subject.

Dr. Brainerd did point out that there are still some underexploited resources in subSaharan Africa so not all the news is gloomy.

Section 6 - Partnership between National Aquatic Research Systems and ICLARM in Africa

Mr. Boyd Haight noted that the strengthening of national programs currently accounts for approximately 20% of ICLARM's expenditure. Other sources of funds for this purpose are limited. Throughout Africa, the resources focused on fisheries are inadequate and very few countries have the mix of skills in the many disciplines necessary to address the problems of fisheries. An integrated approach involving economists, social scientists and biologists is required but the resources are currently not available. There are obviously great opportunities for strengthening partnerships between national agencies, and ICLARM could play a major role. The possibility for increasing even national government support for fisheries research by correctly presenting the link between research and development in fisheries was also identified as warranting further attention.

Dr. Mark Prein presented results from an excellent project in Ghana where small-scale aquaculture and agriculture are integrated. As for other small-scale projects of this sort previously mentioned, more than 90% of the produce is actually vegetables, with fisheries as a smaller component (approximately 5%).

Dr. Prein stressed the importance of the skills and abilities of individual researchers and extension officers in

supporting small-scale projects. He also acknowledged the need for many committed individuals to provide the infrastructure and support for those in the field. He highlighted the tremendous opportunity for ICLARM in this area but stressed that ICLARM cannot be expected to do everything.

Conclusions

There are obviously a great number of research issues in this region which truly warrant support. There is a great deal of similarity between the problems faced in the coastal and inland areas and the need for a multidisciplinary approach to many of the issues. ICLARM has the ability and the proven track record to be able to assist in many areas but its resources are limited, thus it will need to be selective to optimize returns.

It was noted that there has been a considerable cutback in fisheries aid to the region in the last ten years. For example, fisheries project funding provided by the United States Agency for International Development (USAID) was down to 50% during this period and only one out of 3,500 current employees of USAID is a fisheries person. The World Bank is restructuring and reducing its efforts in fisheries. This cutback in support for fisheries is not peculiar to developing countries for most developed countries are at best not increasing funding for fisheries research. We obviously have a lot of work to do to sell the value of our work much better than we do at present.

During the question time following the session on African lakes, I mentioned somewhat facetiously that if a fish species had not been driven to extinction then the research could be adjudged to have

been successful. I was only being partially facetious in this statement for fisheries researchers have often failed to point out to governments the consequences of not doing adequate research and not heeding the results. The loss of fisheries, or at least a serious decline in their productivity, is far too common throughout the world for capture fisheries productivity tends to be highest shortly after a fishery first starts. That is when virgin stocks are exploited. After, catch rates quickly decline. Meanwhile, research is placed on the back foot to argue for more resources to support a declining source of government revenue. Not surprisingly, we do not often raise much sympathy. Capture fisheries differ significantly from agriculture in that the fruits of our research seldom increase productivity. On the other hand, aquaculture production should increase with good research and extension. Even then, fisheries researchers have a history of pointing out the problems and not aggressively selling the successes of their trade.

The collective result of the plight of world fisheries is that donors are very sceptical of supporting more research in this field. We must then change the way we sell our profession.

There are certainly exciting opportunities for fisheries research and development and a great need for increased conservation of resources in this region. These are exciting times and there is great scope for increased involvement for ICLARM. The real problem ICLARM faces, however, is to identify where its efforts will be most handsomely rewarded and where individual research inputs can have a truly regional impact.

I have learnt a great deal in the last two days and have enjoyed the experience immensely. I thank ICLARM for the opportunity.

PART I: CORAL REEF RESOURCE SYSTEMS

ICLARM's Research on Coral Reef Resource Systems*

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Current Research Activities

ICLARM's current research programs on coral reef resource systems are focused on three main areas:

- increasing sustainable yields and economic benefits from coral reef systems by the cultivation of desirable species or enhancing natural recruitment by the release of hatchery-reared juveniles;
- improving ecosystem and resource management, through integrated coastal resources management, including the role of marine protected areas (MPAs), the valuation of resource systems and alternative uses of resources (tourism, recreation), and the development of a global database on coral reef ecosystems; and
- assessing and managing multispecies fishery resources.

There are also areas of common interest with other research projects within ICLARM such as FishBase, the

electronic encyclopedia of fishery resources, and in the development of data acquisition systems for small-scale fisheries.

Current projects encompass the development of village-based farming systems for giant clams and pearl oysters and of mass culture techniques for tropical sea cucumbers, with a view to stock enhancement. ICLARM has a project studying the recovery of overharvested invertebrate stocks in a newly proclaimed MPA in the Solomon Islands. A project starting shortly in the Caribbean, on the other hand, will investigate the scientific basis for establishing MPAs in terms of their benefits and costs to the local fishery, migration rates or "spillovers", and recruitment rates in both heavily exploited and relatively pristine areas.

A major component of ICLARM's current work is the development of ReefBase, a global database on coral reef resource systems, which aims to cover all the coral reef areas of the world and will include data, in particular, on areas (stratified by depth), coral cover, human impacts and reef

*ICLARM Contribution No. 1281.

status, harvests, uses for tourism and species present. The database will be accompanied by maps and diagrams to the most detailed level possible. The first release of the CD-ROM bearing the database is expected by June 1996.

Proposed Research Activities

The coral reef resource systems of the Indian Ocean and Red Sea are among the least known in the globe. Most of the Red Sea, parts of the Gulf of Suez, all of the Indian Ocean islands, and the East African coast from southern Somalia to southern Mozambique are fringed by coral reefs, but there is limited published information on the state of these reefs, their areal extent, depth penetration or ecological condition. The status of these coral reef fisheries seems not to be well known, although it is likely that they are under heavy fishing pressure when close to population centers.

Thus, there seems to be scope for a regional project aimed at acquiring the needed information on the reef resource systems of the region. Data sources could range from published nautical charts and scientific works to unpublished survey data. Where no data can be found, shipborne expeditions, supplemented by aerial surveys could fill the gaps. Frame surveys and data acquisition systems could reveal the relative importance of coral reef fisheries. Ecological surveys could reveal threats to the resource system.

The success elsewhere in developing small-scale farming systems for high-valued species such as giant clams and

pearl oysters may be possible in the Indian Ocean and Red Sea. The bêche-de-mer or sea cucumber resources of intertidal and coastal shallows are a resource of huge value, easily harvested and processed, but easily depleted. Stock enhancement systems suited to local conditions could be investigated.

The development of effective systems for gathering newly settled postlarvae of reef fishes opens many possibilities for extensive aquaculture or stock enhancement of selected species. These are options which have yet to be explored in the region.

Knowledge of the biology and ecology of coral reef fishes and invertebrates required for the formulation of management options for the Red Sea and Indian Ocean fisheries is limited. Thus, there is a need for additional studies on these areas' exploited communities.

Fisheries management options that could be investigated in the region include co-management systems, individual transferrable licenses and cooperative arrangements. The role of MPAs, both as a fisheries management tool and for promoting tourism, is finding favor in the region, but there are many unanswered questions pertaining to the size of MPAs, the valuation of their resources and the economic benefits or losses resulting from their alternative uses.

The use of research tools, such as ICLARM's ECOPATH II for modelling coral reef systems, could greatly expand our understanding of management options, particularly in relation to the known effects of exploitation (such as the high abundance of sea urchins on Kenyan coral reefs).

Coral Reefs of Kenya: Research Activities and Priorities

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Background

Coral reefs are the most diverse and productive ecosystems in the marine environment. However, coral reefs worldwide are experiencing damage due to overexploitation and other indirect human impacts. Kenya has a 450-km coastline with an almost continuous, fringing coral reef which breaks only where rivers and creeks discharge into the sea. The coral reef communities are similar in structure and faunal composition to reefs in the central and western Pacific. Fringing and patch reefs usually have an algal-covered crest which is usually exposed during low tide. The diversity of coral species is similar to islands and atolls of the central Indian Ocean.

The extractive activities carried out on the coral reefs of Kenya include fisheries, usually at the artisanal level, aquarium fish and curio trades. Nonextractive uses include tourism, with most of the tourist activities occurring in areas adjacent to coral reefs. Tourism is the main foreign exchange earner for Kenya. Recreation, research and education are also indirect uses of coral

reefs. Interactions also occur with other ecosystems, including offshore and adjacent seagrass beds, lagoons and mangroves. For example, many seabirds nest on island reefs in Kenya and turtles feed and breed on reefs.

The resources of the coral reefs of Kenya are managed jointly by the Kenya Fisheries Department, whose role includes licensing and enforcement of fisheries regulations and collecting and documenting fisheries stocks; the Kenya Wildlife Service (KWS), whose role is to protect and conserve the fauna and flora of marine protected areas; and the Kenya Marine and Fisheries Research Institute (KMFRI), whose role is to carry out research on the marine and terrestrial aquatic systems of Kenya.

Previous Research on Kenyan Coral Reefs

Much of the research work on Kenyan coral reefs has been carried out by the Coral Reef Conservation Project (an affiliate of the Wildlife Conservation Society) jointly with KMFRI, KWS and the Kenya Fisheries Department. Additionally, two surveys have been

undertaken by the Tropical Marine Research Unit of the University of York as well as a number of theses and dissertations by several Kenyan and international university graduates.

The research areas that have been investigated include:

- corals and coral reef community structure;
- coral reef fish and overfishing;
- coral reef gastropods;
- environmental stress and sediments; and
- coral reef sea urchins.

Current Research Activities

Current coral reef research projects are carried out jointly by KWS, KMFRI, the Coral Reef Conservation Project, which is funded by the United States Agency for International Development, and the Netherlands Wetland Project. These activities are:

- coral reef community structure and reef mapping;
- pollution monitoring;
- tourist activities and their impacts;
- fishing within inshore waters; and
- turtle conservation project.

Research Priorities for Coral Reefs in Kenya

The following research priorities were designed for marine parks and reserves of Kenya but could easily be translated to cover the whole of the east African coast:

- database development and resource inventories for important biotopes of the Kenyan coast, including coral reefs and seagrass beds;
- establishment of long-term monitoring programs to follow

changes in the main biotopes, i.e., coral reefs and seagrass beds;

- study on the status of endangered species, including the sea turtle and dugong;
- monitoring of the water quality within lagoons and creeks of the Kenyan coast to assess potential sources and effects of pollution and recommend ways to minimize it;
- study on tourist activities along the Kenyan coast to assess tourist damage;
- study on fishing activities within the inshore waters to assess the health of the fishery and predict its future;
- monitoring of coastal developments and land use practices and their impacts on the marine environment; and
- feasibility study of the aquaculture potential along the Kenyan coast to reduce pressure on the coral reefs and inshore lagoons.

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PART II: COASTAL AQUATIC RESOURCE SYSTEMS

African Coastal Fisheries

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Introduction

This report on coastal fisheries will be restricted primarily to water surrounding the African continent. This region includes Food and Agriculture Organization (FAO) marine statistical areas 34 (Eastern Central Atlantic), 37 (Mediterranean and Black Seas), 51 (Western Indian Ocean), and 47 (Southeast Atlantic). The coastal fisheries in this broad region range from primitive artisanal to highly industrialized large-scale fisheries.

The major fisheries resources of the African coastal areas, with few notable exceptions, are products of coastal ocean waters, adjacent estuaries and lagoons. These resources support the African continent's major artisanal and industrial fishing industries. We are now beginning to more fully appreciate that these fish populations and assemblages fluctuate, sometimes substantially, from year to year in the case of short-lived species and to an even greater extent during long-time intervals. This variability and our lack of knowledge of its causes reduce the effectiveness of many

existing forms of resource management and result in both economic and biological dislocations.

I believe that some of the major research goals of fisheries science as applied to coastal fisheries should include: (1) better recognition and explicit incorporation of uncertainty into management methods and models; (2) development of more accurate prediction tools for both short- and longer-term forecasts; and (3) basic studies on postulated assumptions between recruitment variability and the physical and chemical dynamics of the ocean environment in the coastal zone.

Status of Coastal Fisheries Resources Surrounding Africa

This information on the status of coastal fisheries resources is condensed primarily from a review of the state of world fisheries resources by the Marine Fisheries Service of FAO (Anon. 1994). It has been slightly updated by including data from Vol. 74 of the FAO Yearbook

and observations and opinions of the author based on his experiences in some coastal countries of Africa.

It is evident from the trend in annual world landings of marine resources that capture fisheries are reaching an upper limit in production somewhere near their current levels. The coastal fisheries off Africa show declines in landings of the larger and long-lived high value species, such as snappers and groupers, and increases in landings of small short-lived species, such as penaeid shrimp and cephalopods. Small pelagic species are significant components of the coastal fisheries in each FAO statistical area. The highest concentrations of small pelagic fish are found in highly productive upwelling areas which are mostly located along the western continental coast of Africa. A high proportion of the catches of small (and also larger) pelagic species is taken from a small proportion of the total coastal zone surface area, a highly productive area close to the coastline.

It seems apparent that coastal fisheries in general, including those off continental Africa, are not well understood or managed effectively, although some argue that more effective management is not possible due to high variability induced by both climate and fishing. My contention is that this statement is not valid, and that fisheries scientists have yet to apply the appropriate tools to address this type of problem. Some modest suggestions are made to indicate what is believed to be more viable approaches for future research and ultimately better management.

Research Suggestions for Coastal Fisheries

In view of the great importance of small pelagic species in both artisanal and industrial coastal fisheries, it seems important to emphasize research related to this group. Also, although the importance of interdisciplinary studies (including physical and chemical oceanography, economics, sociology, anthropology and others) is clearly recognized, these research suggestions apply primarily to methods for improved forecasting and management of small pelagic species.

I believe that major, new research paradigms, based on recent developments in artificial intelligence (AI) and mathematics, are required for more effective utilization and management of coastal fisheries. My reason for this statement is that fisheries science has a long history of isolation from other marine science disciplines, thus it is time for considerably greater interdisciplinary cooperation and testing of methodologies used in other disciplines. For example, some steps have recently been taken to accommodate environmental variability in surplus production models and also to more effectively provide for their specific applications. This work culminated in an interactive software package termed *Climprod* (Freon et al. 1993) which contains an embedded expert system to aid in user decisionmaking. This approach is believed to represent real progress due to the interactive nature of the expert system with the user.

Saila (in press) has recently completed a survey of AI tools and their applications to fisheries science. It was found that the use of these tools to date by fisheries scientists was very limited in contrast to other disciplines such as ecology, agricultural science and oceanography. However, the potential value of some AI tools such as expert systems, neural networks, genetic algorithms and simulated annealing was determined to be high in fisheries science applications.

Potentially valuable contributions to fisheries science also seem possible using recent developments in mathematics. These include chaos theory applications for fisheries forecasting and modelling as well as applications of the fuzzy set theory and logic to accommodate more effectively the high levels of uncertainty in conventional fisheries models, model parameters and predictions.

In summary, I believe that any new scientific institution, such as that

proposed for Abbassa as a center for research in aquaculture and capture fisheries, should not only provide a new and better physical environment for research but also an intellectual environment which is capable of providing leadership in using some of the newer advances in science which have been largely ignored to date by the fisheries science community.

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Aquatic Resource Management in the Western Indian Ocean African Region

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Introduction

In multidisciplinary studies of aquatic systems, water must be considered as a resource as well as one with biological and physical resources. Prominent for communities living around aquatic systems are their fisheries resources. These resources play an important role in providing them with employment; they also play an important part in their nutrition.

Exploitation of Aquatic Resources

FISHERIES RESOURCES. The majority of fishers in the region are artisanal. Industrial fishing is still not common and practised mostly by foreigners. Artisanal fishers fish mainly in lagoons and shallow waters around coral reefs, using canoes and sailboats, as only a few have engine-driven boats. Gear are mostly beach seines, cast nets, traps and fishing lines.

The main marine fisheries resources include various types of finfish; tuna

and tuna-like fish; crustaceans (lobsters, prawns/shrimp, crabs); and molluscs (octopus, squid, cuttlefish, bivalves).

Total catches by the countries of the Western Indian Ocean African region contribute less than 7% of the total annual catches of the Western Indian Ocean region (FAO 1990). This is probably due to lack of appropriate technology and vessels that can be used to fish offshore. Fishing on the high seas requires substantial investment which is not easily affordable in the local countries. This may also explain the significance of foreign investments in the fishing industry in this region.

Looking to the future, fish yields from offshore ocean areas are predicted to increase (World Resources Institute 1992). However, it is unlikely that countries with low standards of fishing technology which also lack ships to venture on to the high seas will significantly increase their catch beyond the shallow water coral reef zones. The latter therefore will continue to be threatened by the effects of overfishing.

MANGROVE RESOURCES. The Western Indian Ocean region is not well

endowed with mangrove forests (Ruwa 1994). Mangroves provide wood for fuel, building, furniture making, fodder, etc. However, there are no statistical records such as those for fisheries resources to determine the quantities harvested.

ALGAL RESOURCES. The potential for economic exploitation of algal resources in the region has been recognized (Mshigeni 1983). However, the majority of the local communities in the region have yet to appreciate their potential value.

MANAGEMENT OF AQUATIC RESOURCES. With the increased demand for cheaper sources of protein for the burgeoning populations in developing countries, fisheries are now viewed as potential resources to provide cheap protein and create employment opportunities in fishing and related activities such as aquaculture. Whereas artisanal fishing provides for local needs, industrial fishing yields surpluses for export markets and therefore contributes to foreign earnings.

A common problem with all developing countries is the lack of information for proper management that will ensure sustainable use of their resources. In cases where the information is available, data gaps which are also common make considering management decisions difficult. Thus, because of insufficient information, quantifying the contributions of fisheries to nutrition, employment, and foreign exchange earnings or income generation becomes hard work.

Fisheries production is the outcome of various aquatic processes, hence the need for interdisciplinary research strategies. These help us to understand variations in fish abundance in relation to various critical habitat contributions

(e.g., from mangroves, seagrass beds, coral reefs, etc.) and to formulate management strategies.

INTEGRATED COASTAL ZONE MANAGEMENT. In the past, the development of models that addressed particular aspects of the resource was considered sufficient to guide the sustainable management of aquatic resources. However, these models address only part of the problem. What they fail to address are factors such as (1) changes in the use of critical habitats as a result of tourist activities, creation of protected areas, anthropogenic inputs, artificial reefs, aquaculture practices, sand and coral mining, change of fishing grounds, etc.; and (2) changes in legal enforcement and institutional arrangements.

Integrated coastal zone management (ICZM) takes into account a wider range of factors. ICZM can be defined as a process aimed at minimizing resource conflicts in the exploitation and management of coastal resources for their sustainable use and development by considering the interests of concerned stakeholders. The major components of ICZM are interlinkages of research, planning, implementation, evaluation, and educational, legal and administrative institutions. However, the success of ICZM is jeopardized for the following reasons:

- at the national level, the role of institutions is not well defined, thus leading to power or responsibility overlaps and consequent loss or reduction of authority;
- an isolated or sectoral approach is commonly pursued ostensibly for the retention of authority;
- in most cases, coastal and marine research lacks a planned multidisciplinary approach that is necessary for ICZM;

- the planning process in coastal zones does not include or adequately consider the interests of all stakeholders;
- there is significant ignorance of the appropriate environmental education necessary to ensure sustainable use of the coastal and marine environment; and
- an international approach to coastal zone problems is still in its infancy, with its success dependent on the success of national approaches to ICZM.

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Research Agenda for Management of Coastal Aquatic Resource Systems in West Africa

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Background

The marine productivity of the West African subregion ranks high. Periodic replenishment of nutrients has been traced to ocean currents, principally the Guinea current and the underlying Guinea undercurrent. Seasonal upwelling augments coastal nutrient levels and circulation off Cote d'Ivoire and Ghana. Elsewhere, mangroves and river discharges energize nearshore production.

Substratum type, thermocline depth and other ecosystem parameters govern species composition, seasonal abundance and geographical boundaries of fish assemblages. Along-shore mass migrations associated with upwelling waterfronts typify pelagic fish schools, especially clupeids off Ghana and Côte d'Ivoire.

Artisanal fishers use a variety of gear types - anchored or slow drift gill nets, encircling nets, purse seines, hook and line, traps and other gear, essentially passive. Canoes, invariably wooden and up to 6 m long, carry 1-22 crew. Paddles predominate, complemented by sails, often improvised. Imported 5-40 hp outboard motors also contribute to propulsion.

Target species include a variety of pelagic and demersal species, shrimp, and other crustaceans. Small-scale fisheries production is almost entirely for domestic consumption in most West African countries. However, a combination of circumstances unique to small-scale fisheries - scattered landing sites, remoteness from consumer concentrations and insufficient refrigeration - compel fish preservation by smoking and sun drying, exclusively women's activities. Harvested for fuel, but rarely replanted, wood is increasingly in short supply, and swamp deforestation exacerbates waterline erosion and periodic sea incursions.

The overall economics of small-scale fisheries are positive, particularly when analyses recognize the entire household - men, women and children - as the fishing income unit. Small-scale fisheries contribute 60-70% to national marine production in West Africa and provide over 85% of all coastal employment.

In the industrial coastal fisheries, steel or fiberglass vessels, 150 grt or more and ≥ 24 m loa, are common. Often demersal trawls focus on penaeid shrimp and demersal fish. Seasonally skipjack and yellowfin tuna are also caught for export by bait boats and purse seiners.

Research Agenda Details

In conformity with ICLARM's focus on low-income groups and their nutritional well-being through holistic management and sustainability of living aquatic resources, the following research issues should be addressed in West Africa:

- pre- and within season forecasting of pelagic fish production;
- estimation of river discharges, nutrient enrichment and productivity indices;
- determination of appropriate stock units for management of multigear and multispecies fisheries;
- estimation of catch and effort levels in artisanal and industrial fisheries;
- estimation of sustainable yields for coastal fisheries;
- postharvest waste reduction and fuller utilization of fisheries products;
- assessment of food composition and nutrient value of fish products;
- research on socioeconomic impacts and cost/benefit analyses;
- integration of fisheries with other coastal enterprises;
- conflict resolution between and within sectors;
- determination of appropriate management measures; and
- development of estuarine ecosystem case studies.

ICLARM's Coastal and Coral Reef Systems Program*

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Background

Two basic issues drive the urgent need for global research efforts on coastal resource systems: overfishing which is exacerbated by poverty, and competition with other sectors and pollution from them.

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

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

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

Objectives

The objectives of the Coastal and Coral Reef Systems Program are:

1. to understand the dynamics of the aquatic resources of coastal resource systems such that management interventions leading to high yet sustainable catches can be identified and implemented;

2. to understand the dynamics of the living aquatic resources use sector, the fishers (including their economic and social behavior), the fishing communities, markets and policies such that appropriate management interventions can be designed which will be implementable at the

*ICLARM Contribution No. 1282.

community, local government and national levels; and

3. to describe and understand the effects on living aquatic resources of intersectoral factors affecting coastal areas, thereby assisting the International Center for Living Aquatic Resources Management's (ICLARM) client countries in the formulation of coherent policies for sustaining or developing their living aquatic resources through integrated development and management of their coastal areas.

Research Thrusts

The Coastal and Coral Reef Resource Systems Program currently operates through three research thrusts:

1. understanding the dynamics of tropical fish resources which will provide the biological basis for management interventions and which combines the ecosystem with those aspects of the fish resource that are relevant to understanding its dynamics (e.g., growth and mortality rates, recruitment and biomass fluctuations, etc.);

2. development of management strategies for coastal fisheries which will study coastal fisheries systems from the household and community to the national policy levels, with emphasis on identifying and removing sociocultural, economic and institutional constraints to improved management and sustainable fisheries; and

3. development of integrated management strategies for coastal aquatic resources which will draw together knowledge of all aspects of coastal development and national policies impacting on the coastal zone and its fisheries and will synthesize these in rigorous fashion to derive

generalizable management options and policy recommendations for development compatible with sustainable coastal aquatic resources.

ICLARM's Strategic Plan envisions separate coastal and coral reef programs. However, for operational reasons the two programs have been merged. Also, thrusts (2) and (3) described above have been combined.

Proposed Research Activities

The following research activities could be carried out from the Abbassa facility:

1. Integrated coastal fisheries management (includes biology and social sciences). This research will lead to the development of feasible management options, guidelines and strategies (including investment opportunities for alternative livelihoods) that maximize benefits from fisheries resource utilization and minimize sectoral conflicts. Bioeconomic models that integrate biological as well as socioeconomic parameters can be applied. Likewise, the existence of traditional fishery management schemes can be enhanced by, for example, instituting co-management procedures.

2. Consultative Group on International Agricultural Research (CGIAR) systemwide coastal environment initiative. This research draws on the experience of ICLARM in integrated coastal zone management. Specific sites with critical coastal environments can be analyzed using the coastal transects framework. Coastal zone issues that include siltation and sedimentation, water pollution, and resource use conflict emanate from sectors outside the boundaries of the coastal zone, i.e., mining, forestry and

agriculture. This research initiative will tap the expertise of various CGIAR centers, e.g., West Africa Rice Development Association, Center for International Forestry Research, International Food Policy Research Institute (WARDA/CIFOR/IFPRI) to come up with holistic, interdisciplinary management options.

3. Aquaculture/stock enhancement evaluation. This research involves assessment of the potential for aquaculture (mariculture) development of fish species that contribute significantly to the marginalized sectors of society and for which the possibility of breeding exists. Aquaculture techniques should be of the low-cost, low-input variety in order to be accessible to small entrepreneurs. Potential sites should be identified in consonance with rural/urban planning objectives to minimize negative externalities such as environmental degradation and resource use conflicts.

4. Stock assessment for fishery management. A prognosis of the status of exploitation of coastal aquatic resources should first be made to determine its likely development path or, in the case of exploited resources, its management options. ICLARM has established an excellent track record in stock assessment work both in data collection (i.e., trawl surveys in San Miguel Bay, Philippines, Brunei

Darussalam and Sierra Leone) and in the development of electronic/computer-based tools for stock assessment. The latter is a flagship project of ICLARM and has led to the development of widely used techniques for length-based analysis.

5. Resource valuation, including bioeconomic modelling. Decision-makers are often alienated by scientific pronouncements because of communication problems. By expressing the value of resources in monetary units, decisionmakers can be alerted to the issue at hand because they can grasp the actual value of resource destruction. Valuation intends to provide both market and nonmarket values to coastal resources such that environmental attributes as clean air and water, for which no markets exist, can be valued.

6. National aquatic research systems strengthening, communication/information, training. African and West Asian scientists can be trained in the methods developed in research areas (1) to (5). Formal training can be conducted for points (4) and (5), specifically in using and understanding stock assessment and mathematical programming software. Present information networks can be strengthened by providing some clearinghouse functions from the Abbassa facility.

PART III: INLAND AQUATIC RESOURCE SYSTEMS

ICLARM's Approach to Integrated Resource Management in Africa*

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Objectives

ICLARM's research partners in Africa are the various national agriculture research systems (NARS), government and nongovernment organizations, farmers, and fishers. Its goal is twofold: (1) to assist NARS to acquire the technical and informational skills and tools necessary to perform their task of conducting growth-oriented research and development, and (2) to generate, through strategic research, new knowledge of regional and global significance for sustainable, bottom-up economic development. We hope that the ultimate beneficiaries of this work will be the region's resource-poor farmers, the agroecosystems in which they live and all the consumers of their produce.

Background

In the case of inland fishfarming, ICLARM has chosen an approach based on integrated resource management (IRM). In IRM, the farm (including the farm family) is considered as one complete unit united by resource flows. This is in contrast to the classical microeconomic approach of viewing the farm as a collection of independently budgeted activities linked only by opportunity costs. When studying IRM systems, decisionmaking is not preempted by extension agents and researchers. Instead farmer-participatory methods are used to better understand and improve the production system. This approach makes better economic and ecological sense and increases the uptake of improved technologies by smallholding farmers.

*ICLARM's IRM activities in Africa have been generously supported since 1985 by the German Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ) through the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). ICLARM Contribution No. 1283.

AQUACULTURE-BASED INTEGRATED RESOURCE MANAGEMENT.

Integrated farming is a step in the right direction to increased food production. In an integrated system, "waste" resources from one enterprise are used to improve production on another, thus increasing the efficiency of both. Integrating aquaculture into smallholder agriculture is a particularly effective type of integrated farming (Lightfoot 1990; Hatch and Hanson 1992; Stewart 1993).

Using crop residues to fertilize the pond can reduce dependence on external inputs and should lead to increased stability and profitability. Lightfoot and Noble (1993) and Prein (1994) found that increased production of vegetable plots (due to application of pond mud and water) was the largest factor in improving profitability of integrated smallholdings. These and other findings indicate a clear potential for integrated aquaculture to improve farm productivity without substantially increasing the cost of production. The potential which integrated aquaculture offers for reducing dependence on external inputs and improving farm function and productivity makes it a logical component of a more sustainable approach to farming.

FARMER PARTICIPATION IN INTEGRATED RESOURCE MANAGEMENT.

ICLARM and its collaborators began working in Malawi, Africa by trying to develop, in situ, technologies for direct application to the problems faced by the region's smallholding fishfarmers. While some of the technologies developed were adopted by the farmers, the impact on rural fish production was less than expected. To determine why production was less than expected, the farmers were invited to the experiment stations for a field day.

The results of this farmer-scientist interaction were remarkable. In the three

years which had passed since rice-fish farming had been first shown to Malawian farmers, only about 10% of the farmers contacted had adopted it. Within two years, over half of the farmers doing rice-fish culture had never had any contact with aquaculture extension agents. But within six months of the field day, almost 80% of the attending farmers had taken it on. Most importantly, the farmers were spreading the technology among themselves, although none of them had adopted the technology as it was originally demonstrated for all had modified it in various ways to suit their own situations.

To understand why farmers make certain decisions, ICLARM diversified its approach in Africa to include new regions, cultures and perspectives in farm-level decisionmaking. In 1991, activities were initiated in Ghana and a variety of scientists were approached to provide inputs. In 1993, ICLARM developed the Farmer-Scientist Research Partnership model (Brummett and Noble 1995) to guide station-based research and development. This model attempts to simulate farm conditions on the experiment station using real farm conditions as experimental controls in order to generate more realistic and easily adoptable aquaculture technology. The results of these studies show quite clearly that farmer participation must be an integral part of farming systems research if lasting impacts are to be made in the shortest possible time.

ECOLOGICAL FOOTPRINTS AND SUSTAINABILITY.

Whatever human beings do, they are bound to have an impact on the environment. The farm is linked to the surrounding ecosystem through resource flows just as the various on-farm enterprises are linked to each other. The size of these flows will in many ways determine how long the farming

system will function within the existing natural resource base. Obviously the smaller the flows into the farm, the longer the system will function without having to access new natural resources. The area needed to support the inputs and absorb the outputs of any human activity is its ecological footprint. By definition, the smaller the footprint, the more sustainable the activity.

If we compare the footprints of various types of aquaculture, we can see that integrated farming is more sustainable than fish-only systems (Kautsky et al. 1995). Combined with the findings of the farmer-participatory work described above, it becomes clear that improved systems designed in collaboration with farmers and based on small ponds integrated into existing farm activities should be not only more environment friendly but also more widely adoptable by smallholders. Wider adoption means a greater and more sustainable improvement in agriculture output and profitability.

Proposed Research Activities

INTEGRATED RESOURCE MANAGEMENT. A planning session held at ICLARM in August 1995 resulted in the following researchable issues regarding IRM for Africa:

1. sustainability of (mostly rainfed) IRM systems (e.g., farm ponds on smallholdings, rice-fish systems, small water bodies);
2. policy issues and governance of the resource systems that can support subSaharan Africa's inland fish production; and
3. watershed management.

POND TROPHIC DYNAMICS. One researchable issue which does not directly affect IRM work but which remains a part of ICLARM's Strategic

Plan is an investigation of pond trophic dynamics. Its environmental components could be either controlled or simply incorporated into experimental designs. The variability within these parameters is, in any case, so large that research done anywhere is broadly transferable to other sites.

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Towards an Agenda for Strategic Research and Training on Sustainable Use of Inland Aquatic Resource Systems in Africa*

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The 1992 Strategic Plan, through which ICLARM was admitted to the Consultative Group on International Agricultural Research (CGIAR), was formulated through wide consultation with advisors from the developing regions, including Africa. Prioritization of plans was done on the basis of: number of beneficiaries; extent of impact on beneficiaries; extent of potential use by clients; extent results will strengthen national programs; contribution to sustainability of aquatic resources and their environments; probability of achieving research objectives; potential for spillover to nonclient and nonbeneficiary groups (multiplier effects); and cost-benefit ratios of the research.

Inland aquatic resource systems were categorized as: uplands; ponds (including rice floodwaters); reservoirs and lakes; and streams, rivers and floodplains.

Ponds were assigned high priority for research and reservoirs and lakes much

lower priority globally. However, for Africa, where freshwater fisheries account for over 50% of the regional catch, it was recognized that special priority cases could be made for strategic research on reservoirs (especially farm dams), lakes, streams, rivers and floodplains.

ICLARM's Medium-term Plan for 1994-1998 proposed an inland aquatic resource systems focus on farm ponds fully integrated with other farm enterprises and available resources (an approach termed "integrated resources management" (IRM)) and on research for genetic improvement of farmed fish to raise productivity.

Maximizing fishpond productivity *per se* on resource-poor farms was not seen as the primary goal. The approach chosen was to pursue improvement of overall productivity and profitability through sound management of water and other resources supporting mutually synergistic farm enterprises: crops, vegetables, fruits, livestock, fish, etc. The key to this is the ecological transformation of the farm. Such a farm is not primarily a fishfarm. The farmer

*ICLARM Contribution No. 1284.

is not primarily a fishfarmer. The pond is a *farm* pond, not primarily a fishpond.

Research based on this cross-sectoral IRM perspective is only just beginning. It is important that evaluation of IRM-based developments are made on the basis of productivity, profitability, sustainability, equity issues and environmental effects at farm, community and watershed levels - *not* just on the farm level economics of pond construction and fish production.

Biodiversity and genetic resources are important parts of the 'R' in IRM to be used in simple, selective breeding programs designed for low, external input, sustainable systems. There are many African species of fish not yet even assessed for aquaculture potential.

Similar, cross-sectoral IRM perspectives could be applied to research for sustainable utilization of inland aquatic resource systems other than ponds, e.g., integrated watershed management involving uplands, streams, rivers, reservoirs, lakes and floodplains, and including downstream interactions with the coastal zone. A strategic research and training agenda for this in Africa has yet to be formulated, but ICLARM and its collaborators are beginning to develop approaches and methods. For example, a coastal transects approach developed by ICLARM and partners could be applied to watersheds. Systemwide soil, water and other resource management programs in CGIAR may afford mechanisms for multiple partnerships and networking in this area.

The single, most important development in global and African

regional research and development planning since the formulation of ICLARM's Strategic and Medium-term Plans has been the entry into force of the Convention on Biological Diversity (CBD), to which most African nations are signatories.

CBD emphasizes conservation and sustainable use of all living resources, with equitable sharing of benefits. Marine and coastal biodiversity have been assigned immediate priority (1995) by the Conference of the Parties of CBD, with agrobiodiversity and forestry next (1996).

Freshwater biodiversity has not been prioritized explicitly, but it is well recognized by CBD and its various advisory and implementing bodies that freshwater biodiversity is of very high value and suffering from serious threats and losses. Hence, the time is ripe for assigning high priority to the documentation and evaluation of African freshwater biodiversity and for researching how to use this *sustainably* in aquaculture and fisheries.

The African members of the ICLARM-coordinated International Network on Genetics in Aquaculture (INGA) (currently Côte d'Ivoire, Egypt, Ghana and Malawi - hopefully more nations will join) are placing high emphasis on biodiversity research. Multiple research and training collaborations and networking, like INGA, can facilitate rapid progress and the sharing of experiences, methods and steps to safeguard the *native* freshwater biota of Africa.

Research Needs for Inland Aquatic Resource Systems in West Africa

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Background

The inland aquatic resource system consists principally of rivers, lakes and floodplains characterized by sandy river bottoms, fast water currents, and seasonal rise and fall in water level as a result of annual floods. This affects natural productivity, fish behavior and movement and consequently activities in capture fisheries.

Culture fisheries are carried out mostly in ponds and *acadja* systems in lakes, rivers and lagoons, where polyculture is commonly practised. The culture system of choice in most West African countries is integrated farming of fish with livestock (i.e., poultry and pigs).

Some aquatic weeds have constituted a menace to fishing and fisheries activities. However, *Azolla pinnata* has been successfully included in fish diets replacing up to 30% of palm kernel cake, therefore reducing the cost of fish feeding by about 10-20%.

Research Needs for Inland Aquatic Resource Systems

CAPTURE FISHERIES. The overall research goal for capture fisheries is to increase fish production and conserve genetic biodiversity of resources. Research needs include:

- assessment of the biological productivity and determination of the annual potential yield of finfish and shellfish;
- development of systems to collect catch and effort statistics;
- development of techniques to enhance the lifespan of outboard engines, crafts and gear;
- management of floodplains for increased fish production;
- environmental impact assessment of industrial/agricultural activities on fish production;
- investigations into various socio-economic aspects of fisheries; and

- development of improved techniques for fish preservation and product development.

CULTURE FISHERIES. Major research needs for aquaculture development in Africa include:

- development of techniques to produce good quality fingerlings of cultivable fish;
- development of low-cost methods of pond construction;
- improvement of farm production;
- development of genetically improved cultivable fish species;

- improvement of hatchery management techniques to mass produce fingerlings of cultivable finfish and postlarvae of shrimp;
- utilization of alternative, unconventional protein sources of feed ingredients for fish feed formulation;
- development of techniques for mass production of live organisms for larval feeding;
- development of farmer-participatory approaches for aquaculture;
- development of culture systems for increased fish production; and
- investigations into socioeconomic aspects of fishfarming.

Aquaculture Development in Egypt: Research Needs and Activities

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Introduction

The Egyptian supply/demand situation for fish is similar to the world situation. High rates of population growth, recent increases in per caput income and the development of export markets have contributed to the rapidly growing demand for animal and fish products. Fish consumption is expected to continue to rise with the increase in population, per caput real income and prices of alternative animal protein. The capacity to meet the currently unfulfilled potential as well as the increased demand caused by future population growth must be addressed through aquaculture.

Total fish production in Egypt is about 365,000 t·year⁻¹, while fish consumption was estimated in 1994 at about 400,000 t·year⁻¹ or 7 kg·caput⁻¹. Currently about 14% of the fish consumed in Egypt comes from aquaculture, while the remainder is supplied by domestic capture fisheries and imports.

Aquaculture has been practised in Egypt for thousands of years. However, systematic pond culture is relatively new,

expanding noticeably in the 1970s until it became the major type of fish culture in Egypt. Another approach that has expanded since the mid-1980s is the use of cage culture.

Integrated agriculture/aquaculture is practised with rice/fish (carp) culture on a large scale, with about 150,000 ha of rice currently cultured with common carp and tilapia.

Existing Research Activities

To provide leadership in research, training and extension to applied aquaculture, the Central Laboratory for Aquaculture Research (CLAR) was established at Abbassa. Research projects are currently carried out in the following areas:

- study of tilapia biology, food requirements and reproductive management;
- propagation of underutilized fish species, such as African catfish;
- pond management to increase fish production per unit area through biological methods as well as

through improvement of the pond environment;

- management and utilization of aquatic weeds and snails;
- development of fish strains that perform better under different, local environmental conditions;
- nutritional studies, including the development of specialized diets based on food requirements for some native fish species, as well as the formulation of fish feed from locally available ingredients;
- assessment of fish diseases and development of means for their control;
- determination of seed availability for fish culture projects, development of means for their mass production in fish hatcheries and improvement of the survival of naturally produced fry;
- emphasis on the role of native fish species such as tilapia, mullet and catfish in aquaculture;
- determination of the different types of pollution and their effects on fish and their environment;
- economic studies of aquaculture methods to identify practices which promote efficiency and increase production;
- development of fish processing technologies; and
- development of aquaculture extension/education methods.

Research Needs

Future research should address constraints to the growth of aquaculture as follows:

- improvement of the efficiency of pond production systems and the

adaptation of the management of fishponds to different sets of environmental conditions to optimize production;

- enhancement of the efficiency of different integrated systems, such as rice-fish and fish-duck systems under local environmental and market situations;
- development of tilapia strains that possess good commercial traits (growth, survival, cold and salinity tolerance, disease resistance) suitable for different environmental conditions;
- development of methods to increase the survival of fry and fingerlings captured from the wild;
- evaluation of the multiple use of water in aquaculture systems;
- promotion of low-input systems for fish culture;
- determination of the economic returns of various management practices, such as feed types and feeding rates, and various fish combinations;
- management of fish health, disease control and quarantine;
- development of technology for marine fish reproduction;
- development and evaluation of various farming requirements for crustaceans, including reproduction, nutrition, disease control and culture;
- reduction of post-harvest losses through improved handling and processing; and
- protection of aquatic habitats from the effects of pollution and other forms of environmental hazards.

Aquaculture Development Research Priorities in Africa and West Asia

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Background

The research priorities listed below are based on national surveys carried out by Food and Agriculture Organization (FAO)-implemented regional projects as well as reports of FAO field missions. The specific methods used to arrive at priorities are presented in the indicated sources of information. The listed priorities represent those of common concern to a majority of countries at a regional/subregional level. However, information on national priorities is provided in the cited information sources.

SubSaharan Africa

Countries involved; Côte d'Ivoire
Nigeria, Congo, Cameroon, Central

African Republic, Kenya, Tanzania, Mala[^]wi, Zambia, Zimbabwe, Madagascar.

RESEARCH PRIORITIES. The major identified research objectives which address technical development constraints (Coche et al. 1994) are listed below in order of decreasing priority:

1. improved supplementary feeding strategies (75% of countries);
2. biology and farming of local species (50%);
3. improved organic fertilization strategies (42%);
4. improved genetics of farmed species and broodstock management (25%); and
5. socioeconomics (general), market research, small water bodies, cage culture and integrated farming systems (25%).

RESEARCH PROGRAMS. Nine regional network research programs, with strong national components, have been elaborated, grouped into short (five

years) and medium (ten years) time frames, and assigned relative priorities based on the combined regional development and research priorities:

Research programs	Duration	Priority
Information centers	short term	1
Production indicators	short term	1
Socioeconomics of aquaculture and target groups	medium term	1
Pond fertilization and feeds	medium term	1
Fish broodstock improvement and management	medium term	1
Fisheries enhancement in small water bodies	medium term	2
Aquaculture in irrigation schemes	medium term	2
Indigenous species culture	medium term	3
Marine aquaculture	medium term	3

These programs were approved by the Working Party on Aquaculture of the FAO Committee for Inland Fisheries of Africa (CIFA) and subsequently by CIFA. Project concept papers have been prepared for each program and efforts are underway to secure support to assist in the preparation of project proposals for consideration by donors.

North Africa

Countries involved: all countries in the Mediterranean Basin.

RESEARCH PRIORITIES. Five major priority research areas have been identified from information provided by the countries and in consultation with country representatives under the umbrella of the Mediterranean Regional Aquaculture Project (MEDRAP II) (FAO/UNDP MEDRAP II 1991; FAO/UNDP MEDRAP II 1993a; FAO/UNDP MEDRAP II 1993b; Lacroix, in press):

1. species diversification for mariculture to avoid the saturation of markets created by the increase in production of seabass and seabream culture in the Mediterranean;

2. optimization and intensification of production techniques for commercially cultured species, giving special emphasis to:

- pathology
- nutrition
- stock enhancement and freshwater aquaculture
- economics and market analysis;

3. development of information systems to enhance access to research information;

4. upgrading national research capabilities through training and exchange of researchers; and

5. evaluation of existing potential for coastal lagoons and freshwater aquaculture.

RESEARCH PROGRAMS. The approach to and infrastructure for aquaculture research and development in the Mediterranean have been key

concerns of the MEDRAP I (1979-1987) and MEDRAP II (1990-1995) projects. This has resulted in a progressive refinement of the selection of research programs to better accommodate existing regional capabilities. It was found that the more appropriate solution was to establish four inter-related networks which could accommodate the identified development and research priorities. An action plan has been developed on this basis and endorsed by the countries and the FAO General Fisheries Council of the Mediterranean. The plan calls for the support and strengthening of the following networks:

- Système d'Information pour la Promotion de l'Aquaculture en Méditerranée (SIPAM): the information network for promotion of aquaculture;
- Technology of Aquaculture in the Mediterranean (TECAM): the

network for aquaculture bio-technical aspects;

- Socioeconomic and Legal Aspects of Aquaculture in the Mediterranean (SELAM): the network dealing with social, economic and legal aspects of Mediterranean aquaculture; and
- Environment and Aquaculture in the Mediterranean (EAM): the network dealing with environment and aquaculture in the Mediterranean.

These networks are now operative, thanks to the collaboration of the International Center for Advanced Mediterranean Agronomic Studies which supports TECAM and SELAM, and the Mediterranean Action Plan-Priority Action Programme/Regional Activity Center which supports EAM, and to the cooperation of the Governments of Tunisia and France for SIPAM. The distribution of research tasks among the four networks is indicated in the following table:

Network	Research priorities
Technology (TECAM)	<ul style="list-style-type: none"> • biology of new species • nutrition of commercial species • pathology problems • intensification of freshwater aquaculture • new technologies
Socioeconomic and legal aspects (SELAM)	<ul style="list-style-type: none"> • optimization of economics and marketing of commercial species • access to resources • trade regulations
Environment (EAM)	<ul style="list-style-type: none"> • evaluation of sites • farm effluents • coastal lagoon aquaculture
Information (SIPAM)	<ul style="list-style-type: none"> • exchange and provision of information • analytical modules for farm economics • specialized databases

Syria, Iraq and Islamic Republic of Iran

RESEARCH PRIORITIES. Although information on research needs is not available, some likely priority areas may be inferred from development priorities and some known constraints (FAO 1990; FAO 1992). These are:

1. development of feeds from locally available materials (at national and/or farm levels) and improvement of feeding strategies;

2. production of seeds (local and introduced species) and broodstock improvement;

3. development of model production systems for irrigation channels and integration with smallholder irrigated farms;

4. development of efficient polyculture systems (cyprinids and other local species);

5. improved management of pond productivity using local, low-cost inputs;

6. optimization of the economics of cage culture;

7. evaluation of the potential and species selection for culture-based fisheries; and

8. adaptation of technology for marine shrimp and finfish.

Arabian Peninsula

Countries involved: Saudi Arabia, Kuwait, United Arab Emirates, Qatar, Oman.

Aquaculture development in this arid subregion is focused (based on the number of countries involved) on the mariculture of local and introduced high-value finfish and shrimp in intensive systems. Paradoxically most of the

current production is from freshwater culture of tilapia in Saudi Arabia (integrated agriculture/aquaculture and stand-alone farms using freshwater recycling systems). Accordingly research is focused on the following topics:

1. development of culture technology for endemic marine finfish and shrimp;

2. adaptation of intensive marine and freshwater culture systems;

3. local development of feeds (Saudi Arabia);

4. seed production of marine finfish and shrimp; and

5. mariculture of tilapia.

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Aquaculture Research Priorities and the Smallholder Farmer

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Some of the perceived benefits from aquaculture include increased household food security, increased local self-reliance in food supply, supplementation of declining yield from capture fisheries and generation of employment opportunities (Ruddle 1993). However, there are many constraints that smallholder farmers need to overcome in order to achieve sustainable production.

Water Supply

Water is a major constraint for most farmers who have taken up fishfarming. The problem is more serious now because of drought that has reduced both surface and groundwater levels. The challenge for researchers therefore is to come up with innovative ways to maximize use of dwindling water supplies by incorporating water management measures into aquaculture systems.

Rice-fish Farming

Rice-fish farming is a very attractive, but not well understood, farming

system in Malaŵi. More research is required to provide farmers with better pond designs and a selection of appropriate fish species for this integrated system.

Farmer-to-Farmer Communication

There is a need for research on the process of transferring new innovations in aquaculture to other farmers. The positive influence of gender issues in such processes needs to be evaluated.

Irrigation and Aquaculture

The introduction of irrigation systems along the lakeshore and Shire River to improve food production is being seriously considered. As Pantulu (1980) has pointed out, irrigation systems are usually associated with modern, intensive agriculture involving the use of fertilizers and biocides for cultivation of high-yielding crops. It is important to determine how irrigation systems could successfully incorporate aquaculture.

Indigenous Species

Research should be carried out on the selection of indigenous species for better reproductive and growth performance. There is also a need to study the use of fish to control bilharzia in fishponds.

Parasite/Diseases

Research on parasites and pathogens should be expanded to provide a basis for improved management of fishponds.

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PART IV: AFRICAN GREAT LAKES AND RESERVOIRS

The Fisheries Resources of African Lakes

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Summary

This paper reviews the current status of fisheries in African lakes, evaluates their potential for the development of wealth production and identifies research priorities that would reduce uncertainties in this evaluation. The scope of the paper encompasses both natural and human-made lakes; swamps, floodplains and rivers are not included. Present assessments suggest that African lake fisheries are fully exploited, but there is considerable uncertainty in determining the accuracy of existing yield estimates and their relation to potential sustainable yields. The paper attempts to identify opportunities for increased fish production through more effective and appropriate management, new introductions of species to human-made lakes, and improved products and marketing.

The paper focuses on the major research problems impeding a greater understanding of African lake fisheries. Critical operational problems to be overcome include a serious lack of

appropriately trained staff; the need for transnational cooperation in research and management in many lakes; the dispersed nature of artisanal fisheries, and the pernicious social and ecological interaction between poverty and the exploited fish community that leads to Malthusian overfishing. There are fundamental uncertainties about how the ecological production base of lakes translates into harvested fish production in the face of labile food webs, variations in lake level and the enrichment of natural waters brought about by human activities. There is also considerable uncertainty attached to the accuracy of catch and effort data, the choice of assessment models appropriate to African lake fisheries, and how these deficiencies might be remedied. Technical means of incorporating uncertainty in assessment and management need to be further developed for work on African lake fisheries.

Four major issues in the African lakes that may shape the focus of research agendas are presented in the light of ways of evaluating tradeoffs between

exploitation and conservation. First, the current status of African lake fisheries for introduced species is discussed, the factors determining new introductions are evaluated and the methods of estimating potential yield, reviewed. Second, harvesting regimes for endemic faunas in natural lakes with no introductions are examined for opportunities to enhance yields. Third, opportunities for stocking fish in smaller, human-made lakes are explored. Fourth, the importance of reserves in achieving sustainable fisheries is emphasized. Research priorities and training objectives that will allow fisheries scientists in Africa to address these areas are listed, together with suggestions for their implementation.

Priorities for Research on African Lake Fisheries

The following are the author's views on priorities that are necessary to sustain and enhance as far as possible the capture fisheries food production of the African lakes. The priorities encompass training, research and the decision background necessary for sound management of the fisheries. Many of these priorities are congruent with ICLARM's present activities and priorities.

TRAINING OBJECTIVES. The following objectives are considered important if training is to meet the future research and management needs of African lake fisheries:

- appropriate syllabus;
- methods of assessment and coping with uncertainty;
- interdisciplinary studies including social and economic factors;
- suitable qualifications;
- suitable institutes and institutional policies;

- staff development programs;
- research coordination among/ within agencies and NARS; and
- innovative funding for training fellowships and links to the rest of the world.

RESEARCH OBJECTIVES. The following research objectives have been identified:

- *Obtaining good fisheries data and monitoring the fishery.* Well-designed frame surveys with frequent interim analysis to probe the validity of methods and detect changes in the fishery are required.
- *Identifying fish species.* Good field guides remain a priority for the African lakes where taxonomic problems are widespread.
- *Understanding lake and fish ecology.* Fundamental work in limnology is required with objectives that are directly relevant to the fisheries production base of the lake fisheries.
- *Testing and implementing mesocosm experiments.* One experimental paradigm that has become essential to mainstream limnology and fish ecology is the experimental mesocosm technique. For example, carefully planned and controlled experiments with multiple introductions of sardines and their predators or herbivorous fish and their predators could be undertaken if suitable facilities were available.
- *Devising appropriate assessment methods.* Existing assessment methods might not be the most appropriate, cost-effective or accurate for African lake fisheries. Instead methods that are robust in such uncertain data environments may be more appropriate.
- *Devising appropriate management regimes.* Incorporation of socio-economic information is important

if resource production is to be sustainable. In the scattered artisanal fisheries of African lakes, management regimes that are technically feasible are also required, for example, transfer of the kind of rigid controls used for policing and enforcement seen in North American fisheries is impossible in African lakes. Research into suitable methods of self-management (e.g., co-management) would be very appropriate.

- *Surveying of suitable reserves in African lakes.* Many fisheries scientists regard reserves, sanctuaries where fishing does not occur at all, as essential to the sustainability of fisheries in the face of progressive overexploitation and uncertainty in ecological processes, fisheries assessment and management. It is therefore considered a research priority to identify, design and monitor such reserves not just for

threatened fish species by way of conservation but with a clear focus on their use in the sustainable management of the principal African lake fisheries themselves.

- *Choosing appropriate product development and market improvement.* Appropriate low technology or robust, durable and low-cost high technology procedures need to be identified to enhance products and markets for fish products from the African lakes. Socioeconomic effects need to be evaluated from the outset to determine acceptability and minimize adverse impacts on equity and social stability.
- *Coordinating research programs.* International and national agencies need to devise better ways of coordinating their efforts. Improved communication among the research communities concerned with African fisheries would be a key.

The Fisheries and Socioeconomic Characteristics of the Large East African Lakes and Reservoirs

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Introduction

The large African lakes and reservoirs are some of the largest water bodies in the world. They have tremendous development potential and are mostly used for fisheries, irrigation and generation of hydroelectricity. Some of the reservoirs were built primarily for hydroelectricity, although they have subsequently been put to multipurpose use. The lakes are also very deep which has implications for the hydrodynamics and fisheries production in the lakes.

Socioeconomic Indicators

Life expectancy of the populace is generally low and infant mortality is high. This reflects a generally low level of development. The economies of the countries are essentially based on agriculture with the majority of people in rural areas practising subsistence agriculture. Dependency on natural resources, including fisheries, is the norm

which has resulted in some of the problems experienced in the management of the fisheries resources.

Fisheries Characteristics

Fish production is high in Lakes Victoria, Nubia-Nassa and Tanganyika, with most lakes regarded as heavily exploited. For the whole region (including small water bodies), fish production reached 1.2 million t in 1990 (Greboval et al. 1994). The value of fish produced within the region is around US\$400 million.

Fish production is almost exclusively for food and provides a relatively cheap source of protein. The average per caput consumption is 6.5 kg·year⁻¹ and fish exports are low.

The fisheries sector is also a major source of employment mainly at the artisanal level. Overall, 470,000 people are directly employed in this sector in the region (Greboval et al. 1994). When secondary activities and related services

are considered, about 1.8 million people are employed.

The fisheries are basically multispecies which has implications for management.

Fisheries Management

A number of factors affect fisheries management in the African lakes:

- The traditional western approach to management - limits to fishers' numbers, limits to fishing gear, closed seasons, closed areas - are of little practical value to the management of these fisheries. These measures are not tenable socioculturally and politically. Consistent with the western approach to management, decisionmaking and planning are at the national level.
- Data on the number of fishers, type and number of fishing gear, size and composition of catches are hard to obtain.
- There is open and free access to fishing grounds which has often led to both economic and biological overfishing.

Research Needs

The major problem in the area of research stems from the general weakness of most national fisheries institutions. They are weak in policy formulation, formulation and implementation of fisheries programs and

projects, and sectoral planning. There are also poor linkages between research and management. These institutions are poorly funded and staff skills are limited. In most cases, these institutions were built during the colonial period and have run down. Development projects have been expected to revitalize the situation, but have not always been successful. Some of these projects are short and have not been sustainable.

Specific research needs have been identified as follows:

- determination of the status of fisheries resources and their levels of exploitation;
- determination of the factors driving pelagic fisheries production in Lakes Tanganyika and Malawi;
- investigation of socioeconomic factors, including developing an understanding of the demography, perceptions and attitudes of fishers, the structure of local institutions fishers operate within, and gender issues;
- development of data collection systems to support fisheries management decisionmaking; and
- development of integrated lakeshore planning and management.

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PART V: SOCIAL SCIENCES AND CO-MANAGEMENT

Fisheries, Aquaculture and Coastal Resources - Social Science Research in Africa and West Asia*

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Background

The issues of socioeconomic and policy research are very important at ICLARM. Since its inception, its researchers have been at the forefront of social science research in fisheries, aquaculture and coastal resources.

ICLARM's social science research is currently undertaken through its two research programs - Coastal and Coral Reef Resource Systems Program and Inland Aquatic Resource Systems Program (IARSP) - and one special project on fisheries co-management which cuts across resource systems. The Fisheries Co-management Project is based on a mutual approach to gain practical experience in research in fisheries co-management, demonstrate its applicability as a sustainable, equitable and efficient management strategy, and develop models for use and adoption by governments, fishing

communities, nongovernment organizations and others.

ICLARM currently has two social science research activities in Africa. The Fisheries Co-management Project involves research at the community level with partners in Zimbabwe, Mozambique, Malawi, Zambia and the Programme for Integrated Development of Artisanal Fisheries in West Africa. The IARSP, through its Malawi project, is evaluating the socioeconomic constraints to, the potential for, and the impacts of the use of low-input integrated aquaculture systems.

Objectives of Social Science Research at ICLARM

Social science research contributes to ICLARM's goal of improving production and management of fisheries resources for the sustainable benefit of present and future generations of low-income users in developing countries. The basic

*ICLARM Contribution No. 1285.

developing countries. The basic objectives of social science research at ICLARM are:

1. to understand the dynamics of the living aquatic resource use sector, the fishers and fishfarmers, the rural communities, the markets, and policies such that sustainable technological and management interventions can be designed for resource-poor fishers and fishfarmers;

2. to assist national aquatic research systems in strengthening their priority setting and research impact assessment activities related to fisheries research; and

3. to enhance national capabilities for social science research in the fishery sector.

Research Needs in Africa and West Asia

The task facing African fisheries development (including aquaculture) in the year 2000 and beyond is formidable. It must achieve sufficient growth in fish supply not merely to maintain output per person but also to reduce nutritional deficits, and it must be a major employer of Africa's growing labor force. Development must proceed while reversing existing and avoiding further degradation of natural resources that threaten long-term supply.

Despite the enormous variations in biophysical and socioeconomic environments throughout Africa, there is a remarkable commonality in the research requirements to spur fisheries development. Specifically, those requirements are:

- to identify and disseminate new technologies to increase productivity;
- to enhance environmental protection;
- to strengthen rural-urban economic links and improve marketing;
- to encourage rural peoples and associations, including women, to play a greater role in decision-making;
- to provide favorable institutional and policy environments; and
- to strengthen national research capacity.

Proposed Social Science Research Activities in Africa and West Asia

The broad role of social scientists in fisheries research is to bring the human factor - family, community, market and policy levels - into the research agenda and the design and testing of research products. To meet the overall research requirements for Africa and West Asia, social science research activities need to be undertaken in the following areas:

- aquaculture technology adoption by new entrants;
- assessment of property rights issues for inland water and small water bodies;
- market and price analysis;
- economic and social analysis of fishers and fishfarmers;
- institutional and organizational arrangements in fisheries;
- evaluation of ecological economics of coastal resources;
- policy analysis; and
- priority setting and research impact assessment.

Research Needs in the Socioeconomics of Fisheries in the West African Subregion

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Background

In 1985, a total of 1,656,900 t of fish, equivalent to 43% of the total African catch, was landed by West African fishers. Of this catch, 1,190,150 t or 72% was produced by small-scale or artisanal fishers (Bonzon and Horemans 1988). The number of full- and part-time fishers was estimated to be around 884,960. When ancillary employment in fish processing, storage, transportation, marketing, financing, equipment building and repairs is taken into account, the West African fisheries subsector supports over four million workers or 9% of the total labor force in agriculture (Bonzon and Horemans 1988). Over 90% of this employment is in artisanal fisheries. The bulk of the landings of artisanal fishers is sold and consumed locally, so the fisheries subsector supplies between 30% and 65% of the daily intake of animal protein in the region.

In the 1960s and 1970s, many projects were established in West Africa to develop the fisheries sector. Different

projects tackled different deficiencies. However, there were never enough funds nor expertise for a project to tackle all known deficiencies in any one country. The usual procedure was to establish one or two projects in each country.

This method of developing the fisheries sector was not successful in improving the living standards of those in the fishing industry, much less those in the fishing community since the method usually solved one problem but introduced another. For example, the introduction of motorized boats increased catches with increased fishing effort. However, this usually led to overfishing and depletion of stocks (as has happened in Nigeria, Ghana, Côte d'Ivoire and Senegal). Also, increased catches without prior or simultaneous improvement in the marketing system merely led to depressed prices and unprofitable fishing operations.

Many of the projects were designed by government planners and/or development agents without much input from the intended beneficiaries

of the programs and consequently without much support from the groups that were supposed to implement the projects. Such projects could not be sustained when foreign funding ceased and development agents left. Some projects dumped too much equipment and technology on unsophisticated fishing communities. The paucity of technical and managerial skills in these communities left a lot of this equipment underutilized, thus rendering the projects unprofitable. The duration of many projects - five years - was too short to impart any type of capacity, technical or administrative, to the beneficiary group, meaning that the project could not be sustained. Some projects were too small to make any visible impact on the beneficiary group.

Research Needs

Some of the research needs identified are:

Fisheries management

- identification of the systems and mechanisms which can be used to prevent fishery resource depletion; and
- development of alternative employment opportunities to reduce the pressure on the fishery.

Exploitation by women financier-traders

- investigation of the charges that women traders, who are also financiers, exploit fishers by charging them exorbitant rates of interest, tying their loans to the

delivery of the catch and paying them fish prices which are much lower than the prevailing market prices.

Credit use and indebtedness among fishers

- determination of the size, sources, conditions, use and repayment of credit in the fisheries sector; and
- determination of the nature and magnitude of indebtedness among fisherfolk.

Reduction of postharvest losses

- determination of the mechanisms, practices and technology required to reduce postharvest losses.

Effects of the environment on fishery

- determination of alternative waste disposal methods for industry and the general population; and
- investigation of methods to rejuvenate inland and marine fisheries ecosystems.

Feasibility and sustainability of development projects

- determination of approaches to the design of fisheries development projects that are feasible and sustainable.

Reference

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Socioeconomic Research Needs for Fisheries and Aquaculture in Africa

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Status of Socioeconomic Research on African Fisheries and Aquaculture

Research on the socioeconomic aspects of African fisheries and aquaculture covers a wide range of topics and issues. These studies fit into the following broad categories:

- fishing communities, fishers cooperatives and fishing households;
- women's participation in fisheries activities;
- inland water bodies, e.g., rivers, lagoons, lakes, etc.;
- fishing methods, e.g., line and purse seine fishing, etc.;
- impact of introduced technology and technology transfer;
- fisheries management and development planning;
- fish processing, preservation and storage;
- demographic structures, the role of social science and statistical surveys;

- sources of funds and financing of fisheries activities;
- fish distribution, marketing and trade; and
- aquaculture and fishfarming technology.

Socioeconomic Information Needs

Decisions in fisheries management and development have always been based on socioeconomic factors. Even when these factors were not explicit, decisions were not made except in response to demands for an increase in social or economic benefits (or prevention of decrease in such benefits).

Some of the decisions that require socioeconomic information include:

- what kinds of management controls to adopt;
- how to implement the controls;
- how to set up management practices and regulations to achieve desired, distributional goals;

- who should have access to and how much of the resource;
- how to increase income levels of fishers;
- how to maintain the level of employment;
- how to reduce conflicts between artisanal and industrial fishers;
- whether and how to limit entry or effort in domestic fisheries;
- how to estimate the value of stocks that are shared;
- how to formulate and negotiate joint ventures;
- how to determine and minimize costs of enforcement;
- how to extract economic rents;
- how to determine access fees charged foreign fishers; and
- what kinds of other benefits can be extracted.

Critical Areas for Socioeconomic Research

This section identifies critical areas for socioeconomic research based on the state of fisheries and aquaculture in African countries, i.e., whether they are underexploited or overexploited.

RESOURCES THAT ARE UNDER-EXPLOITED BY EXISTING FISHERIES.

For resources exploited by both foreign and local fishers, research should cover the following areas:

- development of methods for placing appropriate economic values on the resource; and
- determination of appropriate access fees.

For resources exploited only by local fishers, research should cover the following areas:

- development of skills or knowledge of fishing techniques, boat handling or fish processing;
- determination of cultural impediments or fishing contrary to religious beliefs;
- determination of alternative employment or income-earning opportunities; and
- investigation into structural problems such as availability of foreign exchange for importing fishing equipment; communication systems, transport or market facilities; demand for fish products; or adequacy of certain market factors such as credit systems for financing fishing activities.

RESOURCES THAT ARE OVER-EXPLOITED BY EXISTING FISHERIES.

For overexploited resources, research should cover the following areas:

- determination of management objectives and identification of the relative roles of large- and small-scale fishers;
- analysis of trends in real fish prices and projections of future price changes;
- determination of the impacts of large-scale fishing operations within the context of national development;
- determination of net benefits between large- and small-scale fishing operations;
- determination of present and likely future costs of overexploitation; and
- determination of the nature and characteristics of small-scale fishing communities and the rules under which they operate.

PART VI: NATIONAL AQUATIC RESEARCH SYSTEMS PARTNERSHIPS

Partnership between National Aquatic Research Systems and ICLARM in SubSaharan Africa

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Introduction

To help identify the opportunities and needs for national aquatic research systems (NARS) strengthening in 12 countries in subSaharan Africa in the context of ICLARM's research programs, this paper briefly reviews the status of NARS in subSaharan Africa and the constraints they face in carrying out strategic living aquatic research. The review focuses mainly on capabilities and constraints in the aquaculture sector.

NARS Status

In the past three years, there have been several reviews of aquaculture development and research constraints and priorities in subSaharan Africa (CIFA 1993; ALCOM 1994; Coche et al. 1994). The most comprehensive of these was

the study by Coche et al. on aquaculture development, research needs and indicative plans for aquaculture research in subSaharan Africa carried out in 1992-1993 in the context of the Study (now Strategy) for International Fisheries Research (SIFR).

Long-term research, such as that envisaged under ICLARM's Strategic Plan, should complement the short- and medium-term research priorities identified in the SIFR study and contribute to alleviating the identified aquaculture development constraints in subSaharan Africa.

THE RESEARCH SECTOR. The public sector predominates, although the private sector is active in Kenya, Zambia and Zimbabwe. Administrative and institutional responsibilities vary from country to country with three types of institutions responsible for research programs: departments of fisheries;

university departments; and research institutes (fisheries, natural resources or animal husbandry).

Most of the aquaculture research stations operate in a freshwater environment, and four stations in the 12 countries reviewed were rated from "very good" to "good" with facilities generally in full use. Financial resources are very limited in all cases and it is only through foreign financial assistance that infrastructure and equipment are improved and operating funds, made available.

INSTITUTIONAL FRAMEWORK. The directions for aquaculture research programs are determined in three ways:

- by the multidisciplinary committee;
- by the institutional board of directors; and
- by the staff of the institution.

Public research funds are usually raised at the institution's level, either as part of the national budget or from donors. Competition for limited funds is severe and the low priority given to the aquatic sector often results in insufficient funding.

The results from aquaculture research are usually not properly evaluated, in general considered to be of low value to extension workers and producers, and have limited use. Collaboration with other institutions is also not well developed and research results are rarely published or disseminated.

HUMAN RESOURCES. With the exceptions of Nigeria and Kenya, there are few, resident national aquatic scientists, with expatriate scientists playing a major role in some countries such as Côte d'Ivoire. These scientists are mainly biologists or ecologists; some have backgrounds in veterinary science, animal husbandry, agriculture and

forestry. Actual time spent on research is limited since many researchers do not have the facilities and/or funds to carry out research or have administrative or development responsibilities.

Opportunities for NARS Strengthening

CONSTRAINTS TO NARS RESEARCH.

From the status of NARS in subSaharan Africa, five broad research constraints can be identified:

- few, high-level professional staff;
- poor service and working conditions;
- little information flow;
- lack of research agendas linked to development needs; and
- limited financial and infrastructural resources.

These constraints relate to both the immediate ability of NARS to effectively work in partnership with ICLARM and the long-term sustainability of NARS' research efforts.

ROLE FOR ICLARM. The first four constraints can be directly addressed by activities envisaged under ICLARM's National Research Support Program. The last constraint, limited financial and infrastructural resources, can be addressed by ICLARM through the financial resources and infrastructure improvements made as part of partnership efforts. While infrastructure improvements can have a long-term impact, direct assistance with operating costs could only take place during an active partnership. Means for meeting long-term operating costs beyond the life of the partnership should then be established.

Information services can contribute to an improved working environment, the setting of research agendas linked to development needs, the quality of research planned and carried out, and the use of research results.

In view of the identified constraints, high-level training in and of itself, while certainly strengthening national program scientists, is not sufficient to guarantee sustained national scientific input to NARS activities. The creation of working environments which will retain and focus the trained researcher on aquatic research is an essential part of research management. Beyond formal training, ICLARM is in the unique position to provide mentoring to young scientists, basic research frameworks and the intellectual environment needed to sustain research. However,

the more practical aspects of the conditions of service can only be addressed by ICLARM in the short term if host institutions adopt research policies and the means are provided locally to make the necessary improvements.

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Partnership between National Aquatic Research Systems and ICLARM in Africa*

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Introduction

ICLARM enters into collaborative partnerships with national aquatic research systems (NARS) when it conducts its research activities. In Africa, ICLARM has conducted research projects in Malawi (ICLARM and GTZ 1990; Brummett and Noble 1995), Sierra Leone (Vakily 1992) and two in Ghana (Prein et al., in press) in which the staff were based with NARS for a number of years. In this paper, one of the Ghana projects serves to exemplify the rationale, implementation and possible outcomes.

The project was a short-term special project grant to ICLARM by Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung/Gesellschaft für Technische Zusammenarbeit from 1991 to 1994 with the title "Research for the Future Development of Aquaculture in Ghana". The objective was to answer the question: "what makes sense for

aquaculture development in Ghana?". Within ICLARM's mandate, the focus was on rural smallholder farmers as "new entrants" into aquaculture. The working hypothesis was that integrated agriculture-aquaculture (IAA), within the context of integrated natural resources management (IRM), is a viable enhancement of local farming systems, given adequate site, water and soil characteristics.

Framework

The project employed a systems approach with farmer-participatory on-farm research as a central element (Lightfoot et al. 1996). The RESTORE toolkit (Lightfoot 1994) was the main set of methods used in the fieldwork with farmers. Besides on-farm work, on-station trials were conducted to verify observations obtained in the field. In all activities, close collaboration with NARS was secured, often in multilateral partnerships which were new to the Ghanaian partners themselves.

*ICLARM Contribution No. 1286.

Partners

The project involved six major partners. The main partner was the Institute of Aquatic Biology (IAB)/Council for Scientific and Industrial Research of the Ministry of Industry, Science and Technology of Ghana which hosted the project office and provided counterpart scientists, staff, and valuable administrative and operational support. Within its Fisheries Division, IAB has the mandate to conduct research for the development of aquaculture.

Second, the Ghana Rural Reconstruction Movement (GhRRM), a successful nongovernment organization created in 1978 with a well-established operation in Mampong Valley (Akuapem, Eastern Region), had valuable links and experiences with farmers in the area which is characterized by a severely degraded environment (denuded hillsides, short fallow periods between maize/cassava/plantain intercropping cycles), smallholder farm households with total landholdings of under 2 ha and a total lack of any form of aquaculture. GhRRM had successfully introduced initiatives for rehabilitation such as agroforestry and biointensive gardening.

The third group of partners were the farmers in the area with whom IAA/natural resource management developments were established and who shared their detailed knowledge and problems. The fourth group was a separate group of farmers termed the "control group", who lived in the same area and under the same conditions, but were outside the operational zone of GhRRM and had no previous exposure to external support for development. These farmers were approached through

traditional mechanisms within the hierarchy of chiefs, development chiefs, village heads and farmers.

The remaining groups were the Irrigation Company of the Upper Regions (ICOUR) in Tono, which was supported by the Fisheries Department, and the farmers within this large irrigation scheme. Here, rice-fish culture within irrigated ricefields was introduced.

Operation

Within the IAB/GhRRM/ICLARM partnership of on-farm research, participatory rural appraisals were conducted by mixed teams in villages and homesteads, workshops were held with farmer groups, individual farm households were interviewed, and options for changes on their farms, including aquaculture, were brainstormed and recorded. Further, during implementation (i.e., pond construction and operation) by the farmers, technical advice had to be given, but in the form of options for the farmers to decide upon, based on their constraints. Farm households embarking on IAA were monitored and all three partners shared in data collection. These data were analyzed to permit final assessments within the aims of the project. Feedback from the farmers was obtained in various forms by the different partners and this proved valuable for understanding underlying reasons for certain decisions the farmers made.

Knowledge was shared between partners on the situations and constraints of farmers, the environmental context, the research methods, and the technical aspects of low-technology aquaculture. All sides contributed smoothly to a common goal.

Results

Farmers developed IAA systems tailored to the situation on their farms. Ponds were dug manually by farmers with the help of family members and friends. The pond sizes ranged from 50 to 120 m² and most decided to establish vegetable beds adjacent to the ponds. Farm income increased considerably, but of the increase through fish and vegetable production, 95% came from vegetables. In some cases, fish yields were higher than anything previously achieved on station. A higher amount of nutrients were recycled, e.g., fish and vegetables were produced from on-farm residues only, such as banana, leucaena, cassava and cocoyam leaves, cassava peels, oil palm chaff, cooking fire ash, manure and kitchen scraps. Further, farms were diversified, adding to their sustainability.

On-station research at the Aquaculture Research and Development Center in Akosombo verified observed production figures based on on-farm inputs. Chicken manure gave higher Nile tilapia yields than cow manure. Manured ponds gave a two- to three-fold higher yield than unfertilized ponds.

At the ICOUR irrigation scheme in northern Ghana, farmers successfully experimented with different forms of rice-fish culture to suit their situation which usually involved lateral trenches and a small fish refuge area.

Impact

Beyond the scientific results, the project established new linkages between NARS and NGOs in Ghana. This success has led partners to seek

additional linkages on their own and further agreements are in the pipeline. NARS partner IAB officially adopted the IAA/IRM research thrust for its own research agenda and has continued its on-farm work after the project was officially completed. Thus, sustainable farmer-to-farmer extension is taking place in Mampong Valley with some support from GhRRM and a voluntary service overseas volunteer. Currently, there are more than 30 IAA farmers in the area after only three years of *research*.

Knowledge was exchanged and disseminated between partners, i.e., NARS and NGO staffs, farmers and the ICLARM scientist shared information and learned valuable, new aspects. A scientific workshop was held involving all partners and important national and international experts and decisionmakers who presented the project's results and their recommendations. These results will be subsequently published. Thus, the Fisheries Department and the unified Agriculture Extension Service now have a blueprint for an operational approach to initiate and document sustainable IAA development at the farm household level. Indeed, ICLARM's experience is that collaboration with and among NARS, NGOs and government organizations can be truly rewarding.

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Appendix 1

ICLARM's Strategic Plan

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Introduction

In March 1992, ICLARM published its Strategic Plan in the document "ICLARM's Strategy for International Research on Living Aquatic Resources Management". The plan contains defined priorities that have been approved by the ICLARM Board, endorsed by the Consultative Group on International Agricultural Research (CGIAR) and supported by donor organizations. The planning exercise that resulted in the defined priorities is described in full in the plan.

When developing a research agenda for Abbassa, ICLARM needs to be guided by the priorities defined in the Strategic Plan. However, this plan should not be static and should evolve to respond to changed circumstances. Therefore, the following three factors also need to be considered:

1. A strategic plan can and should be modified (though cautiously) in the light of significant developments.
2. A pragmatic and dynamic institution like ICLARM should adjust its actions to situations and developments.

3. ICLARM's main requirement remains addressing its mandate and continuing its emphasis on systems-oriented research in collaboration with advanced scientific institutes and national aquatic research systems (NARS) to generate knowledge and methods of global or regional significance. ICLARM also has to place emphasis on supporting activities, mainly NARS strengthening, training and communication.

This document is an outline of the key points abstracted from the Strategic Plan. These include ICLARM's goal and objectives, the objectives of the four main programs, and the priorities for work in the various resource systems, regions and research activities.

Key Points from the Strategic Plan

1. **ICLARM'S GOAL AND OBJECTIVES.** The general mission of CGIAR is to contribute to sustainable improvements in the production of agriculture, forestry and fisheries in developing countries in ways that enhance nutrition and well-being, especially among poor people.

Within this mission, ICLARM has the following goal and objectives:

Goal

Improved production and management of fisheries resources for sustainable benefits of present and future generations of low-income users in developing countries.

Objectives

Through international research and related activities and in partnership with NARS, to:

1. improve the biological, socio-economic and institutional management mechanisms for sustainable use of aquatic resource systems;
2. devise and improve production systems that will provide increasing yet sustainable yields; and
3. strengthen national programs to ensure sustainable development of aquatic resources.

2. **RESOURCE SYSTEMS.** The aquatic sector was divided into a number of large-scale resource systems similar to but not directly comparable with agroecosystems used by CGIAR for agricultural research. Nine resource systems were identified. Two systems were excluded: the uplands, which are generally insignificant for capture fisheries and unfavorable for aquaculture, and the high seas because a CGIAR institute has little comparative advantage in industrial-scale fisheries. The remaining seven resource systems are:

- ponds;
- reservoirs and lakes;
- streams, rivers and floodplains;
- estuaries and lagoons;
- coral reefs;
- soft bottom shelves; and
- upwelling shelves.

The resource systems that received the highest priority for research are:

- coral reefs;
- ponds; and
- estuaries and lagoons.

3. **REGIONS.** The priority by region was determined during the strategic planning process using the agreed priority setting criteria. The regions in priority order are:

- Asia;
- SubSaharan Africa;
- Latin America/Caribbean; and
- North Africa/West Asia.

To quote from the Strategic Plan: "In Africa, freshwater fisheries account for 54% of the total catch and production. It is even higher (64%) if upwelling fisheries are excluded. Therefore, a special case can be made for a focus on the freshwater resource systems which have previously been excluded for the global research agenda - reservoirs and lakes, and streams, rivers and floodplains - to address specifically the special African conditions. These issues will be addressed as the mid-term planning proceeds and the results of exploratory research in Africa become clearer."

4. **RESEARCHABLE ISSUES.** A list of researchable issues was developed during the strategic planning process using the agreed priority setting criteria. The choice of researchable issues to be carried out by ICLARM was made on the basis of those which were not being addressed adequately by other organizations and in which ICLARM would have a comparative advantage. Seven priority issues were identified:

- sustainability of coastal fisheries systems;

- improvement of the management of coral reef fisheries;
- improvement of fish productivity through genetics and husbandry;
- removal of socioeconomic and environmental constraints to aquaculture growth;
- development of farming systems;
- assessment and development of the potential for enhanced fisheries; and
- strengthening of national research systems.

5. ACTIVITY TYPES. Research issues were translated into research activities based on the activity types of the Technical Advisory Committee (TAC) of CGIAR. The types of research activities and the balance of resources for future research and strengthening activities were determined to be:

Activity	% of resources
Resource conservation and management	35%
Fish productivity	25%
Social sciences	20%
Institution building	20%

6 PROGRAMS. Future ICLARM research programs for research and related activities will be built on resource systems rather than on another grouping (e.g., regions, commodities, activity types or disciplines). This will not only foster the kinds of research approaches needed to deal with the critical international issues identified, i.e., bring together biological and social scientists to work on the management of aquatic resources but also build on the strengths, goal and objectives of ICLARM.

An assessment of the priority for each research type in the various resource

systems resulted in the following research programs:

- Inland Aquatic Systems (focusing on ponds);
- Coastal Resource Systems (focusing on estuaries and lagoons);
- Coral Reef Resources (focusing on coral reefs).

A fourth program, National Research Support (NRS), will provide a strong institutional-building role for ICLARM. Closely linked to the research programs, NRS will often rely on their outputs for NARS-strengthening activities.

Inland Aquatic Systems Program

This program will direct its research activities towards the adoption of sustainable inland aquaculture by resource-poor, small-scale producers in three thrusts:

- improvement of fish productivity through genetic gain and better husbandry;
- development of integrated agriculture-aquaculture farming systems; and
- removal of socioeconomic and environmental constraints to aquaculture development.

This program will contribute to ICLARM's objective to devise and improve production systems that will provide increasing yet sustainable yields.

The program's objective is to foster the adoption of sustainable inland aquaculture by resource poor, small-scale producers and thereby to increase fish production and income.

Coastal Resource Systems Program

This program focuses on the sustainability of coastal aquatic resources use by improving the biological, socioeconomic and institutional management mechanisms for sustainable use of coastal resource systems using the following mechanisms:

- understanding the dynamics of the resources;
- developing management strategies for the resources; and
- integrating management strategies into generalizable management options and policy recommendations compatible with sustainable resource use.

The program will contribute to ICLARM's goal of improving the biological, socioeconomic and institutional management mechanisms for sustainable use of coastal resource systems with primary emphasis on living aquatic resources (i.e., the fish resource).

The program's objectives are:

1. to understand the dynamics of the aquatic resources of coastal resource systems such that management interventions leading to high yet sustainable catches can be identified and implemented;

2. to understand the dynamics of the living aquatic resources use sector, the fishers (including their economic and social behavior), the fishing communities, markets and policies such that appropriate management interventions can be designed which will be implementable at the community, local government and national levels; and

3. to describe and understand the effects on living aquatic resources of intersectoral factors affecting coastal areas, thereby assisting ICLARM's client countries in the formulation of coherent policies for sustaining or developing their living aquatic resources through integrated development and management of their coastal areas.

Coral Reef Resources Program

This program will focus on the sustainable use of reef resources for the benefit of adjacent coastal

communities through the following thrusts:

- developing aquaculture and enhanced fisheries systems for coastal communities;
- understanding the interaction between people and reef resources; and
- developing sustainable fisheries management systems suitable for coastal communities.

This program is designed to address critical international research issues related to the potential productivity of coral reef fisheries and the scope for increasing sustainable harvests by developing aquaculture and fisheries enhancement systems. Additionally, a variety of management systems for coral reef fisheries need to be examined, including the role of marine protected areas in sustaining production and conservation of biodiversity. These activities invariably have complex social and economic settings which must be understood before effective management systems can be devised for coral reef resource systems.

The program's objectives are:

1. to improve income-earning opportunities and available foods for coastal villages through the development of village-based aquaculture and fisheries enhancement systems in coral reef environments and

2. to improve management of coral reef resource systems as a result of the effective synthesis of information on the coral reef ecosystem and human interactions, the creation of sustainable fisheries management models, and the development of effective, community-based management systems.

National Research Support Program

This program is designed to strengthen NARS through:

- information (publications, workshops, conferences);
- training (focusing on researchers); and
- assistance in priority setting of NARS research policies and management.

This program is designed to address the critical international issue of strengthening NARS such that they can respond to the challenges of better management of their living aquatic resources in order to improve and sustain capture fisheries and increase production from aquaculture and enhanced fisheries. In so doing, it will contribute to ICLARM's objective in the same area. An additional function this program will play is to ensure effective feedback between NARS and ICLARM in the future.

The program's objectives are:

1. to strengthen national program scientists;
2. to strengthen networking between NARS including nongovernment organizations; and
3. to assist NARS in strengthening their research policies and management related to fisheries research.

7. ADDITIONAL COMMENTS. The following comments made in the Strategic Plan are relevant to the development of a research agenda for the Abbassa facility.

SubSaharan Africa

"SubSaharan Africa" is a region of special needs and opportunities in fisheries research, as in agriculture and forestry. For fish production systems, this region has:

- a need to implement sustainable management of freshwater and marine fisheries;
- theoretical opportunities for enhanced fisheries, particularly in coastal lagoons, farm dams, and other reservoirs and lakes; and
- a perceived potential (although unproven) for aquaculture development, chiefly in freshwater.

"A cautious approach is proposed to research in SubSaharan Africa. Initially existing projects will form the basis to better understanding of the needs and opportunities both in research and strengthening so that future efforts will be cost effective and likely to achieve rapid impact. Africa should have the first priority for an outreach office once the research and strengthening needs are established.

"The SubSaharan Africa Office will initiate and manage collaborative research projects, engage in NARS strengthening activities, and explore needs and opportunities for establishing future networks. It will conduct in-depth studies of the special research needs and likely scope for growth or improvement of African aquaculture and fisheries. These studies will emphasise inland waters.

"As the constraints to the development of African fisheries and aquaculture will be largely sociocultural and resource related, this regional office should be staffed initially by a small multidisciplinary team including social scientists, working closely with headquarters and with project and NARS staff and consultants when required. It will accomplish its work through collaborative projects and networks with related NARS strengthening

information and training activities, conducted mainly in French and English.”

West Asia/North Africa

“The West Asia/North Africa region is characterised mainly by arid or semi-arid coastal states in which scope for small scale inland aquaculture and fisheries is limited. The most important fish production systems are the fisheries

in the upwelling areas on the Atlantic coast of western North Africa and to the south of the Arabian peninsula. Elsewhere there are scattered areas of potential for coastal and inland enhanced fisheries and aquaculture, especially in Egypt which dominates the freshwater production of the region. No regional office or physical facility is planned.”

Appendix 2

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Appendix 3

Workshop Program

ICLARM Research Planning Workshop
Ramses Hilton
Cairo, Egypt
22-27 September 1995

Friday, 22 September

- Registration

Saturday, 23 September

- Visit to Central Laboratory for Aquaculture Research at Abbassa
- Welcome dinner

Sunday, 24 September

- Participants read background documents
- Buffet lunch

Introductory presentations

- Opening remarks
- *Dr. M.J. Williams* (Director General, ICLARM). Introduction
- *Dr. J.H. Annala* (ICLARM). ICLARM's strategic plan and the development of the preliminary research agenda
- *Dr. J.H. Annala* (ICLARM). Background information on trends in population size, fish production and economic indicators in Africa
- Discussion

Monday, 25 September

- Presentation on research needs for specific resource systems and activities
- Buffet lunch

Coral reef resource systems

- *Dr. J.L. Munro* (ICLARM). Research on coral reef resource systems
- *Ms. N. Muthiga* (Kenya). Coral reefs of Kenya - research activities and priorities
- Discussion

Coastal aquatic resource systems

- *Dr. S.B. Saita* (USA). African coastal fisheries
- *Dr. R.K. Ruwa* (Kenya). Aquatic resource management in the Western Indian Ocean Africa Region
- *Dr. T.O. Ajayi* (Nigeria). Coastal aquatic resource systems in West Africa: 1995 status quo and research agenda for management and sustainability
- Discussion

Inland aquatic resource systems

- *Dr. R.S.V. Pullin* (ICLARM). Towards an agenda for strategic research and training on sustainable use of inland aquatic resource systems in Africa
- *Dr. R.E. Brummett* (ICLARM). ICLARM's approach to integrated resource management in Africa
- *Dr. A.R. El Gamal* (Egypt).

Aquaculture development in Egypt - research needs and activities

- *Dr. O.A. Ayinla* (Nigeria). A background paper for the Workshop on Development of the International Program for the Proposed ICLARM Facility in Abbassa, Egypt

Tuesday, 26 September

- Presentations on research needs for specific resource systems and activities
- Buffet lunch

African great lakes and reservoirs

- *Dr. T.J. Pitcher* (Canada). The fisheries resources of African lakes
- *Dr. C. Machena* (Zimbabwe). Notes on the fisheries and socioeconomic characteristics of the large East African lakes and reservoirs
- Discussion

Social sciences and co-management

- *Dr. R. Pomeroy* (ICLARM). Fisheries, aquaculture and coastal resources social science research in Africa and West Asia

- *Dr. K.N. Afful* (Ghana). Research needs in the socioeconomics of fisheries in the West African subregion
- *Dr. T.R. Brainerd* (USA). Socioeconomic research needs for fisheries and aquaculture in Africa
- Discussion

Partnership between national aquatic research systems and ICLARM in Africa

- *Dr. M. Prein* (ICLARM). Partnership between NARS and ICLARM in Africa
- *Mr. B.A. Haight* (Zimbabwe). Partnership between NARS and ICLARM in Africa: NARS in subSaharan Africa
- Discussion
- Chairman's summary of workshop sessions
- Sound and light show

Wednesday, 27 September

- Concurrent topic working group sessions to develop draft research agendas
- Buffet lunch
- Working group chairs prepare reports of topic sessions
- Working group chairs report back to plenary session