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Collaborative Research in the Developing Countries

A Priority Planning Approach

August 1978

Board for International Food and Agricultural Development
Agency for International Development

FISHERIES AND AQUACULTURE COLLABORATIVE RESEARCH IN THE DEVELOPING COUNTRIES

A PRIORITY PLANNING APPROACH

Prepared for the
United States Agency for International Development
and the
Joint Research Committee
Board for International Food and Agricultural Development

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PREFACE

This study of Title XII research opportunities in fisheries and aquaculture, prepared under contract by Resources Development Associates, has been received by AID and reviewed by the Joint Research Committee. The Board for International Food and Agricultural Development formally accepted the report at their October 26 meeting. Aceeptance of the report, however, does not necessarily imply that the recommendations contained herein will be carried out as proposed.

The Joint Research Committee has designated a small working group to consider further courses of action with respect to developing collaborative research programs and will make more definitive recommendations to BIFAD, and to AID at a later date.

The report is being distributed to interested individuals and institutions for their information and reference. While JRC and AID at this time are not actively soliciting comment on the report, any views which you may have would be welcome. They should be directed to: Fisheries Division
Development Support Bureau
Agency for International Development
Washington, D. C. 20523

Acknowledgement

This research and analysis report is prepared by Resources Development Associates for the United States Agency for International Development and the Joint Research Committee, Board for International Food and Agricultural Development under contract AID/afr-C-1135-12. Keith W. Cox, R. Jack Meyers, and P. Patricia Powell were primarily responsible for fisheries/aquaculture technology, socio-economics, and bibliographic sectors of the report, respectively. They were assisted by a Senior Advisory Panel of recognized experts and authorities in several technical areas, many of whom provided major contributions to this report. These included Parzival Copes, Richard S. Croker, William A. Dill, John B. Glude, John A. Peters, William F. Royce and H. Burr Steinbach. Manuscript preparation and typing support were provided by Sarah J. McDowell, Gail G. Muller and Patricia J. Carman. Ms. Muller also served ably as a research assistant and coordinator. The project was conducted and carried out under the overall direction of the senior partners of RDA, Kenneth B. Craib and Warren R. Ketler, who were also major contributors.

This project could not have been completed without the interest, support and active involvement of a number of other key people. These included Philip Roedel, Senior Fisheries Advisor to the Agency of International Development; James A. Storer, Director, Office of Fisheries Affairs, Department of State; Richard Neal, and Douglas M. Jones, Chief, Fisheries Division, AID/Washington. Dr. Jones additionally served as AID Technical Monitor and liaison official throughout this project.

The RDA team also benefited from the substantial assistance, advice and input received from members of the U.S. university community in general and the BIFAD Joint Research Committee in particular. Dr. Frederick Hutchinson, Chairman of the JRC, provided much valuable counsel and guidance. Dr. Hugh Popenoe served as principal JRC liaison.

Finally, RDA wishes to acknowledge the assistance and enthusiastic support received from our many colleagues and friends in the "developing" countries of the world. Without their active involvement and input, this report would have little meaning. It is dedicated to them in the hope and belief that fisheries and aquaculture research, both basic and applied, will not become and end in itself but will quickly lead to solution of the pressing problems they face on a daily basis.

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1.0 EXECUTIVE SUMMARY

The principal objective of the Title XII Amendment to the International Development and Food Assistance Act of 1975 is to provide for substantial expansion of United States agricultural college and university involvement in helping to solve food, nutritional and agricultural problems in the developing countries of the world. This amendment encompasses nearly the entire spectrum of research, development, technical assistance, training, and extension services in and for these countries. One portion of this amendment deals specifically with "collaborative research" programs. Its major premises are as follows:

1. there are a number of agricultural and related problems common to both the United States and developing countries,
2. research conducted jointly among United States universities, research institutes in lesser developed countries, and international research centers will result in discoveries of benefit to both the United States and LDCs.

The basic concept involves several characteristics which set it apart from the commonly accepted approach to foreign assistance. In addition to the multi-institutional aspect, collaborative research is to be:

1. funded jointly by AID and the United States university participants,
2. aimed at specific LDC problems of a global or at least regional nature with high pay-off potential,
3. supported over sufficiently long time periods to ensure continuity,
4. sufficient in scope to require joint or collaborative effort.

A more thorough discussion of the concept and elements of collaborative research is contained in Appendix VII of the BIFAD annual report, November 1977(R-19) (Guideline for the Conduct of Collaborative Research Support Activity under Title XII of the International Development and Food Assistance Act of 1975).

In October 1977, the Agency for International Development, at the request of the JRC and BIFAD, entered into a contract with Resources Development Associates (RDA) for a study to define research and development needs in the lesser developed countries and to explore alternatives to address these needs. This request stemmed from a recognition that the general area of fisheries and aquaculture is both broad and extremely complex, encompassing a large number of biological components and a wide range of technologies. The range of problems which affects fisheries and aquaculture in the developing countries is equally diverse. Thus, some systematic effort to compartmentalize groups of researchable problems and plan approaches to their solution seemed a necessary first step. RDA was additionally requested to identify and inventory the research capabilities of United States universities in fisheries and aquaculture and to assess their interest in participating in such collaborative research programs. Finally, an inventory was required of LDC institutions interested in and capable of participating in fisheries and aquaculture collaborative research.

In summary, RDA was requested to coordinate an initial review and analysis of LDC problem areas, inventory research capabilities and interests of United States universities, identify LDC institutions with current or potential capability to participate in collaborative research support program (CRSPs), outline suggested research programs, develop funding estimates and a priority plan for accomplishment.

It was specifically desired that the final report "reflect considered and informed judgement, if not consensus, of the fisheries and aquaculture scientific community" with respect to priority research needs and objectives, and that all United States

universities and research institutions with manifest interest in fisheries and aquaculture research have an opportunity to have their views considered in the planning process. A restriction was established, however, to the effect that any consultants, advisors, or team members involved in this planning effort could have no direct conneciton or affiliation with any university or organization that might directly benefit from any collaborative research programs resulting from the study.

As a first step, RDA assembled a Research Advisory Panel of senior professional personnel, internationally recognized as authorities in their respective fields, to work with and assist the RDA staff. The panel consisted of the following:

1. Dr. Parzival Copes

   Professor (and previously Chairman), Department of Economics and Commerce, Simon Fraser University, Burnaby, British Columbia. Previously Head of the Department of Economics and Director of Economic Research at the Memorial University of Newfoundland.

2. Mr. Richard S. Croker

   Marine fisheries specialist and independent consultant. Formerly Chief, Marine Resources Branch, California Department of Fish and Game, and subsequently Regional Fisheries Attache for Latin America.

3. Mr. William A. Dill

   Inland fisheries specialist and independent consultant. Formerly Chief, Inland Fisheries Branch, United Nations FAO, Rome.

4. Mr. John B. Glude

   Aquaculture-mariculture specialist and independent consultant. Formerly Aquaculture Program Coordinator, National Marine Fisheries Service, NOAA and Deputy Regional Director, Pacific Northwest Region, NMFS.

5. Mr. John Peters

   Food technology specialist and independent consultant. Formerly Deputy Director for Research, Gloucester Laboratory, NMFS.

6. Dr. William F. Royce

   Fisheries research specialist and independent consultant. Formerly Associate Director for Resources Research, NMFS; Associate Dean, College of Fisheries and Director, Fisheries Research Institute, University of Washington.

7. Dr. H. Burr Steinbach

   Biologist, research administration specialist and independent consultant. Retired President of the Oceanic Foundation and former Dean of Graduate Studies, Woods Hole Oceanographic Institute.

In addition to the formal panel, the RDA team was directly and materially assisted by several government officials who effectively functioned as members of an extended advisory panel. These included:

1. Dr. Douglas M. Jones

   Chief, Fisheries Division, Development Support Bureau, USAID, and technical monitor of the project.

2. Dr. Richard Neal

   Aquaculture specialist, Fisheries Division, DSB, USAID.

3. Mr. Philip M. Roedel

   Senior Fisheries Advisor to the Agency for International Development, on detail from NOAA, Department of Commerce. Formerly Director, NMFS.

4. Dr. James A. Storer

   Director, Office of Fisheries Affairs, United States Department of State.

The requirement for coordination with and involvement of the United States university community was satisfied in several ways. First, letters were directed to all universities on the BIFAD list of "eligible institutions", informing them of the study and soliciting their comments and input. Similar announcements were made through scientific and professional publications and at professional meetings. Early in the planning process, a Research Planning Workshop was held in Denver, Colorado, December 14-15, 1977.

This Workshop was attended by 110 scientists and profesionals, representing 47 universities, institutions, and interested government agencies. In addition to providing an opportunity for direct interaction, this meeting provided the basis for continued correspondence and exchange of ideas with interested and involved research professionals. Additionally, members of the RDA team personally visited many of the eligible institutions for discussions relating to project objectives.

To gather additional information and to obtain first-hand impressions of current needs, LDC priorities, and capabilities to undertake or support research activities, advisors and members of the RDA staff personally visited more than 20 foreign countries during the course of this study. Meetings were held with key government officials and representatives of nearly 100 organizations and institutions involved in fisheries/aquaculture development and research in these countries. Material collected and compiled during the course of these visits constituted a major input to the research planning process and assessment of priorities.

1.1 The United States University Inventory

As a major objective of the project, an extensive survey of United States universities was conducted to determine interest and capacity to participate in the recommended collaborative research programs. Perhaps one of the most striking and significant findings of the survey is the large numbers of colleges and universities in the United States actively engaged in research and development in fisheries and aquaculture. This represents a vast reserve of knowledge and expertise that can be made available for collaborative research support programs in the LDCs. Many of these institutions already have a long and successful working relationship with universities and other organizations in LDCs in fisheries and aquaculture as well as in a wide range of other fields and disciplines.

It is difficult to state with conviction that any one university is better qualified than another in the absence of a final determination by AID and the JRC of what research shall be undertaken in what part of the world and with what budget. The field of fisheries and aquaculture is an extremely broad one, as reflected in the scope of research needs identified and programs recommended for funding support. Accordingly, it seemed best to group universities by broad categories of ability and experience rather than to attempt a rank ordering. Selection of lead and support institutions for specific tasks should properly follow determination of budgeting limitations and receipt and evaluation of research proposals.

Three general categories were established. Category A includes those institutions with extensive capability and experience in the principal research program areas recommended for funding, with considerable depth in a variety of supporting technical and socio-economic fields, with broad management experience in programs involving several institutions, and with specific research experience in and with the developing countries of the world. Category B includes those institutions with well-established and recognized specialty areas particularly related to selected collaborative research support programs and appropriate international experience, but with somewhat less overall strength or broad program management ability. Category C includes institutions with ability to undertake a research project or projects within a collaborative research program, but lacking experience or strength in several key areas.

It should be noted that the effort was directed at an inventory of university capability and interest, as opposed to an evaluation. Placement of institutions within categories was based upon information submitted and capabilities as described by the institutions themselves, supplemented by personal contact and campus visits where necessary. Similarly, no attempt was made to suggest organizational arrangements or consortia of universities. Only individual institutions are identified except where a university system specifically requested that it be treated as a single entity.

Category A: Universities with broad capabilities which could, in general, perform and direct research in any of the recommended program areas.

University of California and California State University Systems

Cornell University - SUNY

University of Delaware

Michigan State University and University of Michigan

Oregon State University

University of Rhode Island

Texas A & M University

University of Washington

Category B: Universities with more specialized capabilities which could perform and direct research in one or more program areas.

Auburn University

Colorado State University

Louisiana State University

Massachusetts Institute of Technology

North Carolina State University

Oklahoma State University

Purdue University

University of Hawaii

University of Idaho

University of Miami (Rosenstiel)

Category C: Universities with narrower fields of specialization that might serve most effectively in supportive roles.

Columbia University

Duke University

Kansas State University

Mississippi State University

Murray State University

Rutgers, The State University of New Jersey

University of Alaska

University of Arkansas, Pine Bluff

University of Colorado

University of Florida

University of Georgia

University of Maine

University of Massachusetts

University of New Hampshire

University of Southern Illinois - Carbondale

University of Vermont

West Virginia University

Other United States institutions with specific research capacities and substantial managerial strength that should be considered for CRSP participation include:

Virginia Institute of Marine Science
Woods Hole Oceanographic Institute
South Carolina Marine Resources Institute

1.2 The LDC Institution Inventory

Another major goal of the planning effort was to prepare an inventory of LDC institutions capable of supporting and working with United States universities in performing priority collaborative research. There are many institutions in the developing countries with acceptable facilities and well qualified and experienced scientific staff. Most of these institutions have specific strengths in special fields which reflect principal or primary local needs and demands. Many of these problems confront other LDCs in the same or similar regions.

A number of these institutions have received assistance and support from foreign governments and international organizations and are particularly suitable as prospective participants in a

CRSP program. As a rule, they have had considerable experience at the international level and the facilities and equipment are generally modern and up to date.

Foreign Universities/Organizations	Capabilities
Ivory Coast	
University d'Abidjan	Fish biology, genetics, induced spawning
Department of Sea and Lagoon Fisheries	Aquaculture, culture methods, fresh water
Oceanographic Research Center (CRO)	Lagoon Fisheries, management gear technology
Ghana	
Food Research Institute	Food technology, intermediate moisture replacement
Institute for Aquatic Research	Fish biology, marine fisheries, small-scale fisheries
University of Ghana	Food technology, fish preservation, smoke, drying, etc.
Nigeria	
Nigerian Institute of Oceanography & Marine Research	Marine fisheries research, food technology
Federal Fisheries Department	Fresh water aquaculture, fisheries development
India	
Fresh Water Fish Culture and Research and Technical Training Institute	Fish culture
Central Food Technological Research Institute	Food technology
Central Marine Fisheries Research Institute	Marine fisheries research
Indonesia	
Marine Fisheries Research Institute	Marine fisheries
Research Institute of Fisheries Technology	Food technology
Bogor University Facility of Fisheries	Fisheries biology

Philippines	
SEAFDEC	Fish culture
ICLARM	Coordination
Central Luzon State University	Aquaculture
Thailand	
Ministry of Agriculture & Cooperatives Department of Fisheries (NIFO)	Fish culture
Kasetstart University	Fish culture
Sudan	
Fisheries & Hydrobiological Research Institute	Limnology of the White Nile, oyster culture
University of Khartoum	Hydrobiology/fisheries of the Nile River systems, Red Sea Marine fisheries
Tunisia	
National Scientific & Technical Institute for Oceanography and Fisheries	Mediterranean fisheries, brackish water aquaculture
Columbia	
INDERENA-Cartagena	Aquaculture, marine fisheries

Other non-LDC institutions that could substantially contribute to CRSPs in a scientific sense include:

Taiwan	
Taiwan Fisheries Research institute	Aquaculture, marine fisheries. oceanography, fishing gear and vessel development, fish processing
National Taiwan University	
Taiwan Provincial College	
Venezuela	
La Salle Foundation of Natural Sciences	Aquaculture, marine and fresh water, native species

Brazil	
Federal University of Ceará	Aquaculture, tropical fresh water fishes, fish technology
Departamento Nacional de Obras Contra as Secas (DNOCS), Fortaleza	Aquaculture
University of Sao Paulo	Aquaculture
Israel	
Fisheries Department	Culture of fresh water, marine fishes
Hebrew University of Jerusalem	Oceanographic research
University of Tel-Aviv	
Israel Oceanic and Limnological Research Ltd.	

1.3 LDC Problems and Priority Research

The priority assistance needs most frequently expressed by a sample of 25 lesser developed and developing countries in Africa, Asia, Latin America, Pacifica and the Caribbean are summarized in Table 1 by order of apparent relative importance to those countries. This listing is based primarily on information obtained through direct personal contact with government officials and key spokesmen in more than 20 countries, supplemented by a comprehensive country-by-country literature review.

The most frequently expressed and highest priority need was for assistance in the general area of capture fisheries stock and resource assessment, followed by fresh/brackish water aquaculture and fisheries administration/management. In general, the more developed countries tended to place more emphasis on product utilization and food technology. This does not mean the lesser developed countries fail to recognize this problem area; rather, they seem to feel the principal problem is harvesting enough in the first place.

The rank ordering shown in Table 1 would seem logical considering that on a worldwide basis most fish production is and will continue indefinitely to be from catching rather than from culture. Some inconsistencies do appear, however. For example, fisheries administration and management is considered a high priority item (#3), while the development of useable and reliable methodologies for catch and effort statistics, which would seem to be a prerequisite for effective fisheries management, is accorded a relatively low priority (#17). Similarly, the economic viability of fresh/brackish water aquaculture (#2) may depend on the availability of a reliable source of seed stock (#20).

It is particularly important to note that these needs and their respective priorities as seen by the developing countries are not limited to items involving or requiring research. Technical training and direct technical assistance ranks high on the list of priorities with most LDCs. Similarly, other needs may or

Problem Areas

Relative Priority	Capture Fisheries	Aquaculture	Product Utilization	Other
1	Stock Assessment			
2		Fresh/brackish Aquaculture		
3	Fisheries Administration & Management			
4	New or Expanded Fisheries Development			
5			Preservation & Processing	
6			Post-harvest Losses	
7				Technical Training
8			Marketing & Distribution	
9				Technical Assistance
10		Mariculture		
11	Facilities & Equipment			
12				Socio-economic Studies
13	Vessel/gear Development			
14				Ecology/habitat Protection
15				Rehabilitation/ Improvement of Inland Waters
16		Genetics, Biology Hybrid Development		
17	Catch & Effort Statistics Methodology			
18	Population Dynamics, Basic Biology			
19		Feed		
20		Seed Production		
21				Aquatic Weed Control
22		Disease (Morbidity/Mortality)		
23				Mangrove Studies

Table 1 . Summary of Needs and Priorities as Expressed by Selected Developing Countries.

may not involve research. For example, many countries expressed a need for assistance in doing stock assessment and resource surveys, as opposed to development of new or simpler methodologies.

Members of the RDA staff, advisory panel, and government advisors who participated in and assisted with this study were asked to define research problems and related programs within the list of needs that would meet the criteria established for collaborative research. These identified research programs were then compared and rated as a function of the following:

1. Number of people in target groups benefiting from this research (high, medium, low)

2. Geographical area benefiting from this research (global, regional, country)

3. Sensitivity of research to geographical selection (sited anywhere, in only certain regions, in only certain countries)

4. Extent to which this research program matches the perceived needs of the LDCs (high, medium, low)

5. Time required to produce results (less than 5 years, 6-10 years, more than 10 years)

6. Cost of program (low, medium, high)

7. Probability of successful completion of research objectives

8. Probability that results obtained will be applied

9. Research capability in LDCs and potential for expansion

10. Research capability in the United States

11. Institutional preparedness in LDCs

12. Institutional preparedness in the United States

Comparative ratings established through this process defined relative priorities among the program areas considered. These are presented in Table 2, ranked in priority from one through nine. Each program is numbered to permit easier reference in subsequent figures and tables. These "program numbers" are for

Collaborative Research Programs

Relative Priority	Capture Fisheries	Aquaculture	Product Utilization
1		1. Principles & Mechanisms of Pond Culture Systems	
2	2. Resource Assessment	3. Feed & Nutritional Requirements 4. Seed Availability	5. Causes & Rates of Spoilage of Catch in Tropical Waters
3	6. New or Expanded Fisheries		7. Loss of Catch due to Insects & Pests 8. Marketing & Distribution
4	9. Fisheries Administration and the Extended Economic Zone		
5			10. Control of Spoilage in Fishery Products
6	11. Environmental Analysis and Habitat Protection		
7		12. Culture Systems for Native Species 13. Morbidity & Mortality Causes & Controls	14. New Product & Processing Technique Development
8			15. Low-Energy Preservation & Processing Techniques
9		16. Genetic Improvement	

Table 2 . Prioritized Collaborative Research Programs

identification purposes only and do not imply relative importance.

1.4 Program Funding

Availability of funds will be the principal constraint in any funding strategy. At the present time, no guidelines exist and no definitive statement can be made regarding the amount of funding support that will be made available for research programs in fisheries and aquaculture as outlined here. Alternative funding and levels of effort may be assumed, however, and program impact examined.

It is impossible of course to define precisely research program costs prior to deciding which institutions and countries will participate and where the research will be performed. Such decisions should be made following receipt and peer review of proposals from interested universities. Budgeting figures presented here represent the best available estimate of total program costs for the 16 priority programs identified.

Two separate estimates were made of costs and time required to address in a responsible fashion the 16 identified research programs. Table 3 presents funding requirements for what is considered to be an optimum level of effort. Funding at this level should produce directly useable results within the five-year time horizon, although as a general rule research activity in most program areas should be continued beyond this point. At least one program (No. 7) might be completed in its entirety.

Table 4 presents funding requirements for the minimum suggested level of effort in each program. Funding at this level should produce usable and useful results, but the principal objective of the separate research programs would probably not be realized in less than 10-15 years. Although funding at this level does not represent the most cost-effective approach, it does indicate a viable alternative. Funding at levels below those

Priority	Program No.	Year					Five-Year Totals ($)*	
		1	2	3	4	5	By Program	By Priority
1	1	$1.0-1.4	$1.8-2.4	$1.8-2.4	$1.5-2.0	$1.3-1.7	$ 7-10	$ 7-10
2	2	0.8-1.0	0.8-1.0	0.8-1.0	1.0-1.4	1.0-1.4	4- 6	15-21
	3	0.8-1.0	0.8-1.0	1.0-1.4	0.8-1.0	1.0-1.4	4- 6	
	4	0.8-1.0	0.8-1.0	1.0-1.4	0.8-1.0	0.8-1.0	4- 5	
	5	0.5-0.7	0.8-1.0	0.8-1.0	0.8-1.0	0.5-0.7	3- 4	
3	6	1.5-2.0	1.8-2.4	2.3-3.1	2.3-3.1	2.3-3.1	10-14	14-20
	7	0.8-1.0	0.8-1.0	0.8-1.0			2- 3	
	8	0.3-0.4	0.5-0.7	0.5-0.7	0.5-0.7	0.5-0.7	2- 3	
4	9	2.0-2.8	2.0-2.8	2.0-2.8	0.8-1.0	0.8-1.0	8-10	8-10
5	10	0.8-1.0	1.3-1.7	1.0-1.4	0.3-0.4		3- 5	3- 5
6	11	1.5-2.0	1.8-2.4	1.8-2.4	1.8-2.4	1.8-2.4	9-12	9-12
7	12	1.3-1.7	1.3-1.7	1.8-2.4	2.0-2.8	2.0-2.8	8-11	18-25
	13	0.8-1.0	1.0-1.4	1.0-1.4	1.3-1.7	1.3-1.7	5- 7	
	14	1.0-1.4	1.3-1.7	1.5-2.0	0.8-1.0	0.5-0.7	5- 7	
8	15	0.3-0.4	0.5-0.7	0.5-0.7	0.5-0.7	0.5-0.7	2- 3	2- 3
9	16	0.8-1.0	0.8-1.0	1.3-1.7	1.3-1.7	1.3-1.7	6- 7	6- 7

*In millions, rounded to nearest million in 5-year totals. Given a 25% contribution from non-federal sources by collaborating U.S. universities, actual Federal funding requirements will be correspondingly reduced from budget figures shown here.

Table 3. Priority Collaborative Research Program Funding Requirements (Optimum Level)

Priority	Program No.	Year					Five-Year Totals ($)*	
		1	2	3	4	5	By Program	By Priority
1	1	0.5-0.7	0.8-1.0	1.5-2.0	1.8-2.4	1.8-2.4	6- 9	6- 9
2	2	0.3-0.4	0.5-0.7	0.5-0.7	0.8-1.0	1.0-1.4	3- 4	11-15
	3	0.3-0.4	0.3-0.4	0.5-0.7	0.8-1.0	1.0-1.4	3- 4	
	4	0.3-0.4	0.3-0.4	0.8-1.0	0.8-1.0	1.0-1.4	3- 4	
	5	0.3-0.4	0.5-0.7	0.5-0.7	0.5-0.7	0.5-0.7	2- 3	
3	6	0.5-0.7	0.5-0.7	0.8-1.0	1.3-1.7	2.0-2.8	5- 7	9-13
	7	0.3-0.4	0.5-0.7	0.3-0.4	0.3-0.4	0.3-0.4	2- 3	
	8	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.5-0.7	2- 3	
4	9	0.5-0.7	0.5-0.7	0.5-0.7	1.0-1.4	1.5-2.0	4- 6	4- 6
5	10	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.5-0.7	2- 3	2- 3
6	11	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.5-0.7	2- 3	2- 3
7	12	0.5-0.7	0.5-0.7	0.8-1.0	1.0-1.4	1.5-2.0	4- 6	10-14
	13	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.8-1.0	2- 3	
	14	0.3-0.4	0.5-0.7	0.5-0.7	0.8-1.0	1.5-2.0	4- 5	
8	15	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.5-0.7	2- 3	2- 3
9	16	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4	0.8-1.0	2- 3	2- 3

Table 4. Priority Collaborative Research Program Funding Requirements (Minimum Level)

indicated here would in general be counterproductive.

To undertake all 16 identified research programs simultaneously at optimum levels would require a first-year budget of $15 to $20 million. In the absence of budgetary limitations, this would be the recommended approach as each of these programs addresses a priority need. Although, as noted earlier, no definite statements have been made in this regard, funding for fisheries and aquaculture research at this level seems unlikely.

With a more limited and perhaps more realistic budget of $4 to $5 million in the first year, programs 1 through 5, identified as Priorities 1 and 2, could be initiated. Such a budget would seem to compare favorably with first-year funding of $12.45 million recommended by the Congressional Office of Technology Assessment in 1977 for research in three high-priority agricultural program areas (photosynthesis, nitrogen fixation, and cell studies) (OTA, 1977: R-589), and with the first-year funding of $3.2 million reportedly recommended by the University of Missouri - Columbia study for collaborative research on the single program area of grain sorghum/pearl millet.

If the first-year budget is restricted to the $2 to $3 million level, two optional approaches to research funding are possible. One alternative would be to fund several programs at the minimum level. A budget of $2 to $3 million would permit initiation of research in all five program areas identified as Priority 1 and 2. It might be more appropriate, however, to fund programs 1, 2, and 5 (Pond Culture, Resource Assessment, and Spoilage) at optimum levels with these same dollars. This recommendation, detailed in Table 5, would be based on the following considerations. First, these programs address areas of major concern and highest priority in the developing countries, and cover each of the three principal program areas. Second, while program number 1, Pond Culture, does not duplicate the work outlined for programs number 3 (Feed) and 4 (Seed), it does contain elements of them which would contribute to knowledge in those sectors.

Priority	Program No.	Year					Five-Year Totals ($)* By Program
		1	2	3	4	5	
1	1	$1.0-1.4	$1.8-2.4	$1.8-2.4	$1.5-2.0	$1.3-1.7	$ 7-10
2	2	0.8-1.0	0.8-1.0	0.8-1.0	1.0-1.4	1.0-1.4	4- 6
3	5	0.5-0.7	0.8-1.0	0.8-1.0	0.8-1.0	0.5-0.7	3- 4
Totals *		2-3	3-4	3-4	3-4	3-4	14-20

*In millions, rounded to nearest million

Table 6. Recommended Program Funding Plan Given a $2-3 Million First-Year Budget

Third, funding these three programs (1, 2, and 5) at optimum levels should produce directly usable and significant results within a five-year period. Funding more programs at a less intensive level would delay the apparent impact of the collaborative research support program and of Title XII itself.

Presentation of funding requirements by priority ranking does not imply that all programs rated Priority 2, for example, must be funded before those rated Priority 3. Any one of these programs might be selected over another as a function of constraints or conditions not considered in this analysis. Similarly, these programs could be funded at a lower level of effort as shown or on an individual basis. The minimum program level of effort is estimated at $300,000 to $400,000 per year. As a general rule, however, funding at this level does not represent the most efficient use of time or resources, and barring unforeseen breakthroughs, useful results should not be expected within the five-year horizon.

1.5 Summary and Recommendations

This report identifies and defines development assistance needs in fisheries and aquaculture as seen by the developing countries themselves, identifies that set of needs that might best be addressed through Title XII collaborative research, establishes relative priorities, and presents budgetary requirements for their accomplishment. An inventory of United States university capability to address these items is presented, together with an inventory of LDC institutions active in these fields and those recommended for consideration as partners in collaborative research.

Once budgetary limitations have been established, the next step should be to request proposals for research from interested United States institutions. These proposals should be subjected to peer review and evaluation to confirm appropriate scientific approach and budget details. In this review, particular emphasis should be placed on research management structure, degree of planning and flexibility evident, proposed monitoring and organizational ties to the LDC institutions involved.

It is suggested that this request for proposals not be limited only to those institutions identified as Category A or B. Several universities have joined together in consortia for purposes of addressing Title XII collaborative research needs. Since these arrangements may be subject to change, these consortia were not considered or evaluated in the course of the study.

As noted in section 3.5 of this report, the impact of the extended economic zone and the emerging Law of the Sea is an area of considerable concern and high priority in most developing countries. A collaborative research program in this area appears both appropriate and desirable. Such a program is, however, more difficult to structure than others at this time due to a lack of detailed information concerning the scope, nature and relative priority of its researchable aspects on a worldwide basis.

In view of the potential impact and worldwide importance of such a program, and in consideration of the United States' position of leadership in this field, it is strongly recommended that AID and the BIFAD undertake a definition study in this area to more clearly describe the scope of the research problem and structure alternative approaches to solutions. Had such information been available to the team responsible for this planning effort, this particular program might well have rated significantly higher in relative priority.

Thorough baseline studies of fishery development opportunities and contraints in the developing countries have not been made available to us and to the best of our knowledge with few exceptions they have not been done. The review of LDC needs and priorities included as a part of this study is but a first step in this regard. It also seems essential to evaluate recent international experience in fisheries and aquaculture development projects to identify factors contributing to past successes and failures.

In summary, we feel this report accurately reflects the considered and informed judgement of the fisheries and aquaculture scientific community as well as the development needs and priorities expressed by the developing countries themselves. Because it is a report of consensus, it is unlikely that any one individual or organization will be in complete agreement with the conclusions, priorities, and recommendations expressed here. We do feel that this report represents a workable compromise between what we each might individually wish and what is possible given practical limitations of budget and time.

One final point might be noted. In our visits to the developing countries, one remark was repeated several times: "Please do not send any more university research teams here to study us. We have been researched enough. We need help, not research." We do not feel this attitude represents a rejection of United States' research assistance. Rather, it seems a plea for understanding, and a request that research be carefully directed to problems of major and immediate importance. Collaborative research programs, involving LDC institutions and personnel as team members rather than research subjects, would seem to be particularly appropriate.

2.0 INTRODUCTION

The principal objective of the Findley-Humphrey Amendment to the International Development and Food Assistance Act of 1975, designated Title XII - Famine Prevention and Freedom from Hunger, is to provide for substantial expansion of United States agricultural college and university involvement in helping to solve the food, nutritional and agriculture problems in the developing world. In this regard, fisheries and aquaculture are appropriately considered to be a part of agriculture. Under Section 297 of the Amendment, the President is authorized to provide assistance on such terms and conditions as he shall determine in order to:

1. Strengthen the capabilities of universities in teaching, research and extension programs;
2. Build and strengthen the institutional capacity and human resources skills of agriculturally developing countries so that these countries may participate more fully in the international agricultural problem-solving effort and to introduce and adapt new solutions to local circumstances;
3. Provide program support for long-term collaborative university research on food production, distribution, storage, marketing, and consumption;
4. Involve universities more fully in the international network of agricultural science, including the international research centers, the activities of international organizations such as the United Nations Development Program and the Food and Agriculture Organization of the United Nations and the institutions of agriculturally developing nations;
5. Provide program support for international agricultural research centers, to provide support for research projects identified for specific problem-solving needs, and to develop and strengthen national research systems in the developing countries.

To assist in the administration of the programs authorized by Title XII, the President established a permanent Board for International Food and Agricultural Development (BIFAD). Among

its other duties, BIFAD is to act as a Federal advisory committee to the United States Agency for International Development (AID) and is authorized to participate in all aspects of AID's food and agricultural development programs. It will render advice and take part in policy, strategy, budget and program development; in short, participate in the full range of Agency policy formulation and program implementation.

BIFAD was also given authorization to create subordinate units necessary to carry out its duties. Two such subordinate committees have been formed: the Joint Research Committee (JRC) which is "concerned with all Title XII research activities directed toward the discovery of new knowledge and development of technology useful to the developing countries." The Joint Committee on Agricultural Development (JCAD) is "concerned with the expansion of institutional capacity in the LDCs to adopt such knowledge and technology."

The BIFAD and AID have identified a "core program" of activities which meet the criteria of university participation under Title XII. This program includes the following areas (BIFAD, 1977: R-19):

1. Research which includes:
   - Support to international agricultural research centers and similar organizations
   - Food production and nutrition components of AID's centrally-funded contract research program
   - A new collaborative research support program
   - Country or regional specific research falling within the Title XII mandate
2. The balance of the centrally-funded technical assistance programs concerned with the adaptation and application of agricultural and nutrition technology
3. Strengthening developing country institutions in research, teaching, extension and other services essential to agricultural development
   - Advisory services to developing country governments and private sectors on such food and nutritional development activities

as agricultural production and marketing, credit, irrigation and water management, general nutrition projects, and technical assistance for rural development, in which developing or strengthening of research, educational or extension capabilities, though often an important by-product, is not the central purpose.

2.1 Purpose of the Fisheries and Aquaculture Planning Effort

It is evident from the foregoing that the Title XII Amendment encompasses nearly the entire spectrum of research, development, technical assistance, training, and extension services in the developing countries of the world. The planning activity to which this report is addressed, however, is limited to but one aspect of Title XII - the new "Collaborative Research Support Program" (CRSP). Its purpose is to provide guidance for initiating collaborative research within the general area of fisheries and aquaculture. Some of the findings presented in this report regarding research needs and institutional capabilities are broadly applicable to Title XII, but the major findings, suggested priorities and plans apply only to collaborative research.

The major premises of collaborative research are:

1. There are a number of agricultural and related problems common to both the United States and developing countries,
2. Research conducted jointly among United States universities, research institutes in lesser developed countries (LDCs), graduate countries, and international research centers will result in discoveries of benefit to both the United States and LDCs.

The concept of collaborative research involves a number of other characteristics which set it apart from the commonly accepted approach to foreign assistance. In addition to the multi-institutional aspect, collaborative research is to be:

1. Funded jointly by AID and the U. S. college or university participants
2. Aimed at specific LDC problems with high pay-off potential
3. Supported over sufficiently long time periods to ensure continuity
4. Sufficient in scope to require joint or collaborative effort.

A more thorough discussion of the concept and elements of collaborative research is contained in Appendix VII, Guidelines for the Conduct of Collaborative Research Support Activity Under Title XII of the International Development and Food Assistance Act of 1975 (BIFAD, 1977: R-19).

The BIFAD instructed the JRC to give initial priority in its activities to the development and implementation of collaborative research programs. As a result, seven priority program areas were identified for early attention. Of these, BIFAD has approved four subject areas in which planning efforts should be undertaken. These are:

1. Small ruminants
2. Sorghum and millet
3. Human nutrition
4. Fisheries and aquaculture.

As of this writing, planning activities have been undertaken on the first two, and this report concerns the fourth area.

2.2 Scope and Objectives

It is important to recognize that there are substantial differences of scale between the planning processes necessary for the broad, complex fields of fisheries and aquaculture, and other CRSPs which AID and BIFAD are currently considering. In fact, the fields encompassed by fisheries and aquaculture are better compared with the whole field of agriculture (including

animal husbandry, horticulture, etc.) as well as that of range management. By way of illustration, research on small ruminants such as sheep and goats, or grain sorghum and pearl millet would be roughly comparable to research on only two closely-related fishes; e.g., trout and salmon.

Largely because of such substantial differences in scope, basic approaches to the research planning process in these separate areas have been quite different and the reader is cautioned against directly comparing this exploratory study to other CRSP planning efforts presently underway. For example, the planning concerning small ruminants and sorghum and millet, essentially programmatic areas, consisted largely of determining the state-of-the-art of research in these subject areas and defining the priority problems that remain. Proposals for collaborative research programs in problem areas were then requested from eligible universities.

In fisheries and aquaculture, however, the basic program areas themselves had first to be defined, the priority problem areas identified, research capabilities determined, and then specified for both United States and foreign institutions.

The specific objectives of the fisheries and aquaculture planning process were to:

1. Identify and define major programmatic areas within the broad field of fisheries and aquaculture which are susceptible to concentrated research efforts, and which could become logical programs for separate collaborative research support
2. Recommend research priorities among the programmatic areas based on:
   - The current state of technology
   - Factors imposing significant constraints to development objectives
   - Unusual opportunities for technological change in fisheries and aquaculture which would enhance the LDCs well-being
   - Availability of research talent and facilities among United States universities and LDC institutions needed to address problem areas

Potential benefits to specific target groups in the LDCs, or other considerations which are deemed appropriate.

3. Develop recommendations with respect to a general plan for allocation of funds among programmatic areas based on an initial five-year implementation period beginning in 1979
4. Summarize the current state-of-the-art for each programmatic area of collaborative research based on the major lines of research being pursued by various research institutions; an assessment of progress or expected research findings; identification and evaluation of significant research gaps; and, recommendations as to priority research needs within the programmatic area
5. Inventory United States university capacity to undertake research in fisheries and aquaculture generally and in the respective programmatic research areas in particular
6. Inventory LDC institutional capacity to undertake or participate in collaborative research activites with United States universities and identify the role these institutes could fill
7. Analyze alternative ways to organize research with respect to relationships between AID, universities and LDC institutions which might facilitate implementing a collaborative research support program.

All of these objectives were met in the course of the planning study except for item 7 which was expressly deleted at the request of the JRC.

2.3 Target Groups

The principal objective of any collaborative research support program funded through the U. S. Agency for International Development is to improve the nutrition and well-being of the "poor majority" in the developing nations of the world. As these programs will also be supported in part by resources provided directly by Land and Sea Grant U. S. universities, an important secondary objective and indeed a requirement is that the research to be undertaken deal with problems of importance to the U. S. economy as well. The major part of benefits expected to flow

from Collaborative Research Support Programs (CRSPs) are aimed at improving the economic well-being of peoples in the lesser developed countries (LDCs). These benefits will generally accrue to members of one of the following groups:

1. The Producers - consisting of small-scale fishermen and fish farmers (aquaculturist). This target group is considered to have an adequate diet in terms of aquatic food (presuming they catch enough) since a good deal of production goes toward feeding the family, with any surplus going to the market-place. Research undertaken with this target group in mind should emphasize improvements in health and economic well-being.

2. The Consumers - comprising the rural and urban poor. This target group is not involved in the production of aquatic food but could benefit from increased supplies from this source. Presently about 800 million people in the world receive insufficient food;most of these persons live in the LDCs. An increased and stabilized supply of food is needed to supplement deficient diets of the malnourished and provide sustenance to the starving.

2.4 Potential Benefits to Producers

Small-scale fishermen have been defined as those "rural inland and coastal fishermen in the poorest of the developing countries whose catch goes largely for human consumption, who are themselves poor, and who fish with relatively unsophisticated gear and vessels in near-shore marine waters or in the freshwater environment" (Roedel,1978:R-147). There are a number of general ways in which the economic level of the small-scale fishermen can be raised. These include:

1. Increasing the catch
2. Improving catch efficiency and reducing cost
3. Improved utilization of the catch

4. Distribution and marketing system improvement
5. Development of improved ports, harbors and infrastructure
6. Optimum use of fish over time; i.e., conservation through sound management to ensure consistent maximum harvest (Roedel, 1978: R-147).

The aquatic farmers consist of that group of producers involved with the husbandry of aquatic resources. They are in many ways analogous to the rural agricultural producers found in the poorest of the developing countries and, as such, are inhibited by many of the same constraints; i.e., lack of technological sophistication and capital. The primary way that the economic level of the aquatic farmer can be raised is by increased production. Research in the areas of disease control, nutritional requirements, selection and breeding, and production systems for examples could help to provide ways to increase production. It should be noted that problems of marketing and product utilization may not be of the same magnitude for the aquatic farmer as for the capture fisherman. Fish farms may be located close to major population centers which minimizes distribution and preservation problems; similarly, the product may be tailored to fit demand, reducing or eliminating by-catch discard.

2.5 Potential Benefits to Consumers

The principal benefit to both rural and urban poor consumers should come in the form of improved nutrition. The production of an increased fish surplus should provide a more readily and more frequently available alternative and less expensive source of protein both for agricultural and other workers. Both groups might similarly benefit from the creation of additional employment opportunities in the aquaculture and capture fishery realms. For example, the FAO has estimated that one full time job is created for every four metric tons of fish produced in aquaculture alone (FAO, 1978: R-565)

Significant benefits could also accrue through increasing rural productivity through a more optimal use of present resources. For example, research and/or extension work might provide motivation for increased entry into pond aquaculture and a greater supply of wild stocks. This could follow from the realization that aquaculture can be profitably integrated with agricultural crop production (for example, as in ricefield fish farming in the Philippines and elsewhere) or animal husbandry (as in animal waste recycling projects, duck-or-pig waste fish farms, as presently operate in Eastern Europe and Southwest Asia).

2.6 Economic Considerations

The Title XII legislation addresses the problem of inadequate food and nutrition in the developing countries of the world. Estimates by the United Nations' Food and Agriculture Organization and by the World Bank show that 800 million people are presently not receiving sufficient food. Projections for the year 2000 suggest that, under current production techniques, the number of people without adequate nutrition will rise to in excess of one billion. Since the majority of these malnourished people are presently located in the LDCs, and since they will be the site of the bulk of the projected population expansion by the year 2000, attempted solutions to the problems must be aimed directly at these countries.

Three alternative approaches to the problem exist:

1. Decrease population or, at least, limit the rate of increase
2. Increase production of all food sources
3. Increase the utilization of resources presently "in hand."

Population decline in the LDCs is an unlikely remedy, barring natural catastrophe or war. While the developed countries have reached near zero population growth, no such progress has been made in the LDCs. Inroads made in the form of birth control programs have been more than offset by increased life span due to medical advances. Consequently, population continues to increase in mostof the LDCs at about 2% per year. The ramifications of this are perhaps best brought out by the National Academy of Science report on World Food and nutrition (NAS, 1977:R-127) which states that in order for these countries to increase per capita food availability by 1% per year they must expand food production by about 3% to 4% per year over the next 25 year period. In other words, the report concludes that the developing countries must double their domestic food production by the turn of the century if they are to begin to alleviate their food and nutrition problems.

In most countries the largest aquatic resource is the marine (capture fisheries) resource. This includes the highly migratory, offshore species that cross the borders to waters of neighboring countries. Utilization of this resource normally requires significantly larger capital investments than for the inshore and coastal resources such as coral and reef fisheries.

The second largest aquatic resource is usually the inland fresh water resource in lakes, rivers, reservoirs, etc. Obtaining the maximum benefits from these resources is best accomplished usually by application of proper fishing regulations and where feasible by stocking artificially reared fish and shellfish and modifying the environment. Major advantages here are minimal investment by the fishermen and proximity to the consumer.

The third resource type is represented by fish or shellfish in privately owned or controlled waters; e.g., production fish ponds, where fish are raised as a crop. In some areas, this activity is conducted as part of a system integrating agriculture and aquaculture.

2.6.1 Aquatic Food Production

At the present time, annual fisheries/aquaculture production is approximately 73 million metric tons (mmt) worldwide. Of this amount, 67mmt is produced by capture fishery methods and 6mmt from aquaculture (FAO, 1947-77: R-48). This is substantially higher than was thought probable 20 years ago based on the then knowledge of world aquatic resources. Our knowledge of these resources has increased dramatically in recent years resulting in a new assessment of aquatic production potential, and FAO has estimated world catch could very well be 130mmt by the year 2000. This estimate is considered to be conservative in that it does not take into account certain "unconventional" marine resources which could boost the potential harvest to a range of from 240 to 455mmt per year (FAO, 1977b:R-73).

Capture fisheries involves a fugitive resource with a common property nature. Accordingly, it presents unique problems to development and expansion of production. In most production functions, a mathematical relationship exists which relates quantity (and quality) of factor inputs; e.g., labor, capital, management, to final food production levels. In capture fisheries, however, output is a function of one very important additional variable - the stock of fish in a given place at a given time and under a certain set of conditions. Because of the common property nature of the resource, it is impossible for any one fisherman or group of fishermen to exercise much control over these parameters. Consequently, production is a function not only of quantity of factor inputs and the level of fishing effort in this period, but also of the level of past efforts, past production, and of biological and environmental factors which might impact on the size of the present stock.

Activities undertaken to increase production from wild stocks should be both responsible and responsive to the present stock condition. As such, planning for these activities should include consideration of the following items:

1. Effective management of any resource requires knowledge of the location, condition, and extent of the resource and the manner in which these parameters change with time. Resource assessment is then a necessary first step in evaluating potential for production increase.
2. Production input should be monitored. Controls or regulation may be required where over-exploitation results in a deterioration in the resource base.
3. The greatest overall net social benefits will accrue through stimulation of production to optimum yield of stocks, formulated on the basis of maximum sustainable yield as modified by relevant social, political, economic or ecological factors.

By the year 2000, aquaculture production can reach five to ten times its present level of 6mmt annually. Since aquaculture production is not dependent on a fugitive resource, it lends itself to more conventional input/output analyses, similar in many respects to those employed in agriculture.

Production here is a direct function of the quantity (and quality) of factor inputs for a given state of technical knowledge. Traditional aquaculture practices in many LDCs may be inefficient due to technological constraints which result in inefficient use of resources. Inefficiency is realized when resources are used in such a manner that either maximum product is not realized or when the use of fewer resources could give the same product. Research which would identify and help evaluate these constraints is needed in such cases.

Increased production through culture methods must include consideration of the following:

1. Technological advances needed to increase production
2. More efficient usage of present resource mixes through training and extension
3. Credit availability
4. Social benefits which could accrue through government programs to support and subsidize aquaculture development.

2.6.2 The Cost of Production

Investment in fishing traditionally has been largely a commercial undertaking; however,the situation has changed significantly over the last twenty years. This is due to many factors of which the dominant ones are the socio-economic role played by governments in many developing countries; e.g., centrally planned economies, the importance of fish as a food, and the lack of sufficient funds by commercial and financial sources for investment in fisheries. Motivation is of critical importance for investment and expansion and has been largely responsible for the shift in emphasis from the commercial investor in many centrally-planned economies where the desire is to produce food without reference to profitability.

Due to this shift in emphasis, increased investment funds will have to come from various sources in addition to commercial; e.g., governments, international development, organization, and development banks. FAO estimates that an investment of $30 billion will be required to reach the potential harvest of 130mmt by the year 2000; a rate of $1,5 billion a year (starting in 1980) (FAO, 1977d:R-75). This amount includes $1,848 million investment in aquaculture ($92.4 million per year). The investment money will be spent on infrastructure improvement and development, loans, subsidies and grants, equipment and machinery, training, research and technical assistance.

It should be mentioned that while $1.5 billion per year is a substantial sum, 130 mmt of fish represents a major amount of protein, and this investment is still less than a tenth of that ($16,000 million a year) required ($16 billion per year) to stimulate agricultural production (FAO, 1977d:R-75).

2.6.3 Improved Product Utilization

The previous section dealt with the economic implications of increased aquatic food production. However, no mention was made concerning the increased utilization of present catch and the significance this could have on increasing catch potential. Under-utilization occurs when there is a social or economic bias against certain species which results in by-catch discard or avoidance of harvesting. In addition to this there is the loss of product both on boat and ashore caused by poor handling practices, ineffective preservation techniques, insects and pests.

Product loss is significant, as high as 40% of world catch (NAS, 1977: R-127). Obviously the reduction of this loss figure would have a great economic impact and would increase the quantity of fish actually brought to market per unit of harvest. The resultant benefits could include an increase of output per unit of effort, greater supply to market and increased income, and all without increasing present catch volume.

The figures in Table 6 represent predicted increases in production and utilization from capture fisheries and aquaculture. But what do these figures mean in terms of food, nutrition, and employment? First, accepting the FAO prediction that annual world demand for fish products increases to 16kg per capita by the year 2000 (33% increase over the present 12kg), and that production increases and decreased loss from both capture fisheries and aquaculture increases supply to 95.5mmt (a 216% increase over the present 30.2mmt), then production could directly satisfy the demand of approximately three billion people (FAO, 1969: R-50).

		Conventional Capture Fishery Resources mmt	Unconventional Marine Resources mmt	Aquaculture mmt	Combined Total mmt
A	Present Catch/Harvest (1976)	67	0	6	73
B	Present Spoilage and Waste (Assuming 30%)	(20.1)[1]	0	(1.8)	(21.9)
C	Present Reduction for Animal Feed (Assuming 30%)	(20.1)	0	0[2]	(20.1)
D	Net Present Loss to Direct Human Consumption (B + C)	(40.2)	0	(1.8)	(42.0)
E	Present Catch Available For Human Consumption (A-D)	26.8	0	4.2	31
F	Projected Future Catch	100	50 to 200	30	180 to 380
G	Future Waste and Reduction at Present Rates	(60)	30 to 120	(9)	(99 to 219)
H	Future Availability at Projected Catch Rates and Present Utilization Rate (F-G)	40	20 to 80	21	81 to 161
I	Increase in Availability For Direct Human Consumption Due To Increased Production (H-E)	13.2	20 to 80	16.8	50.8 to 130.8
J	Future Waste and Reduction Assuming 50% Decrease)	(30)	(15 to 60)	(4.5)	(49.5 to 109.51)
K	Future Availability for Direct Human Consumption (Assuming 50% Reduction in Present Waste and Reduction)	70	35 to 140	25.5	130.5 to 270.5
L	Increase in Availability for Direct Human Consumption Due to Increased Utilization	30	15 to 60	4.5	49.5 to 109.5
M	Future Potential Increase in Availability for Direct Consumption Due to Both Increased Production and Utilization	43.2	35 to 140	21.3	100.3 to 240.3

1 ( ) Indicates negative quantity
2 No reduction for animal feed in aquaculture

Table 6. Potential Increase in Production and Utilization from Fisheries and Aquaculture

Second, on a nutritional basis, fish is considered to be one of the best sources of supply of the necessary amino acids needed to synthesize protein. Animal protein (meat, milk, eggs and fish) presently accounts for 32% of the world's protein supply, of this fish contributes 4%. Altschul (1965): (Stillings, 1973: R-176) has suggested that diets containing an average of 30g per day of protein from animal sources will be adequate in quality regardless of the source of the remainder of the protein. An average of less than 30g per day will result in a diet of questionable quality and an average of less than 15g will certainly result in malnutrition. Given that raw, whole fish contains 14% protein (NAS, 1977: R-127), then 13.37mmt (95.5mmt x .14) of fish protein will have the potential of supplying 6.11g or 20% of the minimum daily animal protein requirements for the world's total population in the year 2000 (estimated to be six billion people).

These predictions of increased production potential are conservative and while showing increased minimal animal protein supply, fall short of meeting world fish demand in the year 2000 by one-half. Total production would have to be 191mmt from both fisheries and aquaculture (assuming 50% yield of edible products) to satisfy an estimated demand of 16kg per capita for a world population of six billion. Expansion of production in fisheries to 200mmt and aquaculture to 60mmt has been predicted (NAS, 1977: R-127). This would meet the anticipated demand. Utilization of unconventional fish (krill, lantern fish, etc.) or by-catch discards would further expand production. But by far the greatest constraint to meeting demand lies in distribution. If the cost of distributing food was zero, present world production could adequately feed the world population. If this were so, present fish production would be able to directly satisfy 9% of the world's animal protein requirements instead of the present 4%. Realistically, the cost of distribution of food will always be a major problem. One answer may be found in producing food where the need lies. Aquaculture has significant potential in this regard.

Finally, employment potential should be examined. As noted earlier, the FAO estimates that one job is created for every four ton increase in products from aquaculture. Assuming that 50% of the predicted 24mmt increase in aquacultural production by the year 2000 takes place in LDCs, then three million additional jobs may be created.

A more complicated analysis is required to determine increased job potential in capture fisheries. The main constraint here is the lack of catch and effort statistics. However, by making some assumptions based on existing data, some reasonable projections can be made. Assuming the average annual catch of a small-scale fisherman in an LDC is about five tons (range of two to eight tons) and the anticipated increased production from LDCs is 10mmt (30% of predicted 33mmt increase), then the increased employment potential could be 1,000,000 jobs by the year 2000.* This discussion has not addressed employment potential from decreased wastage. Presumably this would affect people not involved in the direct harvest of fish; i.e., people involved in service industries. It has been estimated that 50 service industries are created for every fisherman in the United States. This figure is undoubtedly much smaller in LDCs but it still would give rise to a significant multiplier effect.

In summation, it has been shown that expansion of conventional aquatic food production can have a significant effect on human well-being, both nutritionally and economically. Conservative estimates show that conventional aquatic resources can satisfy half the world population in the year 2000. Increases above these amounts will satisfy greater numbers with maximum sustainable yields being around 200mmt. Production from unconventional resources could push this to well over 400mmt, supplying much more than amounts demanded. It has been shown that production from aquatic food sources will be able to supply 20% of the required minimum daily animal protein for a world population of

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* Assuming a 100% efficiency in per capita catch and effort, an increase from five to ten tons.

six billion. Again, production over this amount will raise this percentage, and if unconventional stocks are included, it would be theoretically possible for aquatic resources to supply 100% of the required animal protein for the entire world population. Finally, increased employment possibilities in the LDCs due to the expanded production and utilization could potentially reach four million by the year 2000.

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3.0 COLLABORATIVE RESEARCH IN FISHERIES AND AQUACULTURE

Development of an effective plan for collaborative research in fisheries and aquaculture requires consideration of a variety of factors external to the research work itself. These include budgeting constraints and limitations imposed by the funding agency, political considerations, needs and objectives as expressed by the countries themselves, and the likelihood that research results will in fact be applied.

As discussed in more detail in Section 5.0 of this report the CRSP planning effort was conducted in a series of discrete steps. The first step involved determination of LDC problems, development priorities, and assistance needs as seen by the LDCs themselves. From this listing, a subset of problems or needs were developed whose solution required research. Further screening then identified those problems which might most appropriately be addressed through collaborative research involving United States universities and research institutions. This final listing was then "prioritized" as a function of LDC perceived need, probability of successful completion in the near, medium or long term, number of people benefiting, and several other factors (Section 3.5). At this point, with funding constraints given or assumed, a prioritized plan for undertaking collaborative research could be prepared.

In many cases, the expressed needs of the developing nations can best be met through direct technical assistance and application of existing technology. Research may not be appropriate or necessary for the solution of certain high-priority problems. Similarly, many problems are country-specific in nature, or can best be addressed by a single group or institution working independently. As with technical assistance, programs developed to solve these problems do not meet basic requirements for inclusion in a collaborative research support plan, regardless of their technical or scientific merit. The remaining set are relatively long-term research problems of regional or world-wide importance of sufficient scope to require a team effort involving several institutions.

The following sections review basic development factors and information requirements in the developing countries, priorities and assistance needs as expressed by those countries, and the status of and opportunities for worthwhile research in the United States and in the LDCs. Budgetary support requirements are then developed the import of alternative funding levels is discussed, and a five-year prioritized program plan is presented.

3.1 Factors In Development and Research Program Planning

Certain factors must exist for fisheries and aquaculture research and development programs to be successful in the developing countires. These include:

1. Social and administrative factors:
   - Government policy of encouragement to fishery and aquaculture development
   - Existence of effective fishery management and research organizations
   - Social acceptance of the use of fish as food, and of fishing or fish culture as an occupation
2. Educational and supporting factors:
   - Adequate demand (existing or potential) for fishery and aquaculture products in domestic or export markets
   - Education, training and extension systems
   - Facilities and equipment
   - Financial Assistance
3. Adequate information

Social/administrative and educational/supporting factors are discussed in the sections immediately following. Adequate information implies knowledge of the extent and the condition of the resource, its biology and dynamics, and the social history and values of the human population involved. This subject is a much broader one, and is the principal target for collaborative research within the meaning of Title XII.

3.1.1 Social and Administrative Factors

An official government policy of encouragement to fisheries and aquaculture development might be taken for granted, judging from the statements of most fishery agencies, but actual policy may differ because the full control of fisheries may necessitate control of foreign fishing, coastal protection, enforcement of domestic laws, and the negotiation of foreign treaties, each of which is a function of a different agency of the government. It may be noted that in countries where fisheries and aquaculture are accorded national priority, and where those governments have established specific machinery for promoting development, notable expansion has occurred.

Social acceptance of the use of fish as food and of fishing or fish culture as an occupation is sometimes difficult to achieve. Although fish and fishing are accepted by most people, fishing is often regarded as an inferior occupation, and animals such as mollusks are not considered appropriate food by all cultures. The concept of fish farming and shellfish culture for personal use or for sale has been fully accepted in many parts of the world, especially where terrestrial and aquatic animals are produced in parallel or integrated systems. Elsewhere, fish or shell fish culture is a new concept; educational programs, demonstration farms, and extension service activities are required to encourage its social acceptance.

3.1.2 Educational and Supporting Factors

Other components of fisheries and aquaculture development programs are essential but rarely require research. The education or training of managers of organizations is especially important. Collaborative research support programs in the LDCs should logically incorporate some sort of management training component, if only because many researchers in the LDCs subsequently become adminstrators or managers.

At the field level, prompt and appropriate assistance from extension service specialists, backed by laboratory and technical support, is essential. While not research, extension and related training is an important element in development. In many countries, it will also be necessary to train fishermen, fish farmers, fish processors, gear makers, and boat builders.

Fishery-related supporting services are required in great variety to provide, for example, equipment and supplies, harbors, port facilities, pond systems, ice plants, transportation, etc. The availability of an adequately trained supply of labor is also important.

Finally, financial assistance must be available in the form of investment capital, loans, insurance, tax credits, etc. These may be secured (depending upon the circumstances) from private, governmental or international sources. The two latter sources are especially important in aiding ventures such as new types of capture fisheries or the culture of non-traditional species with their attendant higher risk.

3.1.3 Information Requirements and Research

Although the order of priority will vary with every country or region, there are basic items of information that are always required. In some cases, basic research will be necessary before the needed information can be generated. In other cases, applied research, education, or simply technical assistance will suffice. These items are discussed below in the approximate order of the steps generally taken to get a living resource from the water to the market.

If the fishing is to be regulated for optimum sustainable yield, the regulators must know where the resources are, their extent and condition, biology, rate of growth and migration, the stocks (manageable units), and the effects of fishing on the stocks. Such information is essential for deciding both nature and size of harvest and production equipment and facilities. Techniques for

obtaining necessary information vary from simple approximation methods for minor resources to elaborate and expensive sampling programs for major resources.

In a parallel manner, detailed biological and technological knowledge is needed for successful aquaculture. Basic procedures for rearing certain species are well known, but additional research is needed for many other important freshwater, brackish and marine species.

A knowledge of the soils and waters suitable for private aquaculture is necessary as major opportunities lie in using land and water which are not suited for other purposes; e.g., land which is too wet for agriculture, or water too salty or not needed for irrigating land crops.

The fishermen or fish farmers are the people who will be affected by or involved in any development program. It is essential to know and understand their customs, organizational systems and aspirations.

Statistics on fish production are not only an essential part of the basic information on food production, but also provide information on the state of the public resource and the effects of fishing. Obtaining the required statistics directly from either small-scale fishermen or aquaculturists is difficult, and they are seldom available in most LDCs. The necessary information base consists of reliable data on the resources and the people using them. It is often difficult to develop because of the scarcity or inadequacy of technical and scientific personnel, lack of adequate systems for collection and compilation, and the common failure to maintain existing documents for ready public use.

Development of an appropriate legal and administrative basis for fishery and aquaculture development is essential. Growing international acceptance of an extended economic zone (e.g. the 200-mile limit) has found many developing countries unprepared to effectively use resources previously exploited by distant water fleets from foreign countries or new resources that are now defined

as "theirs". Coastal countries now have both opportunity and at least moral obligation to manage and harvest these resources themselves, or to license their use in whole or part by foreign fishermen. Further, they will need to develop agreements with their neighbors over the use of stocks which cross their common boundaries, or perhaps suffer their loss. The countries must also be aware of the many provisions and implications of the new emerging Law of the Sea regime, whether or not current conferences do in fact result in treaties. Above all, they will need to match their investments in fishery development to the sustainable yield of the resources, and this may require laws to limit participation by their own or foreign fishermen. Some LDCs have fleets that fish in the economic zones of neighboring countries, and they too will need to be guided in making adjustments.

Although legal and administrative factors heavily influence the development of aquaculture, they have not received the attention they merit. Their principal constraints as identified by the FAO Technical Conference on Aquaculture (FAO, 1976: R-64) are:

- Conflicts over water and land use
- Pollution
- Governmental and administrative inaction
- Absence of financial support

Reconciliation of such conflicts, establishment of priorities for water resource use, integration of aquaculture into rural development plans and aids to public systems designed to restock depleted resources or to enhance wild populations are among the measures which might be facilitated by governmental action. Restrictions on transport of species, the sale of species used for recreational fisheries, or the use of certain chemicals for disease control may similarly affect aquaculture development.

Public concern over the effects of pollution and other environmental changes commonly result from its direct effects on fish. Both developed and developing countries are experiencing such change at increasing rates. Fishery agencies are commonly the advocates

for maintenance of an adequate environment. These agencies must understand the dynamics of aquatic ecosystems if they are to advise developers and government decision makers concering possible impacts of environmental change. Aquacultural production systems are no less dependent upon the maintenance of water supply of good quality and adequate quantity than are the fisheries for wild stocks.

Providing for appropriate and adequate fishing methods, vessels, gear and landing facilities in most developing countries is usually a matter of technology transfer and capital investment rather than a task for research. Knowledge of the location and behavior of certain stocks may be required in order to design appropriate fishing gear or methods, and research on improved methods of handling may prevent losses during or subsequent to harvest.

There is a need for aquacultural production systems which are both efficient and cost effective. These may range from simple procedures such as those for carp culture to complicated, high-density systems within a closely controlled environment. Aspects to be considered in the development of production systems include:

- Seed supply
- Grow-out systems
- Feeds
- Animal health
- Harvesting procedures.

The combination of aquaculture with other types of animal production may be especially useful in some countries. As suitable land and water areas become scarce, the use of cages, raceways, and upgrading of present pond systems will increase in importance.

Adequate demand, or the potential for same, must exist for fishery and aquacultural products in domestic or export markets. Although demand for a product can be stimulated or even created, this may be an expensive and risky process.

Harvested fish are especially vulnerable to spoilage, are easy to crush, and are susceptible to insect infestation and the ravages of other pests. The prevention of losses at every stage in the process from capture or pond harvest to the consumer is a constant challenge that involves not only research to improve technology, but changes in the habits of fishermen, fish farmers, processors, carriers and dealers.

The possibilities for fishery development involve not only increased supplies of well known or "conventional" species, but also present special opportunities for using fish which are now discarded because they are unmarketable and for upgrading for human consumption fish which are now used primarily as animal feeds.

Techniques of economic analysis need to be adapted to the particular circumstances in each LDC. Alternatives to and within fisheries and aquaculture development must be carefully evaluated to insure that the resulting decisions are appropriate to the material needs and social objectives of the individual country.

3.1.4 Socio-Economic Analysis

The social sciences have an important contribution to offer in programmatic fisheries research projects affecting LDCs. That contribution is, however, best made in an interdisciplinary context. For this reason, social science research might best be conducted as an integral part of the three major research areas identified (capture fisheries, aquaculture and product utilization) as opposed to standing alone as a subject area for collaborative research.

Economic analysis has a key role to play in several aspects of fisheries research. For any development in the fisheries sphere in LDCs to be of lasting benefit, it must achieve viability in terms of broad socio-economic criteria. Cost-benefit analysis is appropriate at many levels. At a national or a community level

an investment of human, physical and financial resources must be assured of an appropriate return in terms of material benefits. At the level of the individual fisherman, aquacultural worker or fisheries enterprise, the prospects for an adequate net income must be established.

The larger questions of resource management require coordinated research efforts by biologists and economists, assisted by statisticians to develop basic information systems. In addition, the expertise of political scientists and international law specialists is required where LDC fishery management interfaces with foreign fishing effort in the newly created extended economic zone. Sociologists and social anthropologists, together with political scientists, are needed to help determine feasible and desirable changes in the social and institutional environment. Such changes may be required to overcome obstacles to new modes of fishing or aquaculture operations or to consumer acceptance of new and different fish species and products. Business management specialists may be needed to assist in research on management of small-scale fishing and aquacultural enterprises and on the development of distribution and marketing channels.

3.2 LDC Development Priorities and Assistance Needs

Development priorities and needs from the LDC viewpoint were compiled from several sources. As a first step a comprehensive country-by-country literature search and review was completed for a total of 52 developing countries. This provided background information concerning the nature, level of intensity, and current status of fisheries and aquaculture development and research in the individual countries.

In December, 1977, RDA organized and directed a Fisheries Research Planning Workshop in Denver, Colorado. This meeting was attended by 110 scientists and professionals representing 47 U.S. universities and institutions, the BIFAD, the Joint Research

Committee, NOAA, the Food and Agricultural Organization of the United Nations (FAO), and the U. S. Agency for International Development. Many of those attending had spent several years living and working in the developing countries of the world and could speak on the subject of priorities and needs from personal experience. The opportunity to exchange views and ideas in both formal session and informal discussion was particularly valuable.

Research recommendations of the several working groups in aquaculture, fisheries, processing and marketing, social-economics, and international aspects were presented and discussed at this two-day meeting. These were subsequently published as a proceedings document together with reports and presentations made by representatives from the BIFAD, JRC, USAID and the United Nations (Craib and Ketler, 1977: R-R-36). These materials, together with comments and suggestions received from university representatives subsequent to the workshop meeting, provided significant guidance to the RDA team.

To gather additional information and to obtain first-hand impressions of current needs, LDC priorities, and capabilities to undertake or support research activities, advisors and members of the RDA staff personally visited more than 20 foreign countries during the course of this study. Meetings were held with key government officials and representatives of nearly 100 organizations and institutions involved in fisheries/aquaculture development and research in these countries. Selection of specific countries to be visited was based on information obtained through the literature review, recommendations of U.S. university personnel, advice and guidance received from USAID and the Department of State, and the personal experience of the RDA team.

Expression of development assistance needs and relative priorities obtained through these visits and supplemented by the literature were primarily of a general nature. This was a function both of limited time to discuss the various subjects and of the fact that relatively few of the developing countries have established detailed and official statements of needs and priorities

in the areas of fisheries and aquaculture. Further it appears that few previous "baseline" surveys have been performed to establish status of research and development needs in the developing countries as a whole from their point of view. The current effort does not purport to provide a comprehensive survey. Time and budgeting limitation made this impossible. Some general facts and trends do appear, however, from the limited sample obtained.

The priority assistance needs most frequently expressed by a group of 25 lesser developed and developing countries in Africa, Asia, Latin America, Pacifica and the Caribbean are summarized and grouped in 23 broad categories in Table 6 . Numbers shown in the column reflect the relative priorities as reported by the various developing country institutions. Where two or more organizations within a country differed on priority rankings, two or more numbers may appear in the same column. An X is used whenever countries recognized a major problem area but could not or had not established relative priorities.

Nineteen (76%) of the countries sampled expressed a need for assistance with problems related to capture fisheries stock assessment. For nine of these, this area was considered to be their highest priority need. Sixteen countries or 64% considered fresh/brackish water aquaculture to be a problem area of major importance. Of these, eight felt this to be their highest priority assistance need. Eighteen countries (72%) felt fisheries administration and management was a significant problem area, but only six considered it a "number one" priority. Similiarly, 17 countries (68%) considered new or expanded capture fisheries development to be a problem area needing attention, with only four rating this number one. Technical training also rated high on the priority needs list with 16 countries (64%), although only two felt it deserved the highest priority.

These data are further summarized and presented in Table 7 by order of apparent relative importance to those countries included in this sample. Some inconsistencies appear. For example, fisheries administration and management is considered a high priority item (#3), while the development of useable and reliable

Problem Areas

Relative Priority	Capture Fisheries	Aquaculture	Product Utilization	Other
1	Stock Assessment			
2		Fresh/brackish Aquaculture		
3	Fisheries Adminis-tration & Management			
4	New or Expanded Fisheries Development			
5			Preservation & Processing	
6			Post-harvest Losses	
7				Technical Training
8			Marketing & Distribution	
9				Technical Assistance
10		Mariculture		
11	Facilities & Equipment			
12				Socio-economic Studies
13	Vessel/gear Development			
14				Ecology/habitat Protection
15				Rehabilitation/ Improvement of Inland Waters
16		Genetics, Biology Hybrid Development		
17	Catch & Effort Statistics Methodology			
18	Population Dynamics, Basic Biology			
19		Feed		
20		Seed Production		
21				Aquatic Weed Control
22		Disease (Morbid-ity/Mortality)		
23				Mangrove Studies

Table 7. Summary of Needs and Priorities as Expressed by Selected Developing Countries.

methodologies for catch and effort statistics, which would seem to be a prerequisite for effective fisheries management, is accorded a relatively low priority (#17). Similarly the economic viability of fresh/brackish water aquaculture (#2) may depend on the availability of a reliable source of seed stock (#20).

It might also be noted that certain countries included in this sample are not "less developed" as the term is usually applied. The substantial oil revenues enjoyed by Venezuela, for example, result in an annual per capita income which would seem to place this country in the "graduate" category. Income distribution here is skewed, however, and the fisheries/aquaculture sector strongly resembles that of other "developing" countries.

As might be expected, development priorities and assistance needs perceived and expressed by the developing countries are distinctly related to geography and level of individual country development. In Africa, for example, the most often expressed "number one priority need" is for assistance with fresh/brackish water aquaculture, followed closely by the problem of stock assessement. In Latin American and Asia, the highest priority was most often accorded to capture fisheries stock assessment and fisheries management.

As a general rule, the more developed countries seem to place more emphasis on product utilization and food technology. This does not mean the lesser developed countries fail to recognize this problem area; rather, they seem to feel the primary problem is harvesting enough in the first place. The logic of this conclusion, if it indeed is a conclusion, is not defended here.

Finally, we would note that any expression of needs and priorities, whether obtained from a developing country institution or a U.S. university, must reflect the experience and, at least in part, the personal bias and interests of both the particular institution and the spokesman. Furthermore, these needs and

priorities will change over time in response to new developments, social pressures and political necessities. In compiling this list, we have sought to obtain the viewpoints and opinions of recognized and respected country spokesmen at the national level.

3.3 Research Status and Needs

The following sections review the current status of research in the United States and in the developing countries, within the broad categories of capture fisheries, aquaculture, and product utilization. Priority needs are identified and discussed.

3.3.1 Capture Fisheries - Research Status

U. S. universities, government organizations and private institutions have considerable expertise and strength in the principal elements of capture fisheries. Excellent research facilities and capabilities exist, particularly in fisheries science, population dynamics and fisheries management. A somewhat lesser capability exists in the areas of small vessel and related gear design, as the major U. S. effort has been directed at problems faced by the larger-scale commercial offshore fisheries rather than those of the small-scale or artisinal fisherman. There are exceptions, however, and it should be noted that a large and vigorous artis nal fishery exists in the south-eastern coastal area of the United States. In general, this fishery operates at a considerably higher level of sophistication than those found in typical LDCs. Boats and gear are often of advanced design, and many have motors with power take-offs for handling fishing gear.

Research on capture or commercial fisheries in the United States began over a hundred years ago through the United States Fish Commission. Now Federal efforts through the National Marine

Fisheries Service of the Department of Commerce and the Fish and Wildlife Service of the Department of the Interior cover a wide range of research activities.

The National Marine Fisheries Service operates 21 research laboratories reporting through four regional fisheries centers with a budget of some 50 million dollars per year. Fisheries management or development research is conducted at all of these laboratories. The National Marine Fisheries Service is responsible for overall administration and implementation of Public Law 94-265, the Fishery Conservation and Management Act of 1976. In addition, NMFS develops broad criteria and guidelines for managing fisheries as a national resource and fosters state/federal fishery management cooperation and integration of efforts for multi-jurisdictional fisheries. Management activities were expanded when the 200-mile contiguous fishery zone was established in 1976. This included the establishment of Regional Fishery Management Councils and the preparation of management plans for various coastal species.

The National Marine Fisheries Service also conducts a Marine Resources Monitoring Assessment and Prediction Program. The mission of this program is to continually assess the nation's living marine resources through resource surveys, fishery engineering programs, fishery oceanography programs, and fishery analysis. The information concerning coastal stocks of fish and shellfish is used in the development of management plans of various species within the 200-mile economic zone.

Fishery development activities of NMFS include demonstration fishing, shipboard handling, storage studies, marketing research, inspection service, financial assistance, and consumer education.

NMFS also prepares analyses of the status of stocks and fishing efforts as a basis for international negotiations on fisheries and marine mammal issues in cooperation with the Department of State. The United States is a member of eight international fisheries commissions and negotiates bi-lateral agreements with various foreign nations fishing along United States coasts.

The United States Fish and Wildlife Service conducts research primarily in relation to freshwater and anadromous fisheries.

In addition, the Sea Grant Program of the Department of Commerce provides about 35 million dollars annually to various universities and many of the research projects carried out with these funds provide information concerning fishery species.

In summary, Federal and state fisheries agencies and various universities in the United States have a complete range of talents applicable to fisheries research including basic biological studies, population dynamics and fishery management. Excellent research facilities including laboratories and vessels are available at various locations. Highly trained specialists with capabilities for handling nearly any problem of fisheries in the marine, estuarine, or freshwater environment are available. In addition, specialists of the National Marine Fisheries Service, the coastal states, and some universities have had extensive experience in developing plans for extended fishery jurisdiction and negotiation of agreements with other nations. This experience could be helpful to lesser developed coastal countries which are likely to have contiguous fishery zones comparable to those of the United States.

In the developed countries of the world such as Canada, the U.S.S.R., Japan, United Kingdom, France, and members of the EEC, fisheries research is at a high level of sophistication. Within many lesser developed countries, however, the level of current research ranges from modest, as in Indonesia, Ghana, Ivory Coast, and the Philippines, to non-existant in many of the poorest countries. In most cases, the multi-disciplinary teams and research facilities required for research on population dynamics, effect of the harvest on the resource, and similar scientific studies are lacking. Usually research efforts are confined to a few cursory surveys to establish an interim basis for fisheries management. Furthermore, the management of fisheries in many LDCs suffers from a low status of fisheries in the organization of government activities, a lack of trained fishery administrators, and inadequate funding.

In some places, however, effective scientific research programs on fisheries are in progress. In the Philippines, the Bureau of Fisheries and Aquatic Resources has conducted a number of fisheries studies including the distribution and relative abundance of some commercial food species, trash fish caught by otter trawls, oceanographic investigations of fishing grounds, exploratory fishing in prospective fishing areas, hydrobiological and socio-economic surveys of certain areas, and studies of primary productivity and the distribution of important pelagic and demersal species.

India has an extensive fishery development program involving several, specialized research institutions including universities and departments of fisheries of the Federal and the State governments. These are engaged in a wide range of research in many disciplines of aquaculture and fisheries including fish and shell fish culture, fish processing and preservation, oceanographic surveys, exploratory fishing, fisheries training and administration.

The Centre de Recherches Oceanographiques (ORSTOM) in the Ivory Coast has conducted numerous fishery resource studies in the waters off the Ivory Coast and the Gulf of Guinea over a period of many years. Programs have included research in phytoplankton, fish stocks, and aspects of artisanal and commercial fisheries.

The former Federal Fisheries Department of Nigeria conducted fishery resource studies along its coastal region with UNDP/FAO support. Present plans call for an expanded program directed at assessment of deep water fish stocks by the Nigerian Institute for Oceanographic and Marine Resources, the new research body for Nigeria. Ghana has implemented similar projects but on a more limited scale. There are others but these will serve as examples.

In general, while the developing countries recognize the need for fishery research, most of them lack the trained personnel, equipment, facilities, and funds to carry out effective programs.

3.3.2 Capture Fisheries - Research Needs

Development of capture fisheries at the artisinal or small-scale level has only recently begun to receive serious attention by the LDCs. Because of the generally low status of the fisheries and the fishermen themselves in the overall economy of most of the LDCs, the artisanal fishermen, while providing much of the protein foods for the LDCs, have been operating more or less in the same tradition and at the same pace for centuries. It is only recently with the dramatic increases in population combined with the various economic and social changes taking place throughout the world, that the LDCs have begun to realize the importance of the artisanal fisheries in their economic structure and to appreciate the potential inherent in development and upgrading of their small-scale fisheries.

Recognition of the needs to develop their fisheries involves recognition of the problems limiting development and the following section discusses those needs.

3.3.2.1 Administration and Management Systems

Among the top priority needs expressed by the LDCs was that for assistance in the development of effective fisheries administration and management systems. Special problems are involved in designing and enforcing management policies. In addition to research that might be directly aimed at developing improved management techniques and organizations, research is required in the following areas:

- The effects of regulations on stocks (limitation of entry,effort,catch, season or fishing time;areal closures, size and condition limits; restrictions on gear);
- Maintenance or modification of the environment to improve a fishery (e.g.,aquatic weed control, a most important problem in LDCs such as Bangladesh);

- Population manipulation (controls of competitors, prey and predators);
- Introduction of new species and their effect on existing stocks and the environment;
- Maintenance stocking (as in large lakes or reservoirs) or so-called "aqua-ranching."

Such techniques differ widely depending upon the milieu (marine, brackish or fresh water) and their size and ownership. It is obvious that the institution of management measures may be delayed in the absence of data-compilation services such as systems concerned with catch and effort statistics.

Effective administration and management cannot be achieved without trained personnel. While training is not "researchable" in the CRSP sense, it is an essential part of any fisheries development program and should receive priority consideration under Title XII or other technical assistance programs.

3.3.2.2 Resource and Stock Assessment

One of the most critical needs expressed by the LDCs engaged in capture fisheries was for assessment of their fisheries resources. Although these countries are generally aware of the extent and composition of their fisheries, there is a need for more precise and accurate information regarding the identification of the fish stocks, the numbers of species involved, their distribution in time and space and population dynamics.

Within the field of stock assessment, research is required in the following areas:

- development of rapid, simple methods of assessment to be used either initially or as a means of monitoring the status of stocks under the impact of fishing;
- development of methods for assessment of multi-species fisheries (e.g., in the Gulf of Thailand a single trawl haul may include 50 or more species of a total of about 200 demersal species which may enter the catch. Many inland lake fisheries are similarly concerned with a large assemblage of species);

- development of methods to assess stocks which do not lend themselves to trawl surveys (e.g., those coral reefs or hook-and-line fisheries);

- development of stock assessment techniques for use in large rivers (particularly important in Africa and South America);

- development of methods to define the biological potential of inland waters, using environmental parameters.

In addition to needs for resource stock assessment, the development of suitable techniques for obtaining basic catch data was given high priority by the LDCs. While a few of these countries compile catch and effort statistics, the greater majority do not, usually because they lack the necessary infrastructures or trained personnel or both. A very basic need exists for unsophisticated techniques or methods to obtain basic catch statistics as applicable to small-scale fisheries. Accurate fisheries data is essential to the LDCs if they are to implement effective management and control of their fisheries.

3.3.2.3 Biology and Life History Studies

The managment of fishery resources also requires a thorough understanding of the basic biology and life histories of the species utilized in each fishery, or those which may be candidates for utilization. Also included should be those species which affect the fishery either as prey or predator/competitors of the exploited species. Research needs in this area include: taxonomy (including genetic separation of races), distribution (areal, depth, or by habitat), reproduction (maturity, spawning, etc.), age and growth, embryonic and larval development, nutrition, behavior (including movements and response to stimuli), physiology, and their parasites, diseases and competitors.

Such studies (and the list can be extended) are often necessary for more <u>applied</u> fishery research such as that concerned with: population dynamics and stock assessment; fish capture (biotechnical gear research); and the protection and maintenance of stocks. Important as these studies are--even indispensable

in some cases--it must be cautioned that their completion does not by itself lead either to better evaluation or utilization of the stocks. Capitalization on their results will, therefore, require additional time; i.e., it will involve additional applied research or await the opportunity or need for application. These qualifications must be considered in establishing priorities for fishery research in LDCs where time is generally believed to be of the essence.

3.3.2.4 Ecosystems and Environment

If effective management procedures are to be implemented it is essential to develop an understanding of the ecosystems in which the fish species live. Such studies may involve research on environmental parameters with respect to their satisfaction of the requirements of species or species assemblages or, as they may affect them adversely. In such cases, the studies might result in the formulation of criteria needed for protection and maintenance of particular stocks, e.g., water quality or quantity criteria, needs for shelter, etc. Or, as another example, they might involve research into indices of pollution as reflected by changes in the environment.

Another type of environmental study of particular importance in LDCs which often possess considerable areas of water and land still largely unaffected by man's activities (industrialization, agriculture, etc) is to determine the intricate relationships of factors critical to determining their fishery production or the production of outlying areas. Estuaries, for example, have extremely high biological productivity, and (by functioning as nurseries) may make a considerable contribution to offshore fisheries for shrimps and finfish. They are generally accessible for exploitation by artisanal or small-scale fishermen. They may also be easily damaged in the biological sense.

Several LDCs have expressed a need for studies of their mangrove swamplands. They are concerned whether these areas can survive current and proposed exploitation by agriculture, aquaculture,

forestry and mining. This concern results from a growing realization of the importance of this resource as a component of the tropical ecosystem as well as a source of income. When exploited, the halophytic trees and shrubs yield charcoal, lumber, firewood extracts for tanning, etc.; unexploited, the swamplands where they grow serve as breeding and nursery grounds for many commercially important aquatic species. The swamplands potential for brackish water aquaculture is also considerable, and some fish farmers would prefer they be cleared altogether.

At present little base-line data is available on the ecology and productivity of mangrove swamps and it is not possible to draft meaningful management plans for these areas. Research that will appraise the present status of knowledge of mangrove (and estaurine) ecosystems is needed together with research directed to provide the essential resource information base so that wise policies for its development management and conservation can be formulated and implemented.

In many LDCs, particularly in Africa, vast areas in South America, and river basins such as the Mekong, studies of the interplay of biological, behavioral, physio-chemical and meteorological factors regulating the fisheries of rivers and floodplains are required to improve fisheries management. Such studies, especially when linked with evaluations of alternative uses of such rivers and their floodplains (agriculture, irrigation, rice-culture, stock raising, etc.), can be of great importance to the LDCs as a basis for linkage of fishery development (of both wild and cultivated stocks) with other forms of land and water use.

Coral reef fisheries are important in many LDCs, particularly to small-scale fishermen in tropical areas. Like estuaries, they are easily accessible and vulnerable to man-induced changes, and require protection if their productivity is to be maintained.

3.3.2.5 Alternate Sources of Energy

Research is also needed to develop alternate sources of energy that are cheap, efficient and simple to operate and maintain. One of the most critical problems affecting capture fisheries is the spoiling of up to 50% of the catch before it reaches the consumer. This can be considerably reduced if not eliminated by simple refrigeration. To date there is no simple inexpensive means of providing ice or comparable refrigeration to the artisanal fisheries. As the first step in helping to eliminate these unfortunate losses, research directed to this specific area, while limited in scope, would certainly provide a maximum in benefits.

3.3.2.6 Vessels and Fishing Gear

Vessels and capture gear are a subject of concern in many countries. Artisanal fishermen in typical LDCs use nets, line, hooks and similar gear based on designs that are centuries old. In some instances, they may still be the most effective for small-scale fisheries. Recent developments in net design, the use of synthetic fibers and similar changes adopted in the more developed countries might be appropriately used in other circumstances. Research to develop simple adaptations of effective and inexpensive fishing gear is needed.

Generally speaking, American universities have not done much work in these fields (there are exceptions), but they do possess mathematical and engineering skills and facilities; e.g., hydraulic labs, to do such work. Furthermore, their biological skills in studying behavioral patterns of fish may well be applied to gear design which takes advantage of these factors.

A further possibility exists in using these skills in designing boats and gear which will save energy in traveling to and from the fishing grounds and during the harvest. Cutting down on manpower needs in LDCs is not as important as minimizing the use of fossil fuels; in many LDCs their procurement depends upon possession of foreign currency.

Most boats used by small-scale fishermen are rudimentary in design - a few logs tied together, a hollow log, or shaped planked hulls. Usually the design has not changed to any extent over hundreds of years. There is a need for research to design efficient boats for small-scale fishermen in inland, inshore, and coastal waters, and for inexpensive, simply-designed and easily maintained power units.

Under this Title XII program, emphasis might be placed on research to develop simple small craft and nets for small-scale fisheries (including passive or fixed gear), emphasizing the use of local materials and machines. Similarly, research directed to developing improved methods for conducting fishing operations and catch delivery would both increase quantities landed and improve the quality of the product.

3.3.2.7 "Law of the Sea" and the Extended Economic Zone (EEZ)

Although not the highest priority item for all LDCs, the coastal countries are well aware of the implications of the emerging "Law of the Sea" and the extended economic zone and have asked for assistance in order to meet the impending opportunities and obligations. A large proportion of fishery resources in tropical waters and the southern hemisphere are within these established or potential economic zones. These countries now have a choice of using or not using resources themselves, or of licensing foreign fishermen to use them. Significantly, these waters contain most of the world's conventional and underutilized fisheries resources.

In recent conferences on the Law of the Sea, the new rights and duties of the coastal countries have begun to take shape. The composite single negotiating text of July 15, 1977 represents a substantial measure of agreement, and some coastal states are passing laws in this regard. Articles 61 and 62 of this text provide that coastal states shall determine the allowable catch of the living resources. They shall take into account

the best scientific evidence available and ensure through proper conservation and management measures that the resources are not endangered by over-exploitation, nor wasted by under-utilization. They shall cooperate with regional and global organizations to that end. The measures shall be designed to maintain or restore stocks at levels that can produce the optimum yield. Furthermore, they shall determine their own capacity to harvest the living resources of the EEZ and, when they do not have the capacity to harvest the entire allowable catch, they shall permit other states to do so with appropriate restrictions to prevent over-harvesting. The coastal states shall also cooperate with neighboring states when stocks migrate across national boundary lines, and with regional organizations where appropriate. Whether this will be done in practice remains to be seen.

A major need of coastal nations is to develop effective programs to conduct the required fisheries research, to determine optimum yield for various species, and to develop and implement effective fishery management programs to ensure that fisheries resources are managed as rationally as possible. The world is without much experience in this regard. It is not only a problem of what national laws and regulations "should" be, but also a problem of fitting national programs into an equitable international framework, since in many areas individual countries have small coastal zones and share resources, making regional cooperation and absolute necessity.

The United States has moved ahead of most other countries in meeting the complex EEZ requirements. This experience could be utilized to develop model laws, regulations and procedures for consideration by LDCs. This would include the provision of legal authorities, recommended arrangements for administration of fishery management and establishment of effective procedures for international negotiations.

3.3.3 Aquaculture - Research Status

Research to establish a sound scientific basis for the culture of certain species has been conducted in the United States for more than 100 years. It was directed originally largely toward solving problems which would permit the development of hatcheries for restocking species in high demand by recreational or commercial fishermen. Early efforts concerned trout, salmon and oysters. More recently aquaculture research in this country has been expanded to include clams, catfish, freshwater prawn, lobster, marine shrimp and some other species.

Federally conducted or funded programs related to aquaculture totaled about 16 million dollars per year in fiscal year 1976. About half of this was for research and development programs and the rest for extension services, regulatory activities, etc. In addition most of the individual states have modest research programs concerning species of local importance, although much of this research is conducted to provide a basis for management of public fisheries or to improve the operation of hatcheries. However, some of this work may improve the scientific basis for private as well as public aquaculture.

State funded academic institutions also conduct research which adds to the base of scientific information upon which aquaculture of various species can be established. The Sea Grant program administered by the National Oceanic and Atmospheric Administration has provided funds to more than 30 universities for research and development programs related to the aquaculture of selected species. Under this program federal funds are supplemented by at least one-third matching funds from non-Federal government sources.

The following four categories provide a comparison of the status of culture of various species in the United States (Glude, in press: R-79):

1. Adequate scientific base for commercial culture; currently industry viable

This group includes Eastern and Pacific oysters, rainbow trout, catfish, freshwater crawfish, culture of salmon in floating net pens and culture of the freshwater prawn Macrobrachium rosenbergii in extensive systems.

2. Nearly adequate scientific base; some commercial ventures; viability expected in three to five years

This group includes marine shrimp (Penaeidae), salmon culture by the ocean ranching system, yellow perch, clams, and mussels.

3. No commercial aquaculture ventures; needs three to five years of research and development before viable aquaculture can be expected

This group includes bay scallops, abalone, marine shrimp (Pandalidae), lobsters (Homarus), freshwater prawns cultured in intensive systems, pompano and striped bass.

4. Inadequate biological or technological base for aquaculture, but with a potential for aquaculture in the future

This group includes sea scallops, sablefish, crabs, bait fish for tuna fishing, and other marine fish.

Aquaculture is much more important as a source of food on a worldwide basis than in the United States. Of the worldwide total production of the six million metric tons, mainland China produces 2.5 million metric tons, Japan 945,000 metric tons, India 494,000 metric tons and U.S.S.R 210,000 metric tons. In comparison production from aquaculture in the United States including the shell weight of mollusks was 151,000 metric tons in 1975 according to FAO statistics. Other countries which obtain a large percentage of their animal protein from aquaculture include Indonesia 144,000 metric tons, Taiwan 126,000 metric tons, the Philippines 125,000 metric tons, Korea 83,000 metric tons, Thailand 83,000 metric tons and Bangladesh 76,000 metric tons.

In a paper presented at the 1976 FAO Technical Conference on Aquaculture at Kyoto, Japan, Dr. T. V. R. Pillay (Pillay, 1976: R-138) reviewed the state of aquaculture in comparison

with the situation at the previous world symposium held in 1966. During the past five years worldwide production from aquaculture has doubled to six million metric tons. Major increases have occurred in those countries in which high importance has been given to aquaculture in national economic development plans and the essential investment and support services have been provided.

According to Pillay some significant changes have occurred in the general concept of aquaculture during the past decade. Traditionally, low-density culture with minimum inputs and low production per unit area has been more economical than intensive farming involving the rearing of dense populations. Now many countries are turning to intensive or semi-intensive systems. For example, in Israel, fish ponds producing less than 2.5 tons/ha. are no longer profitable. Even in some Eastern European countries that have fish farms with ponds too large for intensive culture, higher overall productivity and profits are achieved through a combination of duck and fish farming. Also, aquaculturists now try to exercise greater control over the environment and the stocks. In many cases seed is produced by artificial propagation and at least supplemental feeding is used to intensify production.

Several factors that have affected the fishing industry in recent years have brought renewed attention to aquaculture. These include the increased cost of fishing due to steep increases in fuel cost, the fear of decrease in fisheries production as a result of the extended economic zone by countries that depend on fishing in foreign waters, and the need for some countries to relocate or to find alternative or additional employment for large numbers of excess fishermen or underemployed farmers. A continued high demand in developed countries for high-valued species such as shrimps and prawns has also served to promote interest in aquaculture in countries that wish to increase foreign exchange earnings. On the other hand, sharp increases in the cost of some essential inputs such as feed have raised the cost of production. Other adverse factors include water pollution and large scale mortalities of some cultured species such as oysters.

During the last decade a number of technical advances have been made and some new technologies developed (Pillay, 1976: R-138). Some of the research done during this period has been extremely valuable in providing an understanding of the scientific bases of certain traditional practices and has enabled the improvement and modernization of old technologies. Cage and enclosure or pen culture are outstanding examples of this. Although such forms of culture have existed for many years, modifications in design materials and operation together with the availability of suitable feeds including floating pellets have facilitated cage culture of catfish, salmon, trout, yellowtail and milkfish.

Although polyculture of fish is an ancient technology in Asia, especially China and India, experimental work in recent years has given a better understanding of the significance of this system for rearing various species of carp and tilapia with only modest supplemental feeding.

Pond culture of tilapia has existed in tropical countries, particularly in Africa, for many years. However, the problem of overpopulation of ponds and consequent stunting due to frequent breeding made tilapia culture generally unattractive.

Two broad systems of culture have evolved in recent years which make culture of tilapia viable: accelerated growth and use of monosex hybrids. These systems can be used to raise annual production to 5,000 kg/ha of marketable fish, providing a fair return on investment.

Although traditional systems of extensive shrimp and prawn farming have existed in Asia for many years, it was only in the 1960s that intensive culture based on hatchery-produced larvae and juveniles was developed in Japan. Because of high demand for shrimps in world markets and the inability of natural fisheries to meet the demand, much interest in shrimp culture has developed in the last ten years. Initial attempts were made to transfer the Japanese technology, but this has not generally been successful. Successful advances have been made, however, in

a number of countries including United States, Korea, Taiwan, the Philippines, Indonesia, France and United Kingdom, in establishing methods for artificial propagation and hatchery production of juveniles of a number of penaeid species. Development of techniques for the maturation of some species of penaeid shrimp has added to the efficiency of seed production, however, this has not been accomplished for most species.

Macrobrachium rosenbergii was traditionally cultured on a small scale in Asia, but interest in commercial farming has developed as a result of the high demand for shrimps and prawns in the world market and the development of methods for the propagation of this species.

The use of domestic and farm wastes for fish culture is an age-old practice in Asia, but it is only recently that this practice has attracted wider attention as a means of recycling wastes and at the same time contributing to food production. Many developing countries are adopting a system of fish farming in association with duck, pig, or cattle raising so as to utilize the waste for fertilizing fish ponds. The area of sewage-fed fish ponds has expanded to over 12,000 hectares in India. Duck-and-fish farming, which is an efficient means of recycling duck droppings has become wide spread in Eastern Europe and has been introduced in Central Africa and Nepal. It has also been conclusively shown that productivity in the aquaculture of fish or shellfish can be significantly increased by the controlled use of treated sewage for increased production of plankton.

A new technology that has developed at a rapid pace during the last decade is the reconditioning and re-use of water for aquaculture. The availability of water will become a limiting factor for aquaculture development in an increasing number of countries in the future and the cost of pre- or post-treatment may become prohibitive. Several systems of water reconditioning or re-use have been developed and the use of reconditioned water has become fairly commonplace in hatcheries especially in the United States.

During recent years sea-ranching has become an accepted technology in aquaculture. Early attempts to maintain or increase fish populations by releasing hatchery-reared fish were generally considered unsuccessful. This concept has since undergone considerable change with improvements in culture systems disease control and feeding, and the release of larger juveniles which can fend for themselves. Anadromous fish are obviously the best suited for sea-ranching and it is estimated that over two billion juveniles are artificially produced annually and released into fresh and marine waters, mainly from government hatcheries. In Japan several species such as the red sea bream, abalone, and penaeid shrimp are being reared in government hatcheries and released to enhance coastal stocks.

Culture techniques with multi-species applicability developed through research in recent years include methods for controlling reproduction of aquaculture species. The Chinese carps, Indian carps and the grey mullet, which do not generally breed in confined waters of culture installations, have been induced to breed by the injection of pituary hormones. Methods for mass rearing of fish larvae have also been developed and these are now being employed by culturists. Similarly the successful maturation of shrimps in captivity by eyestalk ablation is a breakthrough of considerable significance, but much more needs to be done to perfect this technique for a large-scale application. Also important is the hatchery production of oyster seed which can assure a continued supply and can facilitate genetic selection of strains for special qualities such as disease resistance.

The control of diseases in aquaculture systems has been advanced by the development of vaccines for some bacterial diseases such as vibriosis and the use of effective drugs for treatment of various infections. Meanwhile the recognition of the dangers of transmission of communicable diseases through shipment of live organisms has led to the consideration of an international convention to control the spread of communicable fish diseasess.

Improved pelleted feeds have become available for several species such as salmon, trout, catfish and shrimp. These foods have been based upon research to determine the nutritional requirements of certain species, but much more needs to be done in this field to provide cost effective diets for aquaculture of most species. Especially needed are studies to develop efficient feeds utilizing readily available local components in lesser developed countries.

In summary the worldwide body of knowledge upon which aquaculture systems can be based has expanded significantly during the past decade. Although most of this research has been conducted in the more developed countries where aquaculture is viewed as a profit making venture, many of the techniques are applicable in lesser developed countries where subsistence level aquaculture should be developed or expanded. In many cases the applicability of specific culture methods to local situations in lesser developed countries needs to be determined by pilot scale tests before application at production level can be recommended.

3.3.4 Aquaculture - Research Needs

The worldwide interest in aquaculture is expanding rapidly and new laboratories are being built in various countries and staffed by competent researchers. Many of the problems now limiting production-scale aquaculture of traditionally cultured species should be solved within the next decade by efforts largely in the more developed countries. The results of this research should be transferred to lesser developed countries as rapidly as possible with appropriate testing to determine its local applicability. It is likely that specific methods will require modification to permit culture of traditional aquaculture species in local environment.

A recent analysis of aquaculture research needs in lesser developed countries resulted from an FAO/UNDP workshop at La Toja, Spain, June 1978. The summary report of this workshop states in part:

"The projected increases in aquaculture production in the developing world are expected to be obtained by the application of known technologies and so adaptive research, to enable transfer of technologies or the improvement of the techniques involved, will have the highest priority. Such research must be of a multidisciplinary nature and systems-oriented, as problems are very closely inter-related. As pointed out by the TAC Subcommittee on Aquaculture (FAO, 1974a: R-57) aquaculture has strong feed-back components, as, for example, improvement in seed supply requires new food or feed production techniques. Seed and feed production may involve study of nutrition and physiology; management of seed production and rearing would need knowledge of environmental requirements - disease control, etc. The production system as a whole, therefore, has to be considered and the gaps in our knowledge of the systems have to be filled and problems in their application solved through team effort."

In the general area of finfish research, the 1976 FAO (FAO, 1976e: R-70) technical conference on aquaculture concluded that despite promising trends in the development of finfish culture there are many gaps in our present knowledge which need to be filled if significant increases in fish production through aquaculture are to be achieved.

Suitable aquatic species for cultures should be evaluated with regard to their physical and environmental requirements and this related to the siting of fish farms. Production functions relating physical and environmental levels to production costs should be developed for each species and these data should be combined to produce maps depicting locations suitable for culturing various species, as well as their associated production cost and economic opportunities.

The use of local instead of introduced species of finfish should be encouraged even though much less may be known about their life history and environmental requirements. In such cases it will be necessary to learn enough about local species to determine their adaptability to aquaculture and then to develop appropriate culture systems for selected species. Local universities, government fisheries or agriculture agencies, and foreign assistance programs could be most helpful in these projects.

Sex reversal and other methods of sex control should be further investigated. Concerted research should be continued on the reproduction of species such as milkfish and improved systems should be established for collection and distribution of wild-caught fry. Finally strains of fish which are resistant to specific diseases should be developed through selective breeding.

In relation to the culture of crustaceans, the summary report of the FAO Technical Conference on Aquaculture (FAO, 1976e: R-70) noted that in recent years technology for raising larvae has been perfected for several species of penaeids, for Macrobrachium and for the northern lobster Homarus. However, the profitable grow-out of crustaceans from juveniles to market size remains to be solved for most species except for the freshwater prawn and the kuruma shrimp in Japan, for which high prices prevail and for penaeid shrimp raised in low-density systems in Ecuador and Peru.

The constraints to successful commercial culture of crustaceans are the familiar ones for all kinds of aquaculture. Food costs are high because of poor conversion rates. Part of this can be attributed to lack of knowledge of the nutritional requirements of the animals since without such knowledge cost effective feeds cannot be formulated.

For the larval stages, satisfactory substitutes for brine shrimp have to be found or the supply increased. Also while growth rates can be significantly accelerated at elevated water temperatures, the cost of energy to heat large quantities of water makes this uneconomical on a commercial scale unless waste heat from industrial plants, geothermal sources, or solar heating can be employed. Finally although progress has been made in maturation and spawning of some of the penaeid species, further work is needed to perfect this technique for commercial application.

The summary report of the Kyoto conference (FAO, 1976e: R-70) noted that the farming of molluscan shellfish offers the best

immediate means for the development of marine farming. Mussels and oysters are herbivorous, and can be grown on a large scale where there is sufficient phytoplankton in adequately sheltered water that is not polluted. Of the species farmed the mussels (Mytilus and Perna) and the cupped oysters (Crassostrea) were considered the most promising.

Innovations noted in oyster culture included the increasing use of commercial hatcheries for seed, genetic modifications for improvement of stock, and the growth of oysters to market size in a completely controlled environment. New developments include the expansion of raft culture of mussels on the coast of Galicia and potential expansion in Venezuela, South Korea, the Philippines, Chile, and New Zealand.

Constraints to mollusk culture include a selection of suitable sites with adequate phytoplankton, protection from storms and absence of domestic or industrial effluents. It was also recognized that consumer acceptance of mollusks vary widely.

Among the most serious constraints on oyster farming is the periodic occurrence of mass mortalities caused by environmental changes, overstocking, pollution, epizootics or other causes which are unknown or difficult to identify. The need for continuing research on the physiology of oysters and search for primary pathogens was emphasized.

The Kyoto conference also recognized the importance of determining the nutritional requirements of cultivated organisms to provide the basis for development of cost effective feeds. Development of economically viable aquaculture in lesser developed countries will require use of local raw materials to provide low-cost feeds for cultured species.

A number of potential collaborative research programs can be developed within the general area of aquaculture. As with capture fisheries, the following list does not necessarily imply a relative priority ranking among programs identified.

3.3.4.1 Culture Systems for Native Species

In most of the developed countries in the temperate zone of the northern hemisphere and in Southeast Asia several native species of fish, crustaceans, and mollusks are cultured. In many tropical areas however, aquaculture has just begun. Sufficient knowledge which would permit the culture of most native species is lacking. Even in parts of the world where aquaculture of a few species has developed there are additional native species with potential for aquaculture. However, the scientific and technical knowledge of these species is insufficient for development of culture systems.

In southeast Asia, for example, culture of milkfish, mullet, carp, tilapia and shrimp is well established. The culture of additional species such as eels (Anguilla spp.), groupers (Epinephelus spp.), snappers (Lutjanus spp.), sea breams (Chrysophrys spp.), and sea bass (Lates spp.) has just begun (Mistakidis, 1977: R-123). Most of these species are in high demand in domestic or export markets at high prices, but commercial culture methods have not been developed. Seed must still be obtained from natural reproduction and little is known about disease control, environmental requirements, or foods and research is needed in these areas.

Latin America provides a good example of the need for development of an adequate information base to permit the culture of native species and the same need applies in much of Africa.

Swift (Swift, in press: R-568) comments that in warm fresh waters of Latin America there are many native species that appear to have potential for aquaculture, but work in the past to incorporate native species into aquaculture systems has met with little success. Instead exotic species, particularly tilapias have been used to develop successful culture systems.

Considerable controversy developed at the Maracay symposium regarding the advantages and disadvantages of the introduction of tilapia. Many participants believed that aquaculture should be based on native species to avoid the adverse effects resulting from tilapia introduction in some locations. It was generally recognized however that at present no native fish is used in commercial aquaculture systems in Latin America and that carefully controlled culture of tilapia has been beneficial.

The abundant warm waters in lakes and rivers of Latin America and Africa as well, provide substantial opportunities for aquaculture. Also numerous reservoirs in the tropics offer excellent potential for a form of aquaculture in which desirable species are planted by government agencies for public harvest. However, development of aquaculture of native species in these waters is limited by the lack of knowledge regarding these species and their environmental requirements. With a sound scientific base of knowledge, culture systems could be developed.

Culture development systems are needed for fresh, brackish and marine species of fish, crustaceans, mollusks and plants; however, the greatest potential appears to be in the culture of tropical freshwater fishes. With over 1,700 species in the Amazon drainage and numerous fishes in African waters there must be some with high potential for culture.

Not all of the opportunities lie in the direction of pond culture. Numerous reservoirs in the tropics offer excellent potential for a form of aquaculture in which desirable species are planted by government agencies for public harvest. However, development of aquaculture of native species in these waters is limited by the lack of knowledge regarding these species and their environmental requirements. With a sound scientific base of knowledge, culture systems could be developed. Culture systems should include procedures for rearing certain species to harvestable size in captivity, to juvenile size for release to stock depleted natural populations, or for stocking in reservoirs or seasonal ponds.

3.3.4.2 The Efficiency of Pond Culture Systems

Two-thirds of the aquaculture products in the world are finfish mainly produced in low-technology, low density pond culture systems (FAO, 1976: R-316). Crustaceans, marine shrimp, freshwater prawns, and crayfish are also reared in ponds following the low-density systems traditionally used in China and Southeast Asia.

The yield from pond culture varies greatly among countries and depends on the system used. For example, milkfish production in Indonesia, Malaysia and the Philippines following traditional culture systems varies from 200 to 500 kilograms per hectare per year (kg/ha/yr). Improved systems in the Philippines which stimulate the production of blue-green algae (lab-lab) and green algae (lumut) yield over 2,500 kg/ha/yr. Milkfish culture in pens at Laguna de Bay, Philippines, can yield up to 4,000 kg/ha/yr (Brown, 1977: R-26) and yields up to 10,000 kg/ha/yr have been reported (Mistakidis, 1977: R-123). In Taiwan the yield of milkfish reared in ponds averages 2,000 kg/ha/yr with best yields of up to 5,700 kg/ha/yr.

Carp culture without fertilization in Malaysia, Mainland China and Taiwan produces less than 600 kg/ha/yr. Even in India the average yield from private ponds has been reported at only 890 kg/ha/yr. In constrast, culture systems in Taiwan in which duck droppings fertilize carp ponds can produce 3,500 kg/ha/yr and systems using organic fertilizers, some of which are used directly as fish food, can yield 7,000 kg/ha/yr. Polyculture experiments by the Central India Fisheries Research Institute have yielded up to 8,845 kg/ha/yr of various carps.

In Israel commercial fish farms rearing various species of carp in polyculture systems produce 3,500 kg/ha/yr and up to 7,000 kg/ha/yr with fertilization and supplemental feed. The highest yield from polyculture of carps in pond culture systems appears to be 20,000 kg/ha/yr. This was achieved in Israel by

applying 1.5 metric tons of manure per hectare per day.*

Reported yields from finfish culture in various locations are summarized in Table 8 .

In summary, recent scientific developments in the Philippines, Taiwan, India and Israel have shown that it is possible to increase production in ponds by a factor of at least ten.

Most of the improvements in pond culture systems have resulted from the application of empirical methods. The relation between fish populations, pond fertilization, feeding, and pond ecosystems has not been thoroughly investigated. Research is needed to determine the principles involved in the flow of nutrients through pond systems. This will provide a better scientific base for upgrading existing pond culture systems and for starting aquaculture in new areas with traditional or new species. This will be especially important in developing systems for culture of native species in Latin America and Africa where many of the species are different from those cultured in Southeast Asia.

Another aspect of improving the efficiency and, hence, the cost effectiveness of pond culture involves the use of energy. Development of systems which require less energy and protein input will reduce the cost of production. The use of agricultural wastes, recycled water, surplus heat, geothermal and solar energy are examples.

Intensive culture in cages, enclosures, and raceways permits high yields in areas where land or water areas are limited. These techniques are being adopted at an increasingly rapid rate in developed countries where many technological improvements have been incorporated in the design, installation, and the technical aspects of operations.

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* Personal communication Dr. B. Hepher, Fish and Aquaculture Research Station, Dor, N. D. Hof-Hacarmel, Israel to Dr. Ed Scura, Hawaii related to John Glude, May 1978.

Species	Country	Culture system	Yield (kg/ha/yr)	Comments	Reference
Milkfish	Indonesia	ponds	340	Could be doubled by adding super phosphate	Djajadiredja and Poernomo, 1972 (R-304)
Milkfish	Malaysia	ponds	400		Fisheries Division, Malaysia, 1972 R-385
Milkfish	Philippines	ponds	460-480	1964	Djajadiredja and Poernomo, 1972 (R-304)
		"	565	Average yield	Brown, 1977 R-26
		"	300-500	Traditional culture systems	Bardach, 1972 R-13
		"	1000	Improved methods	Bardach, 1972 R-13
		"	200-500	Traditional culture systems	Blanco, 1972 (R-281,282)
		"	2500	With "lab-lab" and "Lumut"	Blanco, 1972 (R-281-282)
		"	2660	With "lab-lab" and improved culture methods	Blanco, 1972 (R-281-282)
		pens	4000	Best yield, Laguna de Bay using natural phytoplankton	Brown, 1977 R-26
Milkfish	Taiwan	ponds	1863	(1968)	Djajadiredja and Poernomo, 1972
		"	1900-2500		Chen, 1972 R- 291
		"	2000	Average yield	Brown, 1977 R-26
		"	5700	Best yield	Brown, 1977 R-26
Carps	Malaysia	ponds	280		Fisheries Division, Malaysia, 1972 R-358
Carps	China	reservoirs	180-300		Brown, 1977 R-26
		natural lakes	300-450		Brown, 1977 R-26
		enclosures in rivers	900-1800		Brown, 1977 R-26
Carps	Taiwan	ponds	500-600	Unfertilized	Ling, 1977 (R-356)
		"	3500	Ducks cum fish	Ling, 1977 (R-356)
		"	7000	With organic fertilizer, some used as food	Ling, 1977 (R-356)
Carps	India	ponds (polyculture)	890	Average yield in private ponds	Ranadhir, 1976 (R-384)
		ponds (polyculture)	8845	Experimental - Central India Fisheries Research Institute	IPFC, 1975 (R-98)
Carps	Israel	ponds (polyculture)	3500	Commercial fish farms	Brown, 1977 (R-261)
			7000	Gan Shmuel farm; with supplemental feed	Brown, 1977 (R-261)
			8000	Experimental; with daily application of liquid cow manure	Brown, 1977 (R-261)
Tilapia	Taiwan	ponds	2000	Average yield	Brown, 1977 (R-261)
		"	5700	Best yield	Brown, 1977 (R-261)

TABLE 8 - Yields from Finfish Culture in Various Countries

The broad estuarine zones of the world have high natural productivity because of their enrichment by nutrients carried by surface runoff through rivers to the estuaries. These zones are inhabited by a rich and complex array of plant and animal life especially adapted to this fertile, dynamic environment. Vast estuarine areas composed of mangrove swamps and adjacent shallow brackish water exist in tropical regions around the world.

Fishing has been the only method of harvesting the productivity of tropical estuaries since, with a few exceptions, efficient methods of brackish water aquaculture in the tropics have not been developed. However, the molluscan shellfish which live in these zones are attractive candidates for aquaculture in many developing countries. Oysters, clams and mussels are efficient converters of plant to animal protein, feeding directly on phytoplankton which grows abundantly in fertile estuarine waters. They are sedentary organisms and thus more suitable for farming than highly mobile animals. They can survive for hours or days after being removed from the water which makes them suitable for shipping short distances without preservation even in the tropics.

Molluscan shellfish farming has become a profitable industry in a number of developed countries but in very few developing countries. The chief constraint to successful aquatic farming in developed countries has been its labor-intensive nature. This, however, should not be a problem in LDCs.

In parts of Southeast Asia, clams, oysters and mussels are being farmed successfully and the development of shellfish farming and the demonstration of its practicality in other tropical areas holds a high potential for increasing food and employment.

In developing countries where aquaculture has been practiced extensively for many decades, there has been little incentive to improve production per unit of area. However, increasing scarcity of good land and water areas for aquaculture purposes even in developing countries makes it desirable to expand aquaculture in cages and enclosures or to upgrade the efficiency of existing pond culture systems following the examples of Taiwan, India, and Israel.

Given an adequate scientific and technical information base it may be possible to develop a variety of alternative production systems, both confined and unconfined. Some are already being used, although on a fairly limited basis. They range from simple procedures such as planting seed oysters on intertidal beaches or stocking public lakes and reservoirs to estuarine impoundments or sea ranching. A variety of systems is required to provide the basis for cost effectiveness determinations for various species in differing environments.

3.3.4.3 The Availability of Seed for Aquaculture

The availability of seed (fish fry, post larval crustaceans, and molluscan spat) is a basic requirement for existing aquaculture systems and even more important if production is to be enhanced. For some species such as yellowtail, milkfish, mullet, marine shrimp, freshwater prawns, osyters, clams, and mussels it is possible to collect seed from natural reproduction. When this is possible it is undoubtedly cheaper than rearing seed in hatcheries. However natural supplies are limited and expanded culture of some species will not be possible until reliabile seed sources are available. Mistakidis (Mistakidis, 1977: R-123) comments: "Any future increases in milkfish production, apart from the application of improved aquaculture methods, are directly dependent on the availability of fry for stocking purposes. Shortages of seed as a result of wide natural

fluctuations (128 million fry in 1972 as compared to 207 million in 1970 in Taiwan), or more recently from pollution, are not uncommon in the major producing countries."

The problems of developing seed sources is complicated because methods for maturing brood stock of some species in captivity have not been developed. This is generally true for milkfish, mullet, yellowtail, most species of marine shrimp and for other species that have not yet been grown in aquaculture systems. Research on this problem is being conducted in a number of countries and some breakthroughs have occurred recently in the maturation of milkfish, mullet, marine shrimp, and several marine fishes. The completion of the life cycle in captivity is also a prerequisite to genetic studies.

Expanded seed supplies are needed in Southeast Asia and it is generally recognized that government hatchery programs should provide seed for the expansion of aquaculture (IPFC, Directorate General of Fisheries, 1976: R-337). This was also one of the major conclusions of the 1976 FAO Technical Conference on Aquaculture in Kyoto.

In addition to the maturing of brood stock in captivity, it is necessary to develop systems for culture of larvae and juveniles to a size at which they can be planted in aquaculture facilities or released to enhance natural populations and this will require research. It is also important to develop procedures for collecting, holding, and distributing seed from natural reproduction.

At some stage in the development of aquaculture the technology of seed production should develop to the point that private industry can supply its own needs. This has already occurred in many places for species such as trout, carp, catfish, oysters, and tilapia.

3.3.4.4 Genetic Techniques

Most terrestrial animals and plants grown in agriculture have been extensively modified by genetic selection and hybridization. As a result these species are more amenable to culture systems than the wild stocks from which they originated.

In contrast few of the aquatic species used in aquaculture have been improved by genetic techniques and in many cases aquaculture systems utilize seed from wild stocks. Logically the improvements that have been achieved by phenotypic selection of terrestrial animals could be equaled with aquatic species and this could result in far higher production than can be achieved at present.

It is recognized that genetics and selective breeding programs are expensive and of long duration but economic returns can be very great. Some experiments have shown significantly increased growth rate even in the first generation of a selective breeding program.

The first step in a genetics program is to develop procedures for completing the life cycle of the target species in captivity. This has been accomplished for many of the commonly used aquaculture species such as carp, tilapia, catfish, oysters, freshwater prawns, and most of the salmonids. Selective breeding programs for several of these species notably salmon, trout, and carp have been highly successful and have provided the basis for commercially viable aquaculture. Other species such as milkfish, yellowtail, and most of the crustaceans and mollusks still require collection of seed from natural reproduction. First efforts toward genetic improvement must concentrate on a few of the most important species that can be grown throughout their life cycle in captivity and on the production characters of greatest economic significance. Eventually genetics programs should be expanded to include all aquaculture species.

Benefits of genetic improvements include improved growth rate, survival, morphometric characteristics, disease resistance, and meat quality. Hybridization has already been applied with tilapia to obtain monosex progeny which alleviates the problem of overpopulation in culture systems. The same technique holds promise for making a variety of improvements in aquatic species.

3.3.4.5 Nutritional Requirements and Cost-Effective Diets

Cost effective food is a primary requirement for most aquaculture since food is often the largest cost item. Scientific research to determine the nutritional requirements for each cultured species is needed first. Rations then can be formulated, often by private industry. Testing of food at pilot scale also is needed to determine conversion rates, long-term diet deficiencies and effect on disease resistance. Because of the broad application, complexity, and long-term nature of nutrition studies, the need for government support is indicated.

Aquatic organisms are known to be efficient nutrient converters, even more so than most terrestrial animals. However, knowledge of digestive physiology and basic nutritional requirements of most aquatic organisms is fragmentary. Even though salmonids and catfish have been studied for many years much is still unknown. Even with these species there is much to be gained by continuing research and nutritional studies of other species, for which even less is known.

Obviously the development of rations cannot wait for complete knowledge concerning nutritional requirements. Studies of feeding habits of wild stocks can provide a reasonable approximation of nutritional requirements and usable diets can be prepared by application of this empirical knowledge. The feeding habits of cultured species should be considered and food provided in a form that will be readily ingested without loss of soluble components and readily assimilated.

It is also important for reasons of economics to utilize locally available food sources whenever possible even though these may not provide ideal diets.

3.3.4.6 Mortality, Morbidity, and Control

Most commercial aquaculturists consider disease control to be a major problem. Even though disease organisms have been identified, treatments are generally unavailable except for salmonid culture in freshwater. Aquatic pathology is a new science deserving much more attention if aquaculture is to succeed. The difficulty and long-term nature of this research and its broad application to various species indicates the necessity for government funding of research.

In addition to bacterial, fungal, and viral diseases, parasites, and predators, adverse physical or chemical conditions in culture systems can cause mortality or morbidity. These include inadequate dissolved oxygen, high levels of ammonia, nitrate or nitrite, high or low pH, or the presence of pesticides, heavy metals or other contaminants.

In addition, the behavorial requirements of cultured species must be known. Habitat, territoriality, cannibalism, migrations, spawning, feeding, antagonistic behavior, etc. may have adverse effects on growth, maturity, and survival.

3.3.5 Product Utilization - Research Status

In the United States the preservation and processing of fisheries products is well established. It is based on sound scientific research with stringent government controls to protect the consumer. Although much of the earlier research was conducted in government or university laboratories, many new applications have been the result of private research and development by private fisheries and food companies.

Public supported research is now largely directed at disclosing causes of deterioration during storage and developing improved procedures for maintaining high quality. In addition some laboratories are investigating waste reduction by machine separation of edible fish from flesh, use of fish as meat extenders and preparation of acceptable products from presently underutilized species. In general there is an abundant supply of research and technological skills in the United States and these are being applied to upgrade fisheries products for the benefit of consumers and development of a viable fisheries industry.

In the other developed countries of the world, preservation, processing, distribution and marketing of fishery products are similarly well established. In many countries aquatic products are more important as a source of food than in the United States. This has led to standard methods for preserving the catch and distributing it to consumers.

In many lesser developed countries, however, fish and shellfish are still landed, distributed and sold by the same primitive methods that have been in use for generations or centuries. Large portions of the catch are lost to insects and rodents and much of the product is badly deteriorated by the time it reaches the consumer.

Although sound preservation and processing methods are known, they frequently are not applied by artisanal fishermen and rural fish dealers. In most cases extension service activities are needed to encourage upgrading of traditional local practices to improve product quality.

In addition to the application of known methods however, there is a need for research, primarily adaptive in nature, to determine whether methods used elsewhere will apply to local species, tropical environments, and be accepted by local residents. Some efforts in this direction have begun but most need strengthening. These are summarized for the main fishing areas of the developing world as follows:

Eastern Central Atlantic Region - Extensive fisheries by several nations have developed off West Africa, but a large part of the landings are by small-scale fishermen. Much of the catch is smoked, the traditional method of preservation. Less than 10% of the catch is canned or frozen; the rest is sold fresh.

National facilities for applied research on processing are limited and with the exception of Morocco, Senegal, Nigeria and Ghana little or no work has been done in this field.

In the inland waters of Africa large lakes, rivers swamps and reservoirs are the major sources of fish and fishery products for the landlocked countries as well as for Tanzania and Kenya which have extensive marine coasts.

Applied research on processing freshwater fish is based in Tanzania and Uganda. In Zambia research has been directed to improvement of quality and wholesomeness of traditionally handled and processed products and the introduction of light salted, dried or smoked products, mainly to prevent the heavy losses caused by insect infestation (Da Costa, 1974: R-42).

Northwest Indian Ocean Region - The coasts of the Arabian Sea already contribute more than two-thirds of the total catch of the western Indian Ocean fishing area. Nevertheless, the per capita consumption in the bordering countries, except Yemen, Kuwait and Sri Lanka, is well below the world average.

Good facilities for fundamental and applied research in the field of fish utilization are located in India with some efforts currently underway in Yemen, Iran, Pakistan, and Sri Lanka.

Latin American Region - Although dominated by the anchoveta fishery and its use for fish meal, shrimp fisheries and more recently culture are important. Nevertheless per capita consumption is low and few research efforts to upgrade product utilization are present.

In the southwest Atlantic area much of the catch is taken by artisanal fishermen; over one-fifth from freshwater. Most of the catch is consumed domestically after processing as filleted, frozen, canned, salted or dried fish.

Facilities and trained personnel for undertaking systematically applied research in fish utilization are somewhatlimited in Latin America. Efforts are centered in Chile, Peru, and Venezuela.

Far East Region - In this region fisheries products play a vital role in the economy as an inexpensive source of protein. Per capita consumption is well above the world average.

Some product utilization research is carried out with the effort centered in Thailand, Australia, the Philippines, Malaysia and New Zealand.

In summary, with the growing importance of capture fisheries and aquaculture in providing for the expanding needs of the developing world research is needed to improve the utilization of fish and shellfish that are landed.

3.3.6 Product Utilization - Research Needs

This section identifies the major areas of food loss and under-utilization in which research is needed to help solve existing problems. It should be mentioned here that for no other class of food is there so much evidence of serious loss at every stage from harvest to consumption and so little available and precise knowledge of the proportion of losses to potential harvest or to what is actually consumed as there is for fish. It has been estimated that up to 40% of fish catch is lost due to spoilage in LDCs. Additional losses occur in by-catch discard, in under-utilization of presently undesirable fish, and in contamination by pests and insects. Since the entire fisheries industry in developing countries is so fragmented by local customs and is controlled by so many indifferent middlemen from harvest to consumer, a great deal of losses occur simply through handling and transfer.

3.3.6.1 Spoilage on Boat and Shore

It is estimated that 20% to 40% of the catch in LDCs is lost by spoilage caused by bacteria, fungi, enzymes, or by poor handling practices. Techniques for chilling fish aboard the vessel to retard spoilage are well known in the United States and in other developed countries. These techniques are, however, most commonly applied to relatively large craft. The procedures fall usually into three categories:

- Conventional icing where about one part of ice is intimately mixed with from two to four parts of fish. This may be done in containers holding from 100 to 1,000 pounds of the mixture or in walled-off sections of the vessel's hold.
- The use of mechanically refrigerated sea water where the fish are put into watertight tanks and the cooled sea (about -1 °C) circulated through the tank. Proportions are generally about one part sea water to three parts fish.
- A more recent method of chilling the fish with a mixture of ice and sea water. Proportions vary considerably but a ratio of one part ice to one part sea water to six parts fish is common.

In the LDCs, little or no chilling of the catch is done aboard the boats. Attempts have been made to help preserve the catch by flooding it with sea water or by covering it with damp cloths. However, the temperature of the sea water is often in excess of 28 °C and the relative humidity in excess of 60%; thus, neither technique will have much cooling effect. As a result, the growth of spoilage bacteria is well advanced by the time the fish are landed, even though they were caught only a few hours earlier. The lack of chilling undoubtedly accounts for a very large part of the 20% to 40% of catch lost by spoilage after harvesting.

Research has been conducted for many years in the United States and other developed countries on the causes of spoilage in fish and fishery products. This research has identified the types of bacteria that cause spoilage and defined the conditions that are both optimum for their growth and the conditions that

are optimum for inhibiting growth. Extensive research has also been conducted on the autolytic enzymes that are responsible for undesirable changes primarily in the proteins and fats in fish flesh. It has been found, for instance, that holding fish at -2° to -4°C, which is about optimum for inhibiting bacterial growth, will provide fat-splitting enzymes with optimum conditions for producing free-fatty-acids which in turn react with the fish flesh proteins to cause toughening of the flesh. In the LDCs, particularly in the tropics, most current research appears to place emphasis on bacteria which cause spoilage since enumeration may be used as a quality control device particularly in those products prepared for export.

The application of ionizing radiation to the control of bacterial growth in foodstuffs has been the subject of much research in the United States and in other developed countries. Commonly the radioactive isotope, Cobalt-60, is used to irradiate the products, but work has also been doen with electronic sources of high intensity radiation. Penetration is very limited, however, so this source is used primarily for sterilizing bandages, sutures, etc. Most research on the radiation of fishery products has been on pasteurizing doses where the product is exposed to doses of 100,000 to 400,000 rads, sufficient to kill over 90% of the bacteria. As a result, the shelf-life of the product (while refrigerated at 0° to 2°C) is doubled and with some fishery products even quadrupled. Sterilizing doses where all the bacteria are killed by the application of two to five million rads are not satisfactory with most fishery products as off-odors, flavors, and colors develop which make the product unacceptable to the prospective consumer. About the only products that are suitable are those which have been heavily smoked; the smoke odor, flavor, and color mask the undesirable ones produced by high level radiation.

At present in the United States, irradiation is not permitted with food products, except in a very few cases where levels of 20,000 rads or less are allowed to kill weevils and their eggs and larvae in wheat, or to prevent sprouting in potatoes. The

United States Food and Drug Administration has set up a requirement that the irradiation process cannot result in the development of cancer-producing compounds in the irradiated product.

Of the LDCs only India has experimented broadly in the application of ionizing radiation to the preservation of foods. During the week of March 12, 1978 a conference was held in Manila, Philippines, to discuss ionizing radiation as a means of greatly reducing the post harvest losses of fish in the LDCs. The proceedings of this conference will be published in the near future. These proceedings should serve as a valuable guideline for future collaborative research between the United States and the LDCs.

3.3.6.2 Loss Due to Insects and Pests

Destruction of food by insects and other pests such as rodents has been a global problem throughout history. In the developed countries, insect loss has been largely prevented through the use of insecticides, insect repellents, and screens. Rodents are kept under control by rodenticides and by constructing buildings of materials through which the pests cannot chew their way. In addition, very strict sanitation procedures are practiced to ensure that the premises both indoors and out are kept free of food wastes that will attract the pests and also free of materials which will provide refuge for them.

In LDCs there does not appear to be a full appreciation of the need to control insects and rodents even though these pests spread diseases as well as cause very large economic losses through the destruction of foodstuffs. In some areas, cursory attempts may be made to control insect infestation by use of simple screening, but these are reportedly not effective. More commonly, the fish catch is offered no protection at all. Some work is being done in the LDCs on the use of pyrethrum, which is non-toxic to warm blooded animals, to control insect attacks on fishery products. As this is primarily a surface application and some insects inject their eggs below the surface of the fish flesh, the technique is not 100% successful.

Packaging is used routinely in the United States to protect products from all sources of quality loss including insect infestation. Packaging materials may have inherent barriers to insect attack by virtue of their toughness or they may be treated to make them repugnant to the pests without at the same time causing contamination of the food. There does not appear to have been much work done in the LDCs on the use of packaging specifically as an insect barrier. Most packaging, if any is used, is designed to provide a unit container or make the product acceptable for the export market.

3.3.6.3 By-Catch, Under-Utilized Species and Improved Processing

With the exception of drying and smoking, most preservation techniques used in the temperate zones are not usable in LDCs. Recent research has indicated, however, the possibility of developing new products and preservation systems that could be used in the tropics.

In recent years, there has been a great deal of interest in the development of intermediate moisture products. These are products that are indefinitely stable at room temperature. No refrigeration, heat processing, or irradiation are necessary to prevent spoilage of the product. An intermediate moisture product is one in which moisture content has been reduced to about 35%. Conventional products such as salt cod at this moisture content are as hard as a board. In intermediate moisture products, soft texture may be maintained by the addition of higher alcohols (glycerine for instance) and possibly of edible fats or oils.

At present, the use of intermediate moisture products in the United States is primarily in pet foods and in moist pellet feeds for aquaculture. In addition, there seems to be an increased demand for intermediate moisture foods as ingredients in goods designed to receive further processing. This area of research is an active one in the United States with new developments being

reported frequently. Although the development of intermediate moisture products has not received nearly as much attention in the LDCs as it has received in the United States and other developed countries, it appears to have good potential for the preparation of shelf-stable food grade products without heat processing or refrigeration.

The acceptance of new products is recognized as a problem especially in LDCs. The best approach appears to be to gain acceptance by a small group that over a period of years may expand to the population as a whole. This process is slow, the results uncertain, and the economics questionable.

The ensilage of fish has been investigated much more in northwestern Europe than it has been investigated in the United States. In Europe, the technique has been developed to the point where the addition of a simple organic acid to comminuted fish will preserve the fish for longer periods of time. The preserved fish is mixed with other ingredients before being fed to farm animals. Several research institutes in the United States have been investigating enzymic digestion using either the enzymes normally found in tissues (autolytic digestion) or using these plus plant enzymes such as papain or ficin. The digested product is intended to be mixed with the usual feed ingredients for use with domestic animals.

Many of the LDCs have been using autolytic digestion for centuries in making products such as Nuoc Nam and there are minor efforts being made toward preparing and preserving the by-catch as a feedstuff for domestic animals through the techniques of ensilage or enzymic digestion. These techniques may also be applicable to preservation of other fisheries' products in the tropics.

The United States fish processing industry is, in general, highly mechanized and it is constantly trying to find new ways to make processing less and less labor-intensive. Methods and machines are available to make fish filleting, for instance,

a highly mechanized operation. Fish can be carried by conveyor or by flume from the vessel to automatic scaling machines and thence to very complex equipment which will remove the edible fillets from the skeleton with very little waste or damage to the end product. In other segments such as canning, automation is even more advanced. New machines and modifications of old machines are constantly being developed; advances appear to be most frequent in the mollusk and the crustacean processing industries. For instance, equipment for roller extraction of crabmeat from the shell has progressed through at least four generations in the last few years, and current models are being widely adopted in North America and in Europe.

The LDCs have an entirely different problem with the emphasis on labor-intensive methods. There is, however, a real need for simple machines that are easy to maintain and to repair. These machines would be used to eliminate production bottlenecks and thus to allow handling of increased landings which cannot be done at present without greatly increasing losses through spoilage while waiting for processing. Also, machines such as the mechanical deboners can be used to recover minced fish flesh from by-catch, under-utilized species, or filleting wastes.

3.3.6.4. New and Low Energy Generating Systems

Following the recent energy crisis, a great deal of research was started in the United States on developing new sources of energy to reduce our dependence on foreign oil. This research took generally two different directions; one was aimed at developing sources in the 1,000 megawatt range for very large-scale use, and the other aimed at sources in the 100 kilowatt range, primarily for domestic use. Sources under investigation are solar energy, wind energy, and energy from water such as harnessing the tides, or the tremendous potential which exists in the tropics

of utilizing the temperature difference which exists between the very cold (0 ° to 4° C) bottom waters and the very warm (35° to 40°C) surface waters, or the rapidly moving ocean currents such as the Gulf Stream.

To date, the energy research has been on developing theory and on designing experimental, usually small-scale units. This research has resulted in the construction of some buildings for which solar energy provides better than 50% of the energy required for heating in winter and cooling in summer, and also in the construction of some wind-driven devices for generating electricity.

In the LDCs, the research which is going on is at a much lower level, despite the need for energy. The lack of energy is very apparent in the fishing industry where there is insufficient power to manufacture ice or to operate simple processing equipment.

3.3.6.5 Marketing and Distribution

Infrastructure development and the free market system have resulted in an efficient moderately priced commodity for the consumer in the United States. Fish caught on the Eastern Seaboard can be processed, shipped, and ready for market on the West Coast in less than a day, and yet remain price-competitive with local species. This is a function both of technological advances and expanded product identification. The consumer in the modern market-oriented society is made aware of more variety and of substitutes, which have expanded his tastes and preferences. These substitute goods may be in the form of a new species of fish or in a processed variety of the same fish.

In the LDCs, marketing and distribution problems are major constraints in solving the food problems. Lack of infrastructure development impedes distribution, laborious market channels

prolong fish exposure. In the former case, poor distribution contracts potential market capabilities besides increasing rates of spoilage. In the latter case, intricate traditional marketing channels involving many middlemen not only increase the cost of the fish at each step, but these channels create a less desirable commodity as spoilage is allowed to set in.

3.4 Potential Collaborative Research Areas

The potential areas of collaborative research are subjects which are deemed suitable as the basis for developing collaborative research support programs. These are areas in which the LDCs both want and need research and which otherwise qualify as candidates for collaborative effort as defined by the BIFAD. It should be noted again that technical assistance, extension services, education, training and technology transfer do not generally constitute research. While they may play some small role in a CRSP, their application is more appropriately considered under other aspects of the core program of Title XII. The one exception to this would be research on one of these subjects; e.g., to improve training methods.

Country specific research is excluded from the collaborative research concept. Consequently, research efforts which would apply only to one, or even two countries, have been avoided. Instead, the programmatic areas specified are ones which are at least applicable to a region of the world. Primarily, the research envisioned is aimed at the derivation of new or improved methods and techniques which would alleviate identified LDC problems. The process is essentially to develop, test and evaluate.

3.4.1 Capture Fisheries

Within the broad area of capture fisheries, four subjects for collaborative research have been identified. Each of these programmatic areas is believed to be a suitable subject for a collaborative research support program. Not all of them are of the same level of importance (or priority) nor are they necessarily of similar magnitude. However, each is of sufficient scope and importance to warrant further consideration.

3.4.1.1 Resource Assessment

The ultimate objective of this research subject is to develop methods for assessing the condition of the fishery resources and the effects of fishing on it. This is a fundamental area of research which is a necessary prerequisite to the solution of nearly every other problem of capture fisheries. It is essential to know what stocks are present, in what quantity, what is being caught and whether or not the catch is commensurate with the stocks available. Effective methods for doing this in LDCs do not now exist or are not directly applicable. To restrict the scope to manageable proportions, it might be necessary to confine the effort to a few species which are common to the LDCs of major interest.

The research area which needs to be addressed consists of four related subsets or projects:

1. Stock Assessment Methods. This involves the development of the means for identifying stocks, determining quantities, and migratory habits, and may include natural mortality rates, growth rates, reproductive potential and other characteristics useful in analyzing and evaluating the potential of the fishery.

2. Catch and Effort Statistics. Methods for estimating the landings and fishing effort which can be applied to LDC conditions and artisinal fishermen have to be devised.

3. Determination of the Effects of Fishing on the Resource. This concerns the development of techniques for evaluating the impact of fishing efforts on the condition of the fishery.

4. Determination of Sustainable Yield Methods suitable to LDC application need to be developed which will provide a basis for management of the fishery.

3.4.1.2 Development of New or Expanded Fisheries

The objective of this area of research is to develop methods to increase the catch of small scale fishermen without substantially increasing the cost and effort. The research effort suggested would take several directions, each intended to address a different aspect of the problem of the harvest. Five potential project areas have been identified:

1. Assess the Potential for Under-utilized Species. This would involve an analysis of the catch in LDCs to determine species not now fully utilized and an investigation of the possibilities for further exploitation.

2. Investigation of Species Characteristics and Behavior to Provide a Basis for Increasing the Catch. This research effort could take three directions: one aimed at how to improve capture methods, another at ways to locate and the third at means for attracting and concentrating.

3. Improved Design of Fishing Boats and Gear for Small-scale Fisheries. Partly as an outgrowth of 2. above, this effort would be directed toward the actual development and test of experimental equipment specifically designed to alleviate the problems of LDC fishermen.

4. Develop Methods for Location and Detection of Fish Aggregations. Also in part an outgrowth of 2. above, this research would concern the development of relatively simple means of identifying fish concentrations.

5. Investigate Techniques for Increasing Fish Concentrations. The inverse of finding where fish are is attempting to lure them where they are wanted. This too is an effort, in large part, related to 2. above. It would involve the development, test and evaluation of methods.

3.4.1.3 Fisheries Administration and the Extended Economic Zone

The problems of fisheries administration in the coastal zone and the EEZ have many common elements. Consequently, one collaborative research program is suggested to deal with both. The ultimate objective of this program is to provide the LDCs with the methods and procedures necessary to cope with the management of their fishery resources. A very basic problem common to nearly all LDCs is the lack of data on which to base decisions. Therefore, this program depends to some degree on the results of Resource Assessment Programs. The programs suggested here consists of three elements:

1. Identify and Analyze Present LDC Fisheries Administration Structures. A survey of LDCs would be made in regions of the world of primary interest to ascertain the existing legal and organizational structures and their effectiveness. Information would be analyzed to determine shortcomings and identify the potential for improvement.

2. Develop Improved Organizations and Procedures for Fishery Management. This would include preparing and assessing alternative administrative structures in light of the cultural and economic conditions of the LDCs.

3. Develop Model Laws, Regulations and Procedures. To facilitate fisheries management both near-shore and within the extended economic zone a proper framework has to be created. This will involve the preparation of guidelines which are consistant with the problems peculiar to the LDCs in various regions of the world.

3.4.1.4 Environmental Analysis and Habitat Protection

The purpose of this program is to determine the effects of man-induced changes on fishery resources, provide a basis for restoring, maintaining and enhancing habitats important to fisheries species and to develop means for implementing such action. Taken in its entirety this would be an enormous under-

taking. Consequently, a more modest effort is envisioned by limiting the research to a one or a few of most serious threats to the LDCs. Two project areas are recommended:

1. Determine the Effects of Major Contaminants and Pollutants on Fishery Resources. This first step in the program would be directed toward identifying the major environmental threats in LDCs in the foreseeable future. It would also involve estimating the impact of these threats if no countermeasures were to be undertaken.

2. Develop Means for Environmental Protection. This research activity would be concerned with devising methods and procedures for minimizing or eliminating the major environmental threats.

3.4.2 Aquaculture

Within the major required research listed in Section are several aspects that are appropriate subjects for collaborative research programs of U. S. universities and foreign universities and institutions.

3.4.2.1 Determine Which Native Species are Amenable to Aquaculture and Develop Culture Systems

The objectives are to provide an alternative to the introduction of exotic species for aquaculture. If acceptable local species are found and culture systems developed, use of native species would reduce the environmental risk inherent in introduction of exotics. Furthermore this would increase the supply of native species which are currently used for food in LDCs. The results of this research would be most beneficial in Africa and Latin America. Four potential projects exist within this program area.

1. Investigate the life history of native finfish and develop systems for culture of selected species

This would require one study in Africa and one in Latin America for freshwater species, and studies in Southeast Asia and the South Pacific for culture of species for restocking depleted coastal populations. Another study might investigate culture of native bait species for tuna fishing.

2. Investigate the life history of native crustaceans and develop systems for culture of selected species

This would require studies in Africa and Southeast Asia for marine shrimp and in Latin America for freshwater prawn.

3. Investigate the life history of native mollusks and develop systems for culture of selected species

This would require a U. S. research team working with a local university and the local fisheries agency in two representative LDCs. In addition to life history studies activities will include collection of oyster, clam, mussel, scallop or abalone seed from natural reproduction, developing planting and harvesting techniques, establishing sanitation procedures to ensure product safety, and if necessary development of methods for artificial propagation to provide a seed supply. Also included would be research on natural toxins such as paralytic shellfish poisoning to determine seasonality and to establish monitoring and inspection programs to protect public health.

4. Evaluate experience with culture of exotic and native species and formulate recommendations for selection of culture species in LDCs

This would require analysis of success or failure of culture of exotic species compared to culture of native species and use of this information to formulate recommendations.

3.4.2.2 Determine Principles and Mechanisms of Pond Culture Systems

The objectives of this program are to determine the principles involved in efficient culture systems for carps, milkfish and tilapia that have been developed in Taiwan, India and Israel and by adaptive research to apply these to other areas and to additional species. In those LDCs where pond culture is currently practiced, production per unit of area might be increased by a factor as high as ten by applying techniques used elsewhere. Results of this research would find application first in Southeast Asia to upgrade existing culture systems and second in Africa and Latin America to develop efficient culture systems for native species. Three project areas exist.

1. Conduct studies of monoculture and polyculture systems to determine energetics or nutrient flow, inter-species relations, and the procedures needed to maintain acceptable environmental conditions at high stocking density

2. Design systems requiring minimum input of energy and protein including utilization of agricultural wastes and surplus industrial water and heat to increase efficiency.

3. Develop high density, controlled environment, culture systems for selected species possibly using cages or raceways heated with geothermal or solar sources and utilizing recirculated water.

This will require analysis of successful culture systems in Taiwan, India, Israel and perhaps the Philippines to determine principles and mechanisms involved. It would also include evaluation of existing high density control systems as well as the design, testing, and economic evaluation of new systems for use in certain environments such as low rainfall areas.

3.4.2.3 Develop Procedures to Ensure Availability of Seed for Aquaculture

The primary objective of this program is to provide a sound scientific basis for development of systems for producing seed for various species.

A secondary objective is to develop systems for rearing juveniles of certain species for release to enhance wild stocks. Adequate seed is recognized as one of the most important requirements for the development of subsistence and commercial aquaculture in LDCs. Three project areas have been identified.

1. Develop procedures for maturing and controlled spawning of brood stock of selected species in captivity

2. Develop systems for culture of larvae and juveniles of selected species to planting size

3. Develop procedures for collecting, holding and distributing seed (fry, spat, or post-larvae) from natural reproduction

This will include studies of milkfish and marine shrimp and marine finfish in Southeast Asia and of various freshwater fishes in Latin America and Africa.

3.4.2.4 Improve Aquaculture Species by Genetic Techniques

The objective of this program is the long-term upgrading of stocks for culture in captivity. This is recognized as a requirement for every species raised in aquaculture systems. There are three separate project areas.

1. Investigate genetic characteristics including heritability of species that can be reared throughout their life cycle in captivity

2. Improve stocks by selective breeding

3. Improve stocks by hybridization

This will require long-term research on a few species at genetics centers in Southeast Asia, Africa, and Latin America.

3.4.2.5 Determine Nutritional Requirements of Species Selected for Aquaculture and Develop Cost-Effective Diets

The objective of this program is to provide a basis for development of high-efficiency, low-cost rations needed to reduce the cost of production. This is recognized as an important problem for all species cultured in aquaculture systems. Three project areas have been identified.

1. Determine natural foods and use this information to develop interim diets

2. Investigate basic nutritional requirements

3. Develop and test diets based on basic nutritional requirements preferably using local food sources

This will require a project preferably at an aquaculture center in Southeast Asia to develop diets to upgrade the efficiency of existing pond culture systems and similar projects in Latin America and Africa to develop information concerning local aquaculture species.

3.4.2.6 Determine Causes of Mortality or Morbidity in Aquaculture Systems and Develop Control Methods

The objective of this program is to reduce the cost of production in aquaculture systems. This is a problem of varying intensity with different species. There are three major project areas.

1. Identify diseases, parasites, pests, and predators in aquaculture systems and develop treatments and prophylatic procedures

2. Investigate the effects of adverse physical or chemical conditions in culture systems including dissolved oxygen, ammonia, nitrate, pH, pesticides, heavy metals, etc.

This information will then be used to define environmental conditions which will control mortality and permit adequate growth of aquaculture species.

3. Investigate behavorial characteristics and their effects on growth, survival, and reproduction

These might include habitat, territoriality, cannibalism, migrations, spawning, feeding, agonistic behavior, etc. This could require a number of investigations of existing aquaculture ventures to determine the importance of mortality or morbidity factors for various species and to develop control methods or prophylactic procedures.

3.4.3 Product Utilization

Within the research requirements listed in Section 3.2 are appropriate subjects for collaborative research programs. These programs are listed with projects in this section.

3.4.3.1 Determine Causes and Rates of Spoilage of Fish and Shellfish from Tropical Waters

The objectives of this research are to find ways to inhibit bacterial growth and to control enzymatic action. There are two project areas.

1. Investigate the role of bacteria in spoilage under tropical conditions

2. Investigate the role of autolytic enzymes in spoilage under tropical conditions on boats and ashore

3.4.3.2 Develop Procedures to Control Spoilage of Fishery Products

The objectives are to develop various procedures for low-cost chilling techniques at sea to reduce immediate spoilage of harvest. There are three project areas.

1. Adapt conventional techniques of icing the catch in reusable containers to tropical conditions on boats and ashore

2. Develop and test simple mechanically refrigerated sea water systems for small vessel use under tropical conditions

3. Develop and test procedures for chilling the catch under tropical conditions using a mixture of ice and sea water

3.4.3.3 Reduce Loss of Catch Caused by Insects and Pests

The objectives are to develop chemical application to apply directly to food fish which will repel insects and yet be non-toxic to consumers; and develop low cost, efficient storage facilities which protect foodstuffs from pests. Three project areas have been identified.

1. Develop simple methods of constructing, erecting and maintaning insect and rodent proof structures for holding and marketing fishery products

2. Develop low cost packaging for dried, smoked or other products to prevent insect infestation in the tropics

3. Develop safe methods for control of insects in LDCs by use of repellants and insecticides non-toxic to consumers

3.4.3.4 Develop New Products and Improve Processing Techniques for use in LDCs

The objectives are to develop better utilization of present fish resources, decrease wastage and help stabilize food supply. Four project areas are identified:

1. Develop and test intermediate moisture food products for use in LDCs

2. Investigate simple ensilage and enzymic digestion systems for preservation of fishery products in LDCs

3. Improve processing techniques

Activities will include development of low-cost, low-maintenance machinery designed to enhance labor-intensive operations.

4. Application of irradiation to control bacterial spoilage

3.4.3.5 Evaluate New and More Efficient Systems for Preserving and Processing Fishery Products

The objectives are to evaluate solar, wind, and low-energy systems as to their application in LDCs.

3.4.3.6 Marketing and Distribution

The objectives are to determine constraints to marketing and distribution. The principal project would be designed to improve the handling, distribution and marketing systems to maintain high quality of fishery products until they reach the consumer. At present the lack of adequate distribution systems prevents expansion of the fishing industry. Cost-effective systems applicable to tropical conditions in LDCs need to be developed and tested.

3.5 A Five-Year Priority Program Plan

As with any planning effort, development of a program plan for collaborative research funding proceeds in a series of steps. First, development needs must be defined. In this context, we refer to needs as seen and expressed by people in the developing countries themselves. This is particularly important if we are to avoid imposing a set of "needs" seen from a developed country perspective. Second, those needs that involve or require research must be identified. These subjects are addressed in detail in preceding sections of this report. Regional or global problems that might best be addressed through collaborative research activities are then listed, relative priorities established, and time and cost estimates prepared. At this point, with budgetary and other constraints given, a plan can be prepared.

Sixteen potential collaborative research programs were identified during the course of this study. Each of these addresses an area of concern to the lesser developed countries, is regional or global in scope, and similarly meets other established criteria for inclusion within a collaborative research support program. Time required, costs, and relative priorities of these programs are discussed in the following sections.

3.5.1 Time and Cost Estimation

Since the research program areas themselves are necessarily broad, cost and time estimates are useful mainly as indications of the relative magnitude and complexity of the described programs. In developing these costs, the following basic assumptions have been made:

1. The most desirable geographic coverage of a project will be a global or regional one involving two to five countries if the nature of the research permits.

2. A multidisciplinary approach is anticipated, although not necessarily with all disciplines at the same time.

3. There will be close collaboration with country experts, country institutions, and other donor agencies.

4. Effective work by United States university people will require a balance of on-campus and overseas work. It is tentatively assumed that faculty will spend half-time on a project of which about half will be overseas. It is further assumed that graduate students will be using their overseas work as subjects for theses and will be on a half-time basis whether on campus or overseas.

5. Projects will require at least a year of planning, familiarization and organization.

6. Projects will have a minimum critical size in order to involve different disciplines as needed and to maintain continuous activity both on campus and overseas.

The minimum size, defined as a "research unit" with an annual budget of approximately $300,000, forms a convenient base for estimating appropriate levels of effort and related costs. The underlying assumption is that the minimum useful project will require a full-time Project Leader, or Principal Investigator, supported by two full-time equivalent research positions that might be staffed by from two to six faculty scientists. This "minimum" team would also include two full-time equivalent research assistant positions that might be similarly staffed by two to six graduate students. Estimates of operational costs for such a research unit include salaries at typical university, AID or FAO scales, non-professional assistants, university overhead, field allowances, travel, equipment, and supplies. Large capital expenditures, such as cost of vessels which must be estimated separately for each region, are not included in these cost projections. Also, it is expected that recipient countries will make some contributions toward local expenses.

With these assumptions and conditions in mind, estimates of annual costs and time were prepared for each potential project within each recommended program area. Costs were then summed within program areas to arrive at overall budget figures. These are presented in Table 10 as cost ranges, reflecting variations

in cost of operations in different LDCs that might be involved, equipment and travel requirements, and the normal uncertainty associated with any research effort.

3.5.2 Research Program Priorities

The most difficult task in developing a program plan for research in fisheries and aquaculture is to obtain concensus on global research priorities. Development needs and social objectives vary widely from country to country, and indeed within countries. This problem is further complicated in that relatively few of the developing countries have prepared a priority statement of development needs and policy that is accepted at the national level. Accordingly, country priorities may appear to vary as a function of the background of the particular spokesman of the moment. This seeming confusion is not confined to the fields of fisheries and aquaculture or to any particular development sector. In the lesser-developed countries of the world, almost every sector of economic activity is "less" developed, and each has its own priorities which it is reluctant to admit might be less important than another's.

Similar difficulties in obtaining consensus of research priorities exist in the developed countries as well. In 1975, the Kansas City Conference on Research to meet U.S. and World Food Needs identified and recommended expanded research on 134 "most important problem areas" in agriculture. The USDA Agricultural Research Policy Advisory Committee subsequently narrowed the list to 117, with a total funding recommendation of $215 million (USDA, 1976, R-593).

This analysis underlying the identification of the 16 research programs mentioned earlier and the limited funding which is likely to be available suggests that priorities must be established so that decisions can be made as to which proposals should go forward. Members of the RDA staff, advisory panel, and government advisors who participated in and assisted with this study were asked to rate these programs against 12 criteria in

order to obtain a concensus of expert views. These criteria were as follows:

1. Number of people in target groups benefiting from this research (high, medium, low)

2. Geographical area benefiting from this research (global, regional, country)

3. Sensitivity of research to geographical selection (sited anywhere, in only certain regions, in only certain countries)

4. Extent to which this research program matches the perceived needs of the LDCs (high, medium, low)

5. Time required to produce results (less than 5 years, 6-10 years, more than 10 years)

6. Cost of program (low, medium high)

7. Probability of successful completion of research objectives

8. Probability that results obtained will be applied

9. Research capability in LDCs and potential for expansion

10. Research capability in the United States

11. Institutional preparedness in LDCs

12. Institutional preparedness in the United States

Comparative ratings established through this process defined relative priorities among the program areas considered. These are presented in Table 9 , ranked in priority from one through nine. Each program is numbered to permit easier reference in subsequent charts and tables. These "program numbers" are for identification purposes only and do not imply relative importance.

Some reviewers have suggested that these programs might be better presented in three priority categories, as "urgent," "important," and "desirable." While we feel this idea has merit, the effort described here did establish clear differences in relative priority among programs which is reflected in the 1-9 rankings.

Collaborative Research Programs

Relative Priority	Capture Fisheries	Aquaculture	Product Utilization
1		1. Principles & Mechanisms of Pond Culture Systems	
2	2. Resource Assessment	3. Feed & Nutritional Requirements 4. Seed Availability	5. Causes & Rates of Spoilage of Catch in Tropical Waters
3	6. New or Expanded Fisheries		7. Loss of Catch due to Insects & Pests 8. Marketing & Distribution
4	9. Fisheries Administration and the Extended Economic Zone		
5			10. Control of Spoilage in Fishery Products
6	11. Environmental Analysis and Habitat Protection		
7		12. Culture Systems for Native Species 13. Morbidity & Mortality Causes & Controls	14. New Product & Processing Technique Development
8			15. Low-Energy Preservation & Processing Techniques
9		16. Genetic Improvement	

Table 9. Prioritized Collaborative Research Programs

One final point concerning program priorities should be made. Program 9, Fisheries Administration and the Extended Economic Zone, is an unusual one in several respects. Many of the organizations responsible for fisheries administration in the developing countries have recognized major problems of inefficiency in organization or operation within their own countries, and have requested assistance from FAO and other international organizations to correct these problems. This is a particularly critical area, considering that if any fisheries research program is to be truly useful its results must be applied, and this application must be made through Fisheries Administration. Secondly, the impact of the extended economic zone and the emerging Law of the Sea is rapidly growing in importance in most of the developing countries. Many LDCs regard this as an item of highest priority; others may come to the same conclusion in the near future. There is a general impression, however, that a collaborative research program in this area, while both appropriate and highly desirable, is somewhat more difficult to precisely define and structure at this time than some others, due primarily to a lack of detailed information concerning the scope and nature of the "researchable" aspects of this problem on a worldwide basis. This impression resulted in a Priority 4 determination for this program area.

In view of the potential impact and worldwide importance of such a program, and in consideration of the U.S. position of leadership in this field, it is strongly recommended that AID and the BIFAD undertake a definition study in this area to more clearly describe the scope of the research problem and structure alternative approaches to solutions. Had such information been available to the team responsible for this planning effort, this particular program might well have rated significantly higher in relative priority.

3.5.3 Program Funding

Availability of funds will be the principal constraint in any funding strategy. At the present time, no guidelines exist and no definitive statement can be made regarding the amount of funding support that will be made available for research programs in fisheries and aquaculture as outlined here. Alternative funding and levels of effort may be assumed, however, and program impact examined.

It is impossible of course to define precisely research program costs prior to deciding which institutions and countries will participate and where the research will be performed. Such decisions should be made following receipt and peer review of proposals from interested universities. Budgeting figures presented here represent the best available estimate of total program costs for the 16 priority programs identified.

Two separate estimates were made of costs and time required to address in a responsible fashion the 16 identified research programs. Table 10 presents funding requirements for what is considered to be an optimum level of effort. Funding at this level should produce directly usable results within the five-year time horizon, although as a general rule research activity in most program areas should be continued beyond this point. At least one program (No. 7) might be completed in its entirety.

Table 11 presents funding requirements for the minimum suggested level of effort in each program. Funding at this level should produce usable and useful results, but the principal objective of the separate research programs would probably not be realized in less than 10-15 years. Although funding at this level does not represent the most cost-effective approach, it does indicate a viable alternative. Funding at levels below those indicated here would in general be counterproductive.

To undertake all 16 identified research programs simultaneously at optimum levels would require a first-year budget of $15 to $20 million. In the absence of budgetary limitations, this would

Priority	Program No.	Year					Five-Year Totals ($)*	
		1	2	3	4	5	By Program	By Priority
1	1	$1.0-1.4	$1.8-2.4	$1.8-2.4	$1.5-2.0	$1.3-1.7	$ 7-10	$ 7-10
2	2	0.8-1.0	0.8-1.0	0.8-1.0	1.0-1.4	1.0-1.4	4- 6	15-21
	3	0.8-1.0	0.8-1.0	1.0-1.4	0.8-1.0	1.0-1.4	4- 6	
	4	0.8-1.0	0.8-1.0	1.0-1.4	0.8-1.0	0.8-1.0	4- 5	
	5	0.5-0.7	0.8-1.0	0.8-1.0	0.8-1.0	0.5-0.7	3- 4	
3	6	1.5-2.0	1.8-2.4	2.3-3.1	2.3-3.1	2.3-3.1	10-14	14-20
	7	0.8-1.0	0.8-1.0	0.8-1.0			2- 3	
	8	0.3-0.4	0.5-0.7	0.5-0.7	0.5-0.7	0.5-0.7	2- 3	
4	9	2.0-2.8	2.0-2.8	2.0-2.8	0.8-1.0	0.8-1.0	8-10	8-10
5	10	0.8-1.0	1.3-1.7	1.0-1.4	0.3-0.4		3- 5	3- 5
6	11	1.5-2.0	1.8-2.4	1.8-2.4	1.8-2.4	1.8-2.4	9-12	9-12
7	12	1.3-1.7	1.3-1.7	1.8-2.4	2.0-2.8	2.0-2.8	8-11	18-25
	13	0.8-1.0	1.0-1.4	1.0-1.4	1.3-1.7	1.3-1.7	5- 7	
	14	1.0-1.4	1.3-1.7	1.5-2.0	0.8-1.0	0.5-0.7	5- 7	
8	15	0.3-0.4	0.5-0.7	0.5-0.7	0.5-0.7	0.5-0.7	2- 3	2- 3
9	16	0.8-1.0	0.8-1.0	1.3-1.7	1.3-1.7	1.3-1.7	6- 7	6- 7

*In millions, rounded to nearest million in 5-year totals. Given a 25% contribution from non-federal sources by collaborating U.S. universities, actual Federal funding requirements will be correspondingly reduced from budget figures shown here.

Table 10 . Priority Collaborative Research Program Funding Requirements (Optimum Level)

Priority	Program No.	Year					Five-Year Totals ($)*	
		1	2	3	4	5	By Program	By Priority
1	1	0.5-0.7	0.8-1.0	1.5-2.0	1.8-2.4	1.8-2.4	6- 9	6- 9
2	2	0.3-0.4	0.5-0.7	0.5-0.7	0.8-1.0	1.0-1.4	3- 4	11-15
	3	0.3-0.4	0.3-0.4	0.5-0.7	0.8-1.0	1.0-1.4	3- 4	
	4	0.3-0.4	0.3-0.4	0.8-1.0	0.8-1.0	1.0-1.4	3- 4	
	5	0.3-0.4	0.5-0.7	0.5-0.7	0.5-0.7	0.5-0.7	2- 3	
3	6	0.5-0.7	0.5-0.7	0.8-1.0	1.3-1.7	2.0-2.8	5- [illegible]	9-13
	7	0.3-0.4	0.5-0.7	0.3-0.4	0.3-0.4	0.3-0.4	2- 3	
	8	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.5-0.7	2- 3	
4	9	0.5-0.7	0.5-0.7	0.5-0.7	1.0-1.4	1.5-2.0	4- 6	4- 6
5	10	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.5-0.7	2- 3	2- 3
6	11	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.5-0.7	2- 3	2- 3
7	12	0.5-0.7	0.5-0.7	0.8-1.0	1.0-1.4	1.5-2.0	4- 6	10-14
	13.	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.8-1.0	2- 3	
	14	0.3-0.4	0.5-0.7	0.5-0.7	0.8-1.0	1.5-2.0	4- 5	
8	15	0.3-0.4	0.3-0.4	0.3-0.4	0.5-0.7	0.5-0.7	2- 3	2- 3
9	16	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4	0.8-1.0	2- 3	2- 3

Table 11 . Priority Collaborative Research Program Funding Requirements (Minimum Level)

be the recommended approach as each of these programs addresses a priority need. Given a budget of $4 to $5 million in the first year, programs 1 through 5, identified as Priorities 1 and 2, could be initiated. Such a budget would seem to compare favorably with the first-year funding of $12.45 million recommended by the Congressional Office of Technology Assessment in 1977 for research in three high-priority agricultural program areas (photosynthesis, nitrogen fixation, and cell studies) (OTA, 1977, p. 20, R-589), and with the first-year funding of $3.2 million reportedly recommended by the University of Missouri - Columbia study for collaborative research on the single program area of grain sorghum/ pearl millet.

If the first-year budget is restricted to the $2 to $3 million level, two optional approaches to research funding are possible. One alternative would be to fund several programs at the minimum level. A budget of $2 to $3 million would permit initiation of research in all five program areas identified as Priority 1 and 2. It might be more appropriate, however, to fund programs 1, 2, and 5 (Pond Culture, Resource Assessment, and Spoilage) at optimum levels with these same dollars. This recommendation, detailed in Table 12 , would be based on the following considerations. First, these programs address areas of major concern and highest priority in the developing countries, and cover each of the three principal program areas. Second, while program number 1, Pond Culture, does not duplicate the work outlined for programs number 3 (Feed) and 4 (Seed), it does contain elements of them which would contribute to knowledge in those sectors. Third, funding these three programs (1, 2, and 5) at optimum levels should produce directly usable and significant results within a five-year period. Funding more programs at a less intensive level would delay the apparent impact of the collaborative research support program and of Title XII itself.

Presentation of funding requirements by priority ranking does not imply that all programs rated Priority 2, for example, must be funded before those rated Priority 3. Any one of these

Priority	Program No.	Year					Five-Year Totals ($)* By Program
		1	2	3	4	5	
1	1	$1.0-1.4	$1.8-2.4	$1.8-2.4	$1.5-2.0	$1.3-1.7	$ 7-10
2	2	0.8-1.0	0.8-1.0	0.8-1.0	1.0-1.4	1.0-1.4	4- 6
3	5	0.5-0.7	0.8-1.0	0.8-1.0	0.8-1.0	0.5-0.7	3- 4
Totals *		2-3	3-4	3-4	3-4	3-4	14-20

*In millions, rounded to nearest million

Table 12. Recommended Program Funding Plan Given a $2-3 Million First-Year Budget

programs might be selected over another as a function of constraints or conditions not considered in this analysis. Similarly, these programs could be funded at a lower level of effort as shown or on an individual basis. The minimum program level of effort is estimated at $300,000 to $400,000 per year. As a general rule, however, funding at this level does not represent the most efficient use of time or resources, and barring unforeseen breakthroughs, useful results should not be expected within the five-year horizon.

4.0 INVENTORY OF INSTITUTIONAL INTEREST AND RESEARCH CAPABILITY

The collaborative research concept of Title XII seeks to develop an arrangement between United States and foreign institutions in the developing world to assist in solution of food and nutritional problems through research. To this end, an inventory was required of institutional interest in and capability to undertake such research under the Title XII concept. The methods by which these inventories were made are discussed in detail in Section 5, The Mechanics of the Planning Process.

4.1 Inventory of United States Universities

This inventory includes those universities eligible for collaborative research support funding under Title XII, as determined by the BIFAD and AID. Based on information submitted to BIFAD, AID and Resources Development Associates, these institutions are grouped by category, reflecting expressed interest and ability to perform in a variety of roles. Specific criteria used to determine placement included:

1. expressed interest and desire to participate in collaborative research support programs under Title XII;
2. research capacity and ability;
3. full time equivalent (FTE) staff available and currently involved in fisheries, aquaculture, and related food technology research;
4. facilities;
5. linkages to institutions in developing countries.

It is difficult to state with conviction that any one university is better qualified than another in the absence of a final determination of what research shall be undertaken in what part of the world and with what budget. The field of fisheries and aquaculture is an extremely broad one, as reflected in the scope of research needs identified and programs recommended for funding support. Accordingly, it seems best at this point in time to group these universities by broad categories of ability

and experience rather than to attempt a rank ordering. Selection of lead and support institutions for specific tasks should properly follow determination of budgeting limitations and receipt and evaluation of research proposals.

With this in mind, three general categories have been established. Category A includes those institutions with extensive capability and experience in the principal research program areas recommended for funding, considerable depth in a variety of supporting technical and socioeconomics fields, broad management experience on programs involving several institutions, and specific research experience in and with the developing countries of the world. Category B includes those institutions with well established and recognized specialty areas particularly related to selected collaborative research support programs and appropriate international experience, but with somewhat less overall strength or broad program management ability. Category C includes institutions with ability to undertake a research project or projects within a collaborative research program, but lacking experience or strength in several key areas.

It should be noted that the effort was directed at an inventory of university capability and interest, as opposed to an assessment. Placement of institutions within categories was based primarily upon information submitted and capabilities as described by the institutions themselves, supplemented by personal contact and campus visits where necessary.

The following list shows the universities in their various categories. Refer to Section 5 for a presentation of the capability inventory.

Category A

University of California and California State University Systems

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Genetics, Disease Control, Production Systems, Food Technology, Socio-Economics, Extension

Fisheries: Food Technology, Extension

Faculty:[1] F-27 A-55

Overseas Experience: Southeast Asia, Africa, Central and South America, India, Pakistan

Cornell University - SUNY

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Production Systems, Food Technology, Socio-Economics, Extension

Fisheries: Limnology and Oceanography, Species and Stock, Fishery Resource Management, Food Technology, Socio-Economics, Extension

Faculty: F-16 A-8

Overseas Experience: Philippines, Ghana, Trinidad, India, Turkey, Kenya, Nigeria, Mexico, Indonesia, Brazil

University of Delaware

Aquaculture: Nutrition and Feed Technology, Production Systems, Food Technology

Fisheries: Limnology, Oceanography, Fishing Resource Management, Species and Stock, Food Technology, Socio-Economics, Extension

Faculty: F-23 A-9

Overseas Experience: Costa Rica, Caribbean, Indonesia, Puerto Rico

Michigan State University and University of Michigan

Aquaculture: Disease Control, Production Systems, Food Technology, Socio-Economics, Extension

Fisheries: Limnology, Species and Stocks, Fishery Resources Management, Food Technology, Socio-Economics, Extension

Faculty: F-27 A-28

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[1] Number of Full-time equivalents in F-Fisheries, A-Aquaculture

Overseas Experience: East and West Africa, Latin America, Yugoslavia, Iran, Russia, India, Indochina, Iraq, Bangladesh, Egypt, Caribbean

Oregon State University

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Genetics, Disease Control, Production Systems, Food Technology, Socio-Economics, Extension

Fisheries: Limnology and Oceanography, Species and Stocks, Fishery Resource Management, Food Technology, Socio-Economics, Extension

Faculty: F-29 A-12

Overseas Experience: India, Iran, Japan, Thailand, Brazil

University of Rhode Island

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Genetics, Disease Control, Reproduction Systems, Socio-Economics, Extension

Fisheries: Food Technology, Socio-Economics, Extension

Faculty: F-18¾ A-7¼

Overseas Experience: Latin America, Southeast Asia, Africa, Indonesia, Sri Lanka, Japan, Okinawa, Fiji

Texas A & M University

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Genetics, Disease Control, Production Systems, Food Technology, Socio-Economics, Extension

Fisheries: Limnology and Oceanography, Fishery Resource Management, Food Technology, Socio-Economics

Faculty: F-35 A-15

Overseas Experience: Bangladesh, Mexico, Dominican Republic, Colombia, Guatemala, Mali, Tanzania, Uruguay, Argentina

University of Washington

Aquaculture: Breeding and Seed Production, Genetics, Disease Control, Production Systems, Food Technology, Socio-Economics

Fisheries: Limnology and Oceanography, Species and Stocks, Fishery Resource Management, Food Technology, Socio-Economics, Extension

Faculty: F-50 A-12

Overseas Experience: Turkey, Guyana, Costa Rica, Thailand, Malaysia, Chile, Brazil, Azores

The University of California and California State University System, including U.C. Berkeley, U.C. Davis, U.C. Riverside, U.C. San Diego (Scripps), U.C. Santa Barbara, U.C. Santa Cruz, CSU Humboldt and CSU San Diego, have requested that they be considered a single unit for purposes of Title XII CRSP purposes, and information for the present inventory of ability and interest was submitted for the system as a unit. Similarly, Michigan State University and the University of Michigan have requested they be considered as a unit. The range and depth of capabilities resulting from these combinations is such that these units must be placed in Category A. This combination, however, would seem to defeat a primary purpose of this inventory, which was to identify individual institutions which might participate in Title XII research. Several universities within the California system, for example, might well qualify for Category A on individual merit. For purposes of consideration for research roles, however, it should be noted that combinations of these types begin to resemble consortia. The BIFAD, JRC, and AID should consider this point in recommending specific collaborative research lead and support institutions for contract award.

Category B

Category B represents universities with well-established specialty areas and capability to undertake research in one or more program areas.

Auburn University

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Genetics, Disease Control, Production Systems, Extension

Fisheries: Extension

Faculty: F-¾ A- 41¼

Colorado State University

Aquaculture: Disease Control, Breeding and Seed Production, Nutrition and Feed Technology, Genetics

Fisheries: Limnology, Fishery Resource Management, Species and Stocks, Extension

Faculty: F-16 A-O

Louisiana State University

Aquaculture: Nutrition and Feed Technology, Production Systems

Faculty: Not specified

Massachusetts Institute of Technology

Aquaculture: Food Technology, Socio-economics, Extension

Fisheries: Food Technology, Socio-economics, Extension

Faculty: F-13 A-not specified

North Carolina State University

Aquaculture: Breeding and Seed Production, Production Systems

Fisheries: Species and Stocks, Socio-Economics

Faculty: F-4½ A-1½

Oklahoma State University

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Genetics, Production Systems, Extension

Fisheries: Limnology, Species and Stock, Fishery Resource Management, Extension

Faculty: F-8 A-2

Purdue University

Aquaculture: Nutrition and Feed Technology, Genetics, Disease Control, Socio-Economics

Fisheries: Socio-Economics

Faculty: F-2 A-2

University of Hawaii

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Genetics, Disease Control, Production Systems, Food Technology, Socio-Economics, Extension

Faculty: F-14 A-14

University of Idaho

Aquaculture: Breeding and Seed Production, Nutrition and Feed Technology, Production Systems,

Fisheries: Limnology, Species and Stock, Fishery Resource Management, Socio-Economics, Extension

Faculty: F-7 A-7

University of Miami Rosenstiel School of Marine and Atmospheric Science

Breeding and Seed Production, Disease Control

Fisheries: Limnology and Oceanography, Species and Stock, Socio-Economics

Faculty: F-33 A-2

Category C

Category C represents universities having capacity to work on specific projects within CRSPs. Most have LDC experience.

Columbia University

Fisheries: Environmental Maintenance and Improvement, Processing, Marketing, Supply/Demand Analysis, Statistics, Government Policy, Pricing, Management, Cost/Benefit Analysis, Credit

Duke University Reproductive Physiology, Behavior, Environmental Factors, Toxicology, Culture Systems, Oceanography, Physiology, Behavior, Age and Growth, Maturity/Reproduction

Kansas State University

Aquaculture: Reproductive Physiology, Nutritional Requirements, Feed Formulation Processing, Feeding, Culture Systems

Mississippi State University

Aquaculture: Nutritional Requirements, Feed Formulation, Feeding, Hybridization, Selection, Handling, Processing, Preservation, Cost/Benefit Analysis, Credit, Marketing, Management

Fisheries: Food, Physiology, Marketing, Population, Management, Cost/Benefit Analysis, Credit

Murray State University

Aquaculture: Reproductive Physiology, Environmental Control, Behavior, Environmental Factors, Species Selection, Parasitology, Virology/Bacteriology, Culture Systems, Holding Facilities, Management, Extension

Fisheries: Limnology, Environmental Maintenance and Improvements, Physiology, Age and Growth, Maturity/Reproduction, Migration

Rutgers, the State University of New Jersey

Aquaculture: Nutritional Requirements, Feed Formulation Processing, Feeding, Virology/Bacteriology, Environmental Control, Product Development, Preservation, Processing

Fisheries: Oceanography, Food, Physiology, Behavior, Age and Growth, Maturity/Reproduction, Migration, Resource Assessment, Storage Processing, Co-operatives, Cultural Aspects

University of Alaska

Mariculture: Toxicology

Fisheries: Physiology, Behavior

University of Arkansas at Pine Bluff

Aquaculture: Environmental Factors, Species Selection, Site Selection, Holding Facilities, Harvesting, Methods/Equipment, Culture Systems, Feeding, Hybridization

University of Colorado

Aquaculture: Reproductive Physiology, Behavior, Environmental Factors, Nutritional Requirements, Site Selection, Holding Facilities, Culture Systems, Environmental Control, Species Selection, Feed Formulation Processing, Feeding, Feed Sources

Fisheries: Limnology

University of Connecticut - Storrs

Aquaculture: Parasitology, Virology/Bacteriology, Toxicology, Culture Systems, Environmental Control, Co-operatives, Statistics, Extension

Fisheries: Environmental Maintenance and Improvement, Regulation, Controlling Competitors, Gear and Methods, Transportation and Distribution, Marketing, Limnology and Oceanography, Co-operatives, Statistics, Extension

University of Florida

Aquaculture: Reproductive Physiology, Hybridization, Environmental Factors, Selection, Environmental Control, Product Development, Processing, Management, Supply/Demand Analysis, Cost/Benefit Analysis

Fisheries: Environment Maintenance and Improvement, Gear and Methods, Processing, Supply/Demand Analysis, Management, Age and Growth, Maturity/Reproduction, Migration, Resource Assessment, Regulation, Handling, Storage, Energy Conservation, Marketing, Co-operatives, Statistics, Extension, Pricing

University of Georgia

Aquaculture: Parasitology, Virology/Bacteriology, Toxiology, Extension

Fisheries: Storage, Management, Cultural Aspects

University of Maine

Aquaculture: Reproductive Physiology, Behavior, Environmental Factors, Selection, Parasitology/Virology, Management, Storage, Marketing, Cultural Aspects

Fisheries: Oceanography, Behavior, Maturity/Reproduction, Migration, Handling, Storage, Processing, Management, Gear and Methods

University of Massachusetts

Fisheries: Oceanography, Behavior, Resource Assessment, Environmental Maintenance and Improvement, Processing, Marketing, Co-operatives, Cultural Aspects, Management, Extension

University of New Hampshire

Aquaculture: Nutritional Requirements, Toxicology. Parasitology, Virology/Bacteriology,

Culture Systems, Preservation, Processing, Reproductive Physiology, Environmental Factors, Species Selection, Feed Formulation, Processing Feeding, Hybridizaiton, Predators and Pests, Handling

Fisheries: Limnology and Oceanography,Vessel Design, Handling, Energy Conservation, Reproduction, Migration, Migration, Resource Assessment, Stocking, Physiology, Behavior, Age and Growth, Environmental Maintenance and Improvement, Stocking

University of Southern Illinois - Carbondale

Aquaculture: Reproductive Physiology, Behavior, Nutritional Requirements, Site Selection, Holding Facilities, Culture Systems, Environmental Factors, Species Selection, Feed Formulation Processing, Feeding, Hybridizaiton, Toxicology, Predators and Pests, Handling

Fisheries: Stocking, Extension

University of Vermont

Fisheries: Migration, Resource Assessment

West Virginia University

Fisheries: Behavior

Other Interested Universities

During the course of the inventory, several other universities expressed interest in becoming involved in Title XII collaborative research programs although they do not at present have the research capability to warrant inclusion in any of the preceding categories. Because of the interest expressed, the desire to initiate and to develop programs in fisheries and/or aquaculture, and their eligibility status on the BIFAD roster, the following universities could be considered for the strengthening component of Title XII funds:

Florida A & M University
New Mexico State University

4.2 Other United States Institutions

Since the main idea behind collaborative research is to bring together the finest talent available to solve world food problems, provision has been made in Title XII for inclusion of organizations other than universities, although not for direct funding on CRSPs. These may include state and federal agencies, foundations, industrial and commerical firms, and associations. Examples of such "other" organizations with both interest in and capacity to participate within CRSPs include the following:

Virginia Institute of Marine Science

Aquaculture:	Reproductive Physiology, Behavior, Nutritional Requirements, Selection, Hybridization, Parasitology, Virology/Bacteriology, Toxicology, Culture Practices, Extension, Resource Assessment,
Fisheries:	Resource Assessment, Gear and Methods

Woods Hole Oceanographic Institute

Aquaculture:	Toxicology, Culture Systems
Fisheries:	Food, Physiology, Behavior, Environmental Maintenance and Improvement, Stocking

South Carolina Marine Resources Research Institute

Aquaculture:	Breeding and Seed Production, Nutrition and Feed Technology, Genetics, Production Systems, Food Technology
Fisheries:	Limnology and Oceanography, Species and Stock, Fisheries Resource Management, Food Technology, Socio-Economics

United States Fish and Wildlife Service, Major Laboratories:

National Reservoir Research Program, Fayetteville, Arkansas
Great Lakes Fishery Laboratory, Ann Arbor, Michigan
Southeast Cultural Laboratory, Marion, Alabama
National Fishery Research Center, Seattle, Washington
Fish Farming Experimental Station, Stuttgart, Arkansas
Fish Control Laboratories, La Crosse, Wisconsin

Tunison Laboratory of Fish Nutrition, Cortland, New York

National Fisheries Center, Leetown, West Virginia

National Fisheries Research and Development Center, Wellsboro, Pennsylvania

National Fisheries Research Laboratory, Gainesville, Florida

Eastern Fish Disease Laboratory, Kearneysville, West Virginia

National Fish and Wildlife Health Laboratory, Madison, Wisconsin

National Fish and Wildlife Laboratory, Washington, D.C.

National Marine Fisheries Services (Headquarters each with satellite laboratories)

The Northeast Fisheries Center, Woods Hole, Massachusetts

The Southeast Fisheries Center, Miami, Florida

The Southwest Fisheries Center, La Jolla, California

The Northwest and Alaska Fisheries Center, Seattle, Washington

United States Department of Agriculture

Other entities too numerous to list in this report include:

State Fish and Game Departments

Foundations

Industrial Firms

Associations

4.3 Inventory of LDC Institutions Active in Fisheries and/or Aquaculture

The following universitites, institutions, or government organizations are reported to be actively engaged in fisheries and /or aquaculture research activities. No attempt has been made to list all of the universities, institutions or organizations present in each of the countries considered; included here are only those that were visited or where sufficient data from the literature was available. Considering the overall increasing strengths and competencies of the universities and organizations in the developing countries many of the institutions in the following list might qualify for CRSP participation. Any United States university considering collaborative research in countries where these institutions are located would be well advised to investigate their capabilities for possible participation. Where such an institution has been specifically recommended for inclusion in CRSPs, more detailed information may be found in Section 4.4.

AFRICA

Country - EGYPT

* Ain - Shams University, Cairo
  Food Technology Department

  Scope of Interests: See Section 4.5

  Institute of Oceanography and Fisheries
  Inland Fishery and Aquaculture Section

  Scope of Interests: Fishery biology, oceanography, limnology, fishery statistics, and aquaculture.

* University of Cairo
  Food Technology Department
  Hydrobiological Institute - Ataqa

  Scope of Interests: See Section 4.5

  University of Alexandria
  Marine Biology and Oceanography Department

  Scope of Interests: See Section 4.5

Country - GHANA

* University of Ghana
  Department of Nutrition and Food Science

  Scope of Interests: See Section 4.4.

* Council for Scientific and Industrial Research (CSRI)
  Food Research Institute

  Scope of Interests: See Section 4.4.

* Institute for Aquatic Research

  Scope of Interests: See Section 4.4.

  Ministry of Agriculture
* Fisheries Department
  Fisheries Techniques Department
  Fish Stocks Department
  Oceanographic Department

  Scope of Interest: See Section 4.4

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* Visited by RDA staff, Research Advisory Panel, or USAID Fisheries Division Staff

AFRICA

Country - IVORY COAST

* Universite d' Abidjan
  Abidjan

  Scope of Interests: (See Section 4.4)

* Directorate de Peches de Mer et Lagunes (Department of Sea and Lagoon Fisheries)

  Scope of Interests: (See Section 4.4)

  Ministere de la Recherche Scientifique de Cote D'Ivoire
* Centre de Recherches Oceanographiques
  (Oceanographic Research Center)

  Scope of Interests: (See Section 4.4)

Country - KENYA

Ministry of Tourism and Wildlife
* Fisheries Department - Nairobi

  Scope of Interests: Fisheries management, administration and development; plans and implements research activities for biological and economic problems of the fishery industry, exploration for new fishery grounds, gear development. Marine fishery research is centered at the new coastal laboratory at Mombasa and six coastal stations. A new mariculture center is under construction near Mombasa - the only one in the East Africa - Indian Ocean area. The majority of the Departments staff is assigned to freshwater fishery programs and to stations on the main inland lakes. Research in fish culture techniques and in trout culture are being carried out at established stations. (See Section 4.5)

University College, Nairobi
Department of Zoology

  Scope of Interest: Fish distribution and parasite infections, reproductive physiology and behavior of tilzpia; ecology of coast and inshore areas including effects of pollution.

Country - NIGERIA

* Nigerian Institute of Oceanography and Marine Research (NIOMR)
  Lagos

  Scope of Interests: (See Section 4.4.)

* Federal Fisheries Department
  Lagos
* Kainji Research Institute
  Lake Chad Research Institute

  Scope of Interests: (See Section 4.4.)

  University of Lagos
  Lagos

  Scope of Interests: This university is initiating courses in fisheries and fisheries biology as a first step towards the eventual establishment of a Department or School of Fisheries which would be the first of its kind for Nigeria. (See Section 4.5)

  University of Ife
  Ilo-Ife

  Scope of Interests: This university has a small but highly qualified staff engaged in fish nutrition, reportedly one of the best in West Africa. (See Section 4.5)

Country - SENEGAL

Centre de Recherches Oceanographique de Dakar-Thiaroye
(Oceanographic Research Center of Dakar-Thiaroye)
Dakar

Scope of Interests: Population dynamics, physical oceanography, icthyoplankton, prawns, tuna, oyster culture.

Department of Water, Forests, and Hunting

Inland Fisheries
Oceanography & Marine Fisheries

Institute de Technology Alimentaire, Dakar
(Food Technology Institute)

Scope of Interests: Technology of fish utilization, fish quality control.

Country - SUDAN

* Ministry of Agriculture, Food and Natural Resources
Khartoum
Fisheries and Hydrobiological Research Section
Fisheries Administration Department
Animal Production Corporation

Scope of Interests: See Section (4.4)

* University of Khartoum
Department of Zoology
Hydrobiological Research Section
Institute of Oceanography

Scope of Interests: See Section (4.4)

University of Gezira (under construction)

Scope of Interests: See Section (4.4)

Juba University (under construction)

Scope of Interests: See Section (4.4).

Country - TANZANIA

University of Dar es Salaam
Department of Zoology
Marine Biological Station
Dar es Salaam

Scope of Interests: Aquaculture, benthic ecology and primary production.

East African Marine Fisheries Research Organization (EAMFRO)
Zanzibar

Scope of Interests: Applied research in fisheries and general oceanography of the Western Indian Ocean.

Fishery Division
Ministry of Agriculture
Experimental Fish Processing Station
Dar es Salaam

Scope of Interests: Methods of fish preservation and processing.

Fishery Training and Marine Institute
Dar es Salaam

Scope of Interests: Training of fishery offices, marine research related to fisheries.

Country - TUNISIA

* National Scientific and Technical Institute for Oceanography and Fisheries
(Institut National Scientifique et Technique d'Oceanographie et de Peche - INSTOP)
Salammbo, Tunisia

Scope of Interests: See Section (4.4)

ASIA

Country - BANGLADESH

Bangladesh Agricultural University
Department of Fisheries Biology & Limnology

Scope of Interest: Fresh, marine fish biology ecology etc.

Department of Aquaculture & Management
Department of Fisheries Technology

Scope of Interest: Culture fresh marine fish, shellfish management from ponds etc. Processing, preservation fish handling.

Directorate of Fisheries
Dacca

Fisheries Technological Station
Fresh water Fisheries Research Station
Fisheries Training Station
Chandpur/Comilla

Scope of Interest: Processing, preservation, handling and distribution of fish. Quality control fish oil technology, biochemical and nutritional studies, fish products and by products, fishing gear and crafts.

Country - INDIA

University of Agricultural Sciences of the State of Karnataka
* College of Fisheries - Mangalore

Scope of Interest: This institution offers a four year Bachelor in Fishery Science degree and a two year Master of Science degree in Fisheries. Facilities are excellent with 5 modern classrooms, 3 laboratories, auditorium, aquarium, library, 2 student hostels and aquaculture ponds on the main campus. The technology branch with excellent fish processing equipment and three small motor trawlers is located about five miles from the campus at the harbor. This installation is well organized, facilities are in order and the faculty is young and enthusiastic and would welcome opportunities to collaborate with U.S. universitites on research programs in fish nutrition, induced breeding, polyculture, pituitary research, fish biology, fisheries hydrography, limnology and fisheries processing, technology and product development. The technological research branch is recommended for participation in collaborative research programs. (See Section 4.4)

Country - INDIA

Andhra University
Department of Zoology
Field Marine Laboratory - Naltair

Scope of Interests: Training in marine sciences, hydrobiology, fish biology, ecology and general biological oceanography. Main interests are in systematics, population dynamics and biology of tropical fisheries and crustaceans both fresh and saltwater.

Annamalai University
Center of Advanced Study in Marine Biology
Marine Biological Station - Porto Novo

Scope of Interests: Laboratory rearing of fish and shellfish larvae, marine microbiology, taxonomy of marine bacteria, fungi, and actinomycetes. Principal interests: include estuarine hydrobiological studies of seasonal variations in biomass nutrients, productivity, and serological and cytological studies related to taxonomy of marine animals.

University of Kerala
Department of Marine Biology and Fisheries - Trivandrum

Scope of Interests: Marine biology, littoral ecology, malacology, marine fouling and corrosion, fisheries biology.

Madras State Department of Fisheries
Government of Tamil Nadu

Scope of Interests: Fresh water fisheries and marine biology.

National Institute of Oceanography (NIO)
Physical Oceanography Division - Goa
Geological Oceanography Division
Chemical Oceanography Division
Biological Oceanography Division
Data and Planning Division
Instrument Division

Scope of Interests: Ocean/atmosphere interactions, currents, sedimentology, pollution, pharmacology, ecology of estuaries, coastal aquaculture, data acquisition, processing retrieval and dissemination, marine instruments.

Country - INDIA

Maharastra Fisheries Development Corporation
Fisheries Technological Laboratory
Sasoon Dock, Bombay

Scope of Interests: Conducts applied research on shark liver oil, fishmeal, canned and trash fish utilization. Major fields of interest are in fish utilization technology and by products. There are chemical and biochemical laboratories and a pilot plant.

Department of Fisheries - Bombay
Taraporevala Aquarium and Marine Biological Research Station

Scope of Interests: This institution is affiliated with the University of Bombay and offers post-graduate study in Zoology and offers courses or short courses in fisheries, marine sciences, hydrobiology and related special programs.

University of Madras

Scope of Interests: Freshwater fisheries, marine biology ecology

Uttar Pradesh State Fisheries Resource Laboratory
Badshahbag, Lucknow
Uttar Pradesh State

Scope of Interests: Investigation on stocks and species of fish and shell fish, pond culture, hydrobiology.

Ministry of Agriculture and Irrigation
* Central Institute of Fisheries Education (See Section 4.4)
Bombay
Barrackpore
Hyderabad
Agra

Scope of Interests: Post graduate and undergraduate training courses in marine and inland fisheries, technology of fish processing, fishing gear and crafts, principles and methods of economics, and statistics.

Country - INDIA

In addition to the above, the following Institutes are concerned with research and surveys in the fields indicated. Unfortunately, sufficient details of staff, facilities, and scope of interests of these organizations was not available at the time for this report. From the limited information available however, those institutes marked with xx are recommended for consideration as possible candidates for collaborative research program support under Title XII.

xx Central Marine Fishery Research Institute (CMFRI)
Cochin

xx Central Institute of Fisheries Technology (CIFT)
Cochin

xx Central Inland Fisheries Research Institute (CIFRI)
Barrackpore

Pelagic Fishery Project (PFP)
Cochin

xx Integrated Fisheries Project (IFP)
Cochin

Exploratory Fisheries Project (EFP)
Bombay

National Institute of Oceanography (NIO)
Panoji

Zoological Survey of India (ZSI)
Calcutta

Country - INDONESIA

Ministry of Agriculture
* Director General of Fisheries

Scope of Interests: Staff and administration

Council of Research and Development
* Inland Fisheries Research Institute
* Marine Fisheries Research Institute
* Research Institute of Fisheries Technology

Scope of Interests: Research (See Section 4.4)

* Bogor Agricultural University (IBP)
* Faculty of Fisheries
  Division of Fish Handling and Processing
  Division of Aquaculture
  Division of Hydrology
  Division of Fisheries Management

Scope of Interests: Teaching, research (See Section 4.4)

Ministry of Research
* Institute of Oceanology

Scope of Interests: Oceanography (See Section 4.4)

Country - PAKISTAN

University of Karachi
Institute of Marine Biology.

Scope of Interests: The Institute of Marine Biology is an autonomous body academically linked with the University. Its object is to carry out goal-oriented research and teaching, coordinate research with other organizations in the country and to disseminate scientific information. Marine research includes: biological oceanography, zooplankton biology, phytoplankton productivity, seaweed biology, shore ecology, shellfish, shrimp and finfish biology, marine chemistry and biochemistry.

Pakistan Council of Scientific and Industrial Research
Karachi

Scope of Interests: Studies on spoilage and preservation of fish, aquaculture, adaptation of marine fish to fresh water conditions, fish processing and fish technology.

Country - PHILIPPINES

* Department of Natural Resources
  Bureau of Fisheries and Aquatic Resources
    Saltwater Fisheries Experimental Stations
  Fisheries Development Council
  Philippine Fish Market Authority, Intramuros - Luzon

  Scope of Interests: Fresh, brackish, marine fishery research, pond management, fishing and gear, culture of marine and freshwater fish, shellfish, fisheries management, development, and marketing. Various aspects of these activities are carried out by the three components of the Department of Natural Resources.

* University of Philippines System
  College of Fisheries - Diliman, Quezon City
    Inland Fisheries Department
    Marine Fisheries Department
    Fisheries Technology Department
  College of Arts and Sciences
    Marine Biological Station Oriental, Mindoro
  College of Sciences and Humanities, Los Baños
    Limnological Research Station, Laguna

  Scope of Interests: Basic and applied aspects of fish culture and inland fisheries, limnology, fisheries management, fishpond construction, fish biology, aquatic intervetebrates, aquatic flora; basic applied sciences of marine fisheries, exploratory research, fishing areas, oceanographic investigations, management of marine resources, biology of marine organisms, fish processing, preservation of fishery products, canning, drying, freezing, quality controls, chemical analysis of fishery products, limnological research, marine biology, and algae. Various aspects of these activities are carried out by the three colleges.

* Central Luzon State University
  College of Inland Fisheries, Muñoz, Nueva Ecija
    Freshwater Aquaculture Center

  Scope of Interests: (See Section 4.4)

Mindanao State University
School of Fisheries
Marawi City, Mindanao

Scope of Interests: Fisheries research

Bicol University
School of Fisheries, Legazpi City

Scope of Interests: Fisheries research

Country - SRI LANKA

* Department of Fisheries
Fisheries Research Station, Colombo

Scope of Interests: All aspects of biological and technical research relative to marine and inland fisheries including aquaculture, vessel and gear

University of Sri Lanka
Department of Zoology, Vidylalnkara Campus
Department of Biological Sciences, Vidyodaya Campus

Scope of Interests: Research on effects of pollution on fish behavior and distribution, coastal fisheries, hydrobiology of coastal lagoons, experimental culture of prawns

Ceylon Institute of Scientific and Industrial Research (CISIR)
Food Technology Section, Colombo
Industrial Microbiology Section, Colombo

Scope of Interests: Chemical analysis of fish samples, pollution studies, bacteriological quality of water

Ceylon Fisheries Corporation
Galle Face

Scope of Interests: Limited resource population and biological studies, fresh and marine

Country - THAILAND

Ministry of Agriculture and Cooperatives
* Department of Fisheries
    Freshwater Fisheries Division
*   National Inland Fisheries Division
*   Brackish Water Fishery Division
*   Marine Fisheries Division
    Fisheries Technological Development Division
    Exploratory Fishing Division

Scope of Interests: (See Section 4.4)

* Kasetsart University
    Faculty of Fisheries
        Department of Fisheries Biology
        Department of Fisheries
        Department of Fisheries Products
        Department of Marine Sciences

Scope of Interests: (See Section 4.4)

SOUTH AMERICA

Country - BOLIVIA

Estacion de Pescicultura de Pongo
(Pongo Fishculture Station)
La Paz

Scope of Interests: Culture of trout for planting in rivers and streams. This installation was built with assistance from USAID, but, when AID support was terminated operations were suspended. It is now back in operation supported by several local government agencies, a private fishing club "Arco Iris", and technical assistance from the Spanish Government.

Country - BRAZIL

* Federal University of Ceará,
Department of Fishery Engineering
Fortelza

Scope of Interests: See Section 4.7.

Ministerio do Interior
* Departmento Nacional de Obros Contra As Secas (DNOCS)
(National Department of Works Against the Drought)
Pentacoste, Ceará

Scope of Interests: See Section 4.7.

Universidade de São Paulo (USP)
São Paulo

Zoology Museum

Scope of Interests: The evolutionary biology of the following marine groups: molluscs, fishes, and crustacea. Large collections are maintained and loans are made to scientific institutions. The Museum publishes two journals: Papeis Avulsos de Zoologia, and Arquivos de Zoologia, which contain papers in these fields.

Institute of Marine Biology

Scope of Interests: General marine biology

Oceanographic Institute (Instituto Oceanografico)

Scope of Interests: See Section 4.7

SOUTH AMERICA

Country - COLOMBIA

Asociacion Colombiana de Piscicultura y Pesca
(Colombian Association of Fish Culture and Fisheries)
Bogota

Scope of Interests: Sport fishery research

* Centros de Investigacion Pesquera de Cartagena (CIP)
(INDERENA)
Cartagena

Scope of Interests: See Section 4.4

Institute of Tropical Pisiculture de la C.V. (ITP)
Bugo, Cauca

Scope of Interests: Culture and rearing of ornamental fish

University of Caldas
Faculty of Veterinary Sciences
Fisheries Research Center

Scope of Interests: Applied research in fish culture of warm water fishes extension services in aquaculture.

University of Cordoba
Cordoba

Scope of Interests: Investigation, development of inland tropical fish culture. Center for research & development of hative species.

Country - ECUADOR

Institutio Nacional de Pesca Del Ecuador
(National Institute of Fisheries)
Guyaquil

Scope of Interests: Scientific research on behalf of fishing industry.

Country - PERU

La Molina National Agricultural University
Fisheries and Oceanography Department
Lima

Scope of Interests: Fishing methods and technology, fish processing, marine technology, physical and biological oceanography. Marine resources, fish culture.

Instituto del Mar del Peru (IMARPE)
(Perivian Sea Institute
Lima

Scope of Interests: Research on biology of marine and inland water species, oceanography, technology, economics, and statistics.

Ministerio de Pesqueria
(Ministry of Fishing
Lima

Scope of Interests: Administration, planning and processing, scientific and technical research, public relations.

Universided Nacional Frederico Villareal
(Frederico Villareal National University)
Lima

Scope of Interests: Oceanology and fisheries

Universidad Nacional Mayor de San Marcos
(Main National University of San Marcos)

Scope of Interests: Research and culture of tropical fresh water fishes

Universidad Nacional San Luis Gonzaga
(San Luis Gonzaga National University)
Ica

Scope of Interests: Fisheries and biology

Country - VENEZUELA

Fundacion La Salle de Ciencias Naturales (FLSCN)
(La Salle Foundation of Natural Sciences)
Isel de Margarita Marine Station
Estacion Cuidad, Guiana

Scope of Interests: See Section 4.7.

SOUTH PACIFIC

FIJI

* Ministry of Agriculture, Fisheries and Forestry of Fiji
  Fisheries Division
  Suva

  Scope of Interests: Resource development, development of fisheries management policy market surveys, specialist surveys and operation and management of a tuna-fishing enterprise in the Fijis. Although primarily concerned with development the Fisheries Division could become involved in Title XII research in association with the University of the South Pacific if called upon to assist.

* University of the South Pacific
  Institute of Marine Resources
  Suva

  Scope of Interests: (See Section 4.5)

THE WEST INDIES

Country - JAMAICA

Ministry of Agriculture
Fisheries Division
Twitchenham Park, Fisheries Station
Kingston

Scope of Interests: Culture of Tilapia for stocking ponds

University of West Indies
Kingston

Scope of Interests: Research on reef biology, oysters, macrobrachium and tilapia

Discovery Bay Laboratory
Discovery Bay

Port Royal Marine Laboratory
Kingston

Scope of Interests: Culture of Tilapia for stocking ponds

Inland Fisheries Development Project
USAID sponsored
Kingston

Scope of Interests: Improve production, improve supply tilapia, train personnel

Country - TRINIDAD & TOBAGO

*Carribean Fisheries Training Institute/UNDP
Port of Spain
Trinidad

Scope of Interests: Seamanship, navigation etc., fishing gear and crafts.

Ministry of Agriculture, Lands and Fisheries
Fisheries Division
Port of Spain
Trinidad

Scope of Interests: Research exploration of deep sea and inshore fishing, lobster and oyster fisheries, oceanography, distribution and processing of fish.

4.4 LDC Institutions Qualified for Participation in CRSPs

The following universities, institutions, and government organizations in LDCs have adequate facilities, staff, and interest for participation in Collaborative Research Support Programs with United States universities. They are designated primarily on the basis of their experience and international reputation in the fields of aquaculture and/or fisheries research. All but two were visited by members of the RDA team and advisors. Institutions included but not visited were recommended by FAO or other international organization personnel familiar with their capabilities and qualifications.

AFRICA

IVORY COAST: Universite d'Abdijan (University of Abdijan)
Directorate de Pisciculture et Peches Continentales (Department of Fishculture and Inland Fisheries)

Centre de Recherches Oceanographiques (Oceanographic Research Center - CRO)

The major strengths of these organizations are in fish culture, fish nutrition, and fish diseases. Each organization has a highly qualified staff of experienced scientists and technicians and a first rate reputation in the world scientific community.

The University, with its strong interest and competency in fish genetics and fish nutrition, together with the Ministry's Department of Fishculture and Inland Fisheries, committed to a program of aquacultural development, and the marine aspects of the CRO's program combine to form a very strong base for collaborative research.

The Oceanic Research Centre (CRO) at Abdijan is supported by French funds. Founded in 1961, it is one of the better institutions in West Africa There is a staff of approximately 30 scientists, and among the facilities are a modern laboratory, an excellent library, and a 120 foot research vessel. The Center participates actively in international marine research cooperative programs and has a high reputation for quality work. Current research is directed to hydrology, oceanography, marine geology, development of the sea fisheries (primarily tuna) and the lagoon fishery for the artisinal fishermen. Both the University of Rhode Island and North Carolina State University are engaged in cooperative research programs in physical oceanography with CRO. Principal strengths and capabilities of CRO are in population dynamics (both sea and lagoon), pollution particularly as it affects the lagoon fishery, and in ocean dynamics.

The Ivory Coast is probably one of the most amenable of the West African Countries with which to form collaborative relationships. The government is stable; communications, both internal and external, are excellent; materials, transport, etc. are all available. However, the economy operates at a high, inflated level and costs are double to triple those in the United States. French is the common language and although many of the scientists know English, a working knowledge of French would be mandatory.

GHANA: University of Ghana, Department of Nutrition and Food Science

Council for Scientific and Industrial Research (CSIR), Food Research Institute

Institute for Aquatic Research

Both the University of Ghana and the Food Research Institute have excellent capacities to collaborate in research on fish processing and preservation.

The Institute for Aquatic Biology, which includes both fresh and marine fisheries, is becoming increasingly involved with aquaculture and has a capable staff which warrents collaborative research support despite a lack of modern research facilities.

The University of Ghana has excellent research facilities for all types and kinds of food preservation and processing methods as well as a superior food technology library. The Food Research Institute works closely with the University and has a highly motivated and qualified staff. Together these institutions represent one of the most promising organizations for collaborative research program support.

However, the general economic state of the country is such that even day-to-day operations are difficult. Problems include astronomical inflation, food shortages, power and water failures, as well as communication and transportation breakdowns. Because of these difficulties, it is questionable whether Ghana can be considered a suitable site for collaborative research at this time. This is extremely unfortunate as the scientific and institutional capacity is certainly there.

NIGERIA:

Nigerian Institute of Oceanography & Marine Research (NIOMR)
Federal Fisheries Department

In 1953 the Nigerian Federal Fishery Service was established under the Ministry of Economic Development, the latter organization was placed under the Federal Ministry of Agriculture and Natural Resources. In January 1970, the Federal Fishery Service was upgraded to a Department under the Federal Ministry of Agriculture and Rural Development. To cope with its new responsibilities a new Division of Development and Planning was established and the Research Division was enlarged to include a new Fish Processing Branch. In 1975 the Nigerian Institution for Oceanography and Marine Research was created from the Marine Biology Division of the Federal Department of Fisheries and the Development and Planning Division became the present Federal Department of Fisheries. NIOMR was given the following terms of reference:

"Conduct research into the resources and physical characteristics of the Nigerian territorial waters and the high seas beyond, and in particular:

The abundance, distribution and other biological characteristics of species of fishes and other marine forms of life and practical methods of their rational exploration and utilization.

The improvement of brackish water fishing and fish culture.

The socio-economic problems of exploiting the resources of the sea and brackish waters.

The effects of pollution on Nigerian coastal waters and its prevention.

The nature of the marine environment including weather forecasting and the topography of the sea bed and the deposits under the sea bed, and

Other related matters."

The Institute also trains marine fisheries and aquaculture personnel for public and private sectors, and conducts aquaculture research throughout the country.

The Institute is composed of three main sections: 1) The Headquarters and research facilities at Lagos, 2) the Buguma Research Station, Pt. Harcourt, for brackish water culture, and 3) the Marine Fisheries School at Lagos.

In line with its policy of expanding and developing fisheries research the Nigerian Government approved the construction of a new, expanded installation now almost complete which occupies over 13 acres on Victoria Island, Lagos and includes the following: the main NIOMR building which is part single and part double story with an overall floor area of @ 1280m^2, containing accomodations for approximately 40 scientists each with a separate laboratory, offices for the Director, Assistant Director and Administration, Conference and Documentation Room, and a library with adjoining stack room. Adjacent to the main building are three separate two-story school blocks, two hostel blocks with accomodations for 112 students, one refectory block, a block of three 3-bedroom junior staff quarters, a 3-bedroom guest house for visiting scientists, several additional apartments and blocks of flats for senior and junior staff, and buildings for maintenance and automobile repair. There is also a large Food Processing and Technology building complete with freezing unit, cold stores, experimental canning and processing equipment, a small testing laboratory, etc.

FAO has approached the government of Nigeria on possible use of the Fish Processing and Preservation plant as a training and research center for Africa.

There is a loading dock and pier, a 21.3m fishing boat, a 15m training vessel and several small speed boats for lagoon and estuary work. A 100-120 ft. offshore research vessel has been ordered and delivery is expected by late 1978. There is a 2.8 hectare fish/oyster farm at Ikoi, Lagos. Current research on fisheries related projects is as follows: monitoring marine fisheries resources, culture of fish (sea-catfish, croakers), and fresh and salt-water shrimps, improving fishing gear and research on utilization. When completed, the installation will have a total staff of approximately 300 of which about 80 will be professional fisheries scientists.

Greatest strengths at the moment of NIOMR are in the biology of local species of fish, particularly the sea fishes and those fresh water species of Lake Kaingi and Lake Chad.

When completed (August 1978), NIOMR's new nine million dollar facilities will be without doubt the most modern and best equipped in Africa, and probably one of the most outstanding in the world. The institute has a highly qualified and motivated staff and is our first recommendation for collaborative research programs in Africa.

The Federal Fisheries Department is directed to training and development rather than research. Principal effort is concerned with the following areas:

1) enhanced production and improved utilization of fishery products,
2) resources survey, fish and shrimp stocks,
3) fishing craft and gear development,
4) marketing and distribution,
5) aquaculture.

All inland (fresh water) research comes under its jurisdiction through the Kainji Lake Research Institute (KLRI). Both the Federal Fisheries and the Kainji Lake Research Institute have well qualified staff at the technical level, but they lack strength in some of the higher, professional cadres.

Fisheries development has received a major priority by the Government of Nigeria and financial support is considerable. The current Third National Development Plan 1978-1980, includes a comprehensive fisheries development plan integrating a series of complementary state and federal projects worth about $160 million out of which the federal component is over $80 million. Of this amount four million dollars has been allotted for the Kainji Lake Research Institute for 1978. Although the present government attitude is not conducive to aquaculture development because of unproven past results, the KLRI is determined to reverse this attitude. The government has indicated renewed interest in supporting coordinated and planned projects.

Both the NIOMR and the Federal Fisheries indicated great interest in actively participating in collaborative research programs with United States universities at the earliest possible opportunity.

Nigeria appears to have the greatest potential of any of the African countries for collaborative research in fisheries. It has the largest number of well-trained scientists, excellent facilities, strong government financial support, and a highly dynamic, motivated senior staff. The principal problems and restraints to development of fisheries and aquaculture (which also affect most other LDCs in Africa) are all present here. Breakthroughs made here could be highly significant to West African LDCs. The country is politically stable and gives every indication of remaining so. Based on past experience, however, Nigeria is a

very difficult country in which to operate. Any United States university planning to engage in collaborative research in Nigeria should be aware of problems that can result from unreliable communications and transportation, frequent breakdowns in electrical power, lack of supplies, chronic water shortages, and a monolithic bureaucracy.

SUDAN:

Ministry of Agriculture, Food, and Natural Resources
- Fisheries Administration Department
- Animal Production Corporation
- Fisheries and Hydrobiological Research Section
  - White Nile Fisheries Research Unit - Korti
  - Lake Nubia Research Unit - Wadi Halfa
  - Blue Nile Research Unit - Khartoum
  - Marine Fisheries Research Station - Port Sudan

University of Khartoum
- Department of Zoology
- Hydrobiological Research Section
- Institute of Oceanography

University of Gezira

Juba University

The Fisheries Administration Department collects partial statistics from fish marketed through central markets and is responsible for extension, marketing and law enforcement. It also operates fishing businesses as a source of income.

The Fisheries and Hydrobiological Research Section is conducting research on the limnology of the White Nile above Khartoum, a study of population dynamics of fishes in Lake Nubia, studies of oyster mortalities on the Red Sea Coast, freshwater aquaculture, use of grass carp to control vegetation in irrigation canals and other aquaculture pilot tests. The FHRS has been involved in various surveys of fishery populations, chemical, plankton and ecological surveys along both the Niles.

The Agriculture Research Corporation (of which FHRS is a part) has a fine facility for agricultural research at Wad Medani. A part of their activities are focused on control of water weeds and the use of fish as indicators of pesticide residues. Research on the use of biological controls of water weeds is also underway and present experimentation involves using a competitor, the spike rush.

The Animal Production Corporation manages a fishery on Lake Nubia.

The Hydrobiological Research Section of the University of Khartoum is deeply involved with the evaluation of the ecological effects of the Jonglei Canal. This 200-mile canal is being built in Southern Sudan to bypass a swampy area where the White Nile loses 14 million m^3 of water per day.

The Zoology Department of the University of Khartoum offers courses in aquaculture, mariculture, capture fisheries, food processing, gear technology and associated fishery subjects. They operate a Marine Fisheries Station south of Port Sudan and have 7 honors fisheries students at present. Four staff members, one lecturer and one teaching assistant have fisheries training.

The Institute of Oceanography Laboratory on the Red Sea is involved with descriptive studies of local marine flora and fauna, surveys of reefs and conservation of the reefs.

The new University of Gezira at Wad Medani will have sections addressing applied animal and plant production problems not presently being studied at the University of Khartoum. Plans include research or population dynamics of fish, uses of irrigation canals for fish farming, and the related development of technology for weed control and fish culture. Sixty professionals are being trained in the U.S. and Great Britain to provide the core staff for the new University.

Another new university, Juba University is being developed at Juba in the extreme southern portion of Sudan, in conjunction with the University of Khartoum. Emphasis here will be placed on natural resources and a degree will be offered in fisheries.

The Fisheries and Hydrobiological Research units comprises relatively small but functional groups with well trained and capable staff. The University places special emphasis on pure and applied hydrobiology as it applies to the River Nile and its tributaries; and the FHRI is concerned with inland, riverine and lacustrine fisheries, fish culture in ponds, reservoirs and irrigation canals and Marine fisheries resources research. Together with the University of Khartoum the combined staff, facilities, etc. would provide a fully complete and complementory unit that could offer considerable support to a collaborative research program.

TUNISIA:

Institute Nation Scientifique et Technique d' Oceanographic et de Peche. (National Scientific and Technical Institute for Oceanography and Fisheries), Salammbo.

This institution has a long-standing international reputation for excellence in fisheries research in the following fields: icthyology (there is good collection of Mediterranean fishes); zoobenthic plankton, eggs and larvael studies; algalogy, population dynamics and fisheries statistics; physical and chemical oceanography; and aquaculture (oyster culture in the principal lagoons). There are three research vessels, 23 meters, 12 meters and six meters in length, a very extensive library, running sea and fresh water, large outdoor ponds and tanks, small aquarium tanks, research collections of mollusks, echinoderms and pisces, machine and wood shops, electrical and electronic shops. The principle scope of activities is directed to general marine biology, general oceanography and exploratory fisheries research.

Because of its reputation, excellent library and facilities and strategic location, this institution is recommended as a possible participant in Title XII collaborative research programs in the fields indicated.

INDIA: Central Inland Fisheries Research Institute

Freshwater Fish Culture Research and Training Institution - Dhauli

Central Food Technological Research Institute - Mangalore

Central Marine Fisheries Research Institute - Cochin, Kerala

The Freshwater Fish Culture Research and Training Institution has been selected by FAO's world-wide Aquaculture Development and Coordination Programme as one of the three proposed centers in Asia for research and training in aquaculture. (The other two are SEAFDEC Iloilo, Philippines; and, the National Fisheries Institution, Thailand.) The Dhauli institution, which has been in operation for a number of years, has a highly trained professional staff and the facilities for participation in a Title XII Collaborative Research Support Program in freshwater fish culture.

The Central Food Technological Research Institute is well staffed both professionally and technically and has a completely equipped fish technology and experimental station at Mangalore. There are separate disciplines for meat, fish and poultry, and a pilot plant for semi-commercial-scale experimental work. This installation appears to be well qualified to participate in collaborative research in fish technology.

Central Marine Fisheries Research Institute conducts research on demersal fisheries resources, marine aquaculture and fisheries biology and population dynamics of selected species. This institution has been recommended as a possible participant in collabarative research programs, It has a well qualified staff and good supporting facilities.

INDONESIA:

Bogor Agricultural University (IPB)
- Faculty of Fisheries
- Bogor

Ministry of Agriculture
- Council for Agricultural Research and Development
- Djkarta
  - Research Institute for Inland Fisheries - Bogor
  - Research Institute of Fisheries Technology - Djkarta
  - Research Institute of Marine Fisheries - Djkarta

Ministry of Research
- Institute of Oceanology
- Ancol

Bogor Agricultural Institute, (IPB), Faculty of Fisheries several years ago, changed its academic program from a 6 year curriculum to a four year bachelor degree, and a two year master degree and last year added a graduate (PhD) program. All of the faculty have advanced degrees from overseas and appear well qualified. For the first two years all students take the general program after which they continue in the following Divisions: Fish Handling and Processing, Aquaculture, Research Development, Hydrobiology, Marine and Brackish water culture, and Fisheries Management. Classrooms and auditorium are adequate laboratories and work offices are badly overcrowded. New aquarium tanks (concrete) were recently installed. Outdoor ponds are yet to be built. Funds are always scarce. Equipment is somewhat scanty and obsolescent. The library is quite good, with plenty of room. The main university library, which is said to be excellent, is available to students and staff. The big city library is also useful. The over-all impression of IPB is highly favorable.

The Research Institute for Inland Fisheries is headquarters for inland and brackish water research and fish culture. The building is in excellent condition after 20 or more years of use, having been recently re-conditioned. The several laboratories are adequate,

also the fish food experimental and processing areas. Equipment is minimal. The auditorium for seminars, etc. is more than adequate. There are only a couple of outdoor ponds, as almost all research and experimental work is done at four branch institutes and three experimental stations, two of which are close by. Pesticide, pollution, parasite and disease work is done partly at Bogor. Work is divided generally into upland waters and lowland, which also includes coastal estuaries and lagoons. Their staff numbers approximately 36, some have graduate degrees from overseas universities. The library is small but adequate. It will soon move to larger quarters. It is on several exchange lists. The very large public library of Bogor is available to the staff. Fields of research include fish breeding and selection, pests, parasites and ecology, fisheries management, productivity and fish feed, and socio-economics.

Research Institute of Fisheries Technology

This Institute is responsible for conducting scientific research on fishery products processing in a broad sense with emphasis on applied research. The Institute also provides education and training for government fishery officials and private fish processors; assists the Directorate General of Fisheries to execute fish inspection and quality control programs; provides assistance and facilities to students for research; and assistance and facilities to students for research; and assistance and technical guidance to private enterprise. There are five Divisions, namely: Administrative, Traditional Processing, Modern Processing, Development and Quality Control and Research Facilities, further supported by four service sections; i.e.; chemical and microbiological laboratories, a workshop and a pilot plant with facilities for experimental processing, freezing, canning etc. Research programs are directed to: reducing production and waste losses; improving quality of traditional and processed products; utilization of shrimp trawl by-catch; finding substitute products to reduce imports; and, research on marketing and distribution. Staff and equipment are excellent and this institution is highly qualified and strongly recommended for participation

in Title XII collaborative research programs.

The Research Institute for Marine Fisheries, or (LPPL) is located near the old Djkarta fish market, now the lumber dock. The building is old and much the worse for wear, but is being repaired and renovated. Laboratories and offices are barely adequate, but most of the scientists are usually at one of the branch stations or off on foreign fellowships. There are over 30 biologists, all with degrees, some with overseas advanced degrees. The library is minimal, rather small and crowded but with a fair number and variety of publications. Most of the research is done at the two principal branch stations and several satelite stations. Lines of research include demersal fisheries, pelagic fisheries, reef fishes, skipjack, and mariculture.

The main laboratory is at Semarang, where the three research vessels are based. The other principal laboratory is the brand-new Mariculture Station at Ancol, 6 km. from the headquarters institute. Experiments are underway on fishes, shellfish and edible seaweed at 2 or 3 small branch stations, one of which is in outer Djkarta Bay.

The Ancol station is close to the city-operated Oceanarium, which supplies its closed circuit water system with sea water. The Oceanarium has just completed an auditorium next door to the mariculture station. It and its future library will be available to the station's staff. Across the court is the new building of the National Institute of Oceanology, operated by the Ministry of Research. Eventually, LPPL will be housed in a new building in this ocean science complex.

Country - PHILIPPINES

Central Luzon State University
College of Inland Fisheries, Muñoz, Nueva Ecija
Freshwater Aquaculture Center

The Freshwater Aquaculture Center has had a close working relationship with Auburn University since 1971 in fisheries education and training. Facilities include a pilot fish hatchery, research and wet laboratory complex, 60 small, 13 large research ponds. Current research and scope of interest is in agro-fishery systems (rice-fish culture; animal-fish culture) fish and invertebrate culture(poly-culture) propagation, nutrition and feed development, management of fish ponds, seed production, pond engineering, pollution, training and extension, processing and preservation, fisheries management, fish disease and hatchery management. The staff is aware of the Title XII Collaborative Research Support Program and would welcome the opportunity to participate. The Center is presently cooperating with ICLARM on fisheries programs in the central rice-growing plain. The institution has a good location, trained staff, adequate facilities and experience working with United States universities and other international organizations. It is recommended for consideration to participate in collaborative research programs in freshwater fisheries aquaculture in this area.

THAILAND:

Institutions

Ministry of Agriculture and Cooperatives:
Department of Fisheries,
National Inland Fisheries Institute (NIFI)

Kasetsart University, Faculty of Fisheries

The National Inland Fisheries Institute is the principal agency in Thailand for conducting inland fisheries research, developing management practices and technology, centralizing information, and undertaking small scale development projects including aquaculture. Emphasis is placed on applied rather than on academic biology.

The NIFI facilities include new, modern wet and dry laboratories, fully equipped for pollution and fish disease studies, extensive aquarium facilities and fish rearing ponds, and a new library, dedicated to becoming one of the most comprehensive fisheries libraries in the region. There are ten organizational units at the Institute; they include Fish Biology, Ecology, Fish Population, Fisheries Management, Water Pollution, Aquaculture Technique, Fish Diseases and Parasites, Fish Nutrition, Taxonomy, and Extension.

With a well trained, enthusiastic staff and with excellent facilities, together with its close working relationship with the University of Kasetsart, and the other Departments in the Division, NIFI is strongly recommended for prominent consideration in any collaborative research program in Southeast Asia.

In addition to the National Inland Fisheries Institute, which operates within the jurisdiction of the Division of Freshwater Fisheries that in turn reports to the Director General of the Department of Fisheries, there are the following Divisions:

Brackish Water Fisheries Division,

Marine Fisheries Division,

Fisheries Technological Development Division, and an

Exploratory Fishing Division.

The Brackish Water Fisheries Division is concerned with coastal lagoons, estuaries, mangrove swamps and is involved in water pollution, biology, and shrimp culture and operates eight field stations along both coasts.

The Marine Fisheries Division operates the Marine Fisheries Laboratory with programs in the following: pelagic fisheries, demersal fisheries, invertebrate fisheries, fishing vessel development, 12 research vessels; it operates the Phuket Biological Center and, two field stations.

The Fisheries Technological and Development Division carries out research in quality control, processing, quality analysis and research and processing engineering.

The Exploratory Fishing Division operates two research vessels which carry out exploration of fish resources and research in oceanography.

Nearly all Thai fisheries biologists have advanced degrees from abroad and are doing research in all fields. Extension workers introduce the results of the fisheries researchers to the people who are most receptive, (simple peasants are inducing spawning by hormone injection). Thai fisheries scientists are among the most competent and experienced in Southeast Asia and could contribute considerably to any Title XII collaborative research program in this area, especially those involving problems of tropical fish culture and marine fisheries.

The Katsetsart University works closely with the Government of Thailand's Department of Fisheries and it has strong ties with American and Canadian universities.

Major support strengths of the Faculty of Fisheries are in the Department of Fisheries Biology, which has a large, well qualified staff and good laboratory and auxiliary facilities. Following is a list of the Departments including the scope of interest and the area of research for each:

a. Department of Fisheries Biology

General fishery surveys, physical, chemical, biological aspects. Taxonomy, biology of fish and shellfish of economic importance, limnology, ecology, embryology, and fish diseases.

b. Department of Fisheries Management.

Aquatic resources, fishery management, fishing gear and their application.

c. Department of Fisheries Products

Processing, preservation, handling, distribution, and utilization of fishery products; techniques and development of new methods of preservation and processing shellfish and fish.

d. Department of Marine Science

Marine biological science and sea fisheries, physical and chemical properties of sea water effecting distribution and productivity of marine animals.

The Faculty of Fisheries of Kasetsart University is highly recommended as a participant in any Title XII collaborative research programs in this area.

COLOMBIA:

Instituto de Desarrollo de los Recursos Naturales Renovables (INDERENA)
(Institute for the Development of Natural Renewable Resources).

* Centro de Investigacion de Pesqueras de Cartagena (CIP)
(Cartagena Center for Fisheries Investigation)
Cartagena

This Center is one of eight institutions operated by INDERENA. Four of these installations are centers for freshwater trout culture; the others are: the principal center for experimental culture of natives species at Repelón, a center for culture of mullets at Bolivar, one for culture of "sabaleta" (Brycon henni) at Medillin, and the Cartagena Center for Fisheries Investigation (CIP). USAID funds and Auburn University management have collaborated with INDERENA in the construction and operation of the Repelón station.

The Cartagena installation in one of the largest in Colombia, consisting of a single story building of 1,222m^2 with offices for administration, a modern completely equipped laboratory with nine separate laboratories for individual study. There is a good library, aquarium and deep freeze for holding specimens. There are several large cement outdoor tanks currently being used for shrimp culture research. The Center conducts research in marine and fresh water biology, marine and fresh water fishes, shellfish, chemical and physical oceanography and fish technology. The staff is well qualified and the facilities and equipment are all more than adequate. This center could provide a valuable contribution to collaborative research programs not only for the competency of its staff and its physical plant, but in addition because of its strategic location and its relationship to the other INDERENA research centers.

4.5 LDC Institutions Recommended for Strengthening

A number of LDC institutions do not at present have sufficient qualified staff or facilities or equipment etc. to participate in Title XII collaborative research programs. However, because they have outstanding individuals or are located in strategic or problem areas, several are worthy of strengthening for possible future participation.

Following is a list of those institutions with suggestions of areas in which additional support is needed to enable the institution to qualify for possible participation in future Title XII collaborative research programs with U.S. universities.

AFRICA

Country - EGYPT

* Ain-Shams University
* University of Cairo
  University of Alexandria

These institutions have staff with good to excellent qualifications, however facilities including laboratories, equipment, reference materials, etc. are almost universally limited and what is available is in need of renewal and upgrading. The Food Technology Division in Ain Shams University is involved in research in fish preservation, processing etc.. The University of Cairo, Department of Zoology is engaged in fishery biology at primarily academic level. The Food Technology Department is also doing research on fish preservation. The University of Alexandria has the most active university fishery program in the country with most of their work being directed towards

aquaculture. There are also ongoing research programs oriented towards marine fisheries and marine biology.

Each university would require considerable input in financial and material contributions as well as some specialized academic and technical assistance in order to enable them to acquire their potential capabilities for participation in collaborative research programs, However because of their strong interest in participating, and their proximity to special problem areas (e.g. arid desert), any beneficial results from a CRSP project concerned with this particular type of climatic area could have a wide, practical application in those LDC where similar conditions exist.

Country - KENYA

University College, Nairobi
Department of Fisheries.

Permission for an official visit to Kenya by the RDA/AID Title XII survey team was refused by the USAID Mission, Nairobi. This inability to make official contacts and visit significant installations was a serious blow to the planning study. The following discussion and recommendations are based on conversations with international experts familiar with the region and U.S. university personnel currently operating in East Africa. The Department of Fisheries marine fishery research station is located at Mombasa where the University of Miami is currently engaged in a cooperative oceanographic monitoring project. This station is reported to be one of the top installations in the LDCs and has excellent facilities but needs support in staffing and equipment.

In addition to the marine laboratory a new regional mariculture laboratory and model aquaculture farm is to be

constructed by FAO/UNDP and the Department of Fisheries on the coastal area near Malindi. This installation will be the only one of its kind in the East African-Indian Ocean region and will be used as a demonstration and research center for the entire area. It will provide facilities for research in brackish water aquaculture and initial effort is to be directed to developing oyster culture. This installation with support and assistance might become a significant collaborator in Title XII research.

Country - NIGERIA

University of Ife
Ilo-Ife

This university has an outstanding and experienced faculty member in fish nutrition, presently engaged in establishing a department within the university in this field. There is a small supporting staff and facilities are limited but current research has resulted in findings of significance to the development of freshwater aquaculture not only in Nigeria but in West Africa as well.

Research on the nutrition of African fishes is extremely important in view of the proposed plans of a majority of the African states for large scale development of aquaculture. Advances made by this institution could have far reaching beneficial results for the entire region.

It is recommended that the University of Ife be considered for support and assistance to encourage present research and to strengthen the staff and department to enable an eventual participation in Title XII collaborative research programs.

University of Lagos
Lagos

At the present time there are no educational institutions in Nigeria concerned with fisheries. A former government fisheries officer, now a professor of biology, is starting a fisheries department at the University of Lagos. At present, courses and instruction are at the basic level, in biology, marine sciences etc. It is the purpose of the university to establish a department that will meet the growing need not only of Nigeria but other African countries as well in the fishery sciences. With the increasing government support in Nigeria for fisheries development, which however is restricted by lack of trained staff, the significance of supporting the university in the program is apparent. With proper strengthening this university has the potential to become a participant in Title XII colloborative research programs in fisheries research.

ASIA

Country - PHILIPPINES

University of Philippines
College of Fisheries

This institution has potential to become an active participant in Title XII collaborative research programs with U.S. universities, however, there is a need for upgrading the faculty and for development of the curriculum in the context of resource development and management. Support is needed to help finance new facilities buildings, etc.; present equipment is run down and worn out and would need replacement. The college

would like to move to Iloilo, where SEAFDC is located, if provided with sufficient funds. This could have considerable impact as it would provide opportunity for assistance and cooperative collaboration with SEAFDC which is the principle fisheries research organization in Southeast Asia.

Country - INDIA

Prior to 1947, fishery research in India was academic, directed principally towards taxonomy and descriptive natural history. With independence and the realization of the importance of research for quicker development and rational management of fisheries, specialized research institutions were set up and organized research activities on multiple disciplines of fisheries were gradually established.

Today there are a number of primary institutes concerned with fisheries research and survey as well as several conventional universities and Departments of Fisheries of state governments, and recently certain agricultural universities, which carry out research of topical or regional interest. A number of these are listed in Section 4. with their individual scopes of interests.

India has a large reservoir of highly trained, experienced scientific and technical staff. However, most universities, organizations and government installations are in need of scientific equipment (microscopes, etc.) and assistance to renovate and upgrade buildings, laboratories, vessels, etc. In most instances research is severely handicapped because of lack of basic materials and equipment and it is suggested that a considerable number of Indian installations would be able to participate in a wide range of Title XII collaborative research programs if they could receive material assistance and support.

SOUTH PACIFIC

Country - FIJI

* University of the South Pacific
  Institute of Marine Resources
  Suva

This is a regional university serving the interests of 11 island countries in the South Pacific including the Solomon Islands, New Hebridies, Nauru, the Gilbert Islands, Tuvalu, Tonga, Western Samoa, Tokelan, Niue, and the Cook Islands. The Institute of Marine Resources undertakes research projects as directed by government, and develops sub-stations in other islands (a fisheries school in the Solomons has been established). The university offers a 2 year diploma course in Tropical Fisheries which is partly funded by the Canadian International Development Agency (CIDA). The university staff is highly qualified and competent; facilities are adequate, but the basic physical plant could benefit from upgrading and an expansion of available equipment would be beneficial.

This institution is particularly worthy of strenghtening for participation in collaborative research programs because of its strategic location and its already well-established relationships with the island countries of the South Pacific area. Research to develop methods for producing bait fish for the tuna industry for example could have a wide spread application throughout the entire South Pacific area; resource assessment of the deeper water species beyond the reefs that are accessible to the artisinal fisheries is another research program that would have wide application.

4.6 International Institutions Active in Fisheries and/or Aquaculture Research

Country - PHILIPPINES

International Center for Living Aquatic Resources Management ICLARM

Manila

The International Center for Living Aquatic Resources Management, (ICLARM), is an international, non profit scientific center which conducts and stimulates research on all aspects of fisheries research directed initially to the LDCs in the Southeast Asia and Southwest Pacific Areas. ICLARM's fields of interest are in aquaculture, traditional fisheries, resource development and management, marine affairs and education and training. ICLARMs basic stragety is to undertake cooperative programs, and to establish linkages with local governments and existing institutions when research facilities are required. In this capacity ICLARM would furnish a highly significant and unique function in collaborative research projects in the following areas:

Aquaculture: Controlled breeding and mass propagation of brackishwater fish. Assessment of the resource base available for the amplification of production from aquaculture in Southeast Asia. Study of mangrove swamps and feasibility of their use for aquaculture.

Traditional Fisheries: Identification of problems and possibilities in long-range improvement of economic status of traditional fishermen. Evaluation of past development efforts. Identify new development opportunities. Identify problems and possibilities in post-harvesting technology. Assessment of near shore, multi-species fish stocks. Identification of clear-cut conflicts between artisanal and commercial fishermen.

Resource Development and Management: Marine affairs, Law of the Sea, pollution problems and effects etc.

Education and Training: Fishery scientists, administrators etc.

Special Projects: (e.g. Southern Ocean Salmon project)

Related Projects: Interface with South China Sea Fisheries Development and Coordinating Program (SCSP) and Southeast Asian Fisheries Development Center (SEAFDEC) Aquaculture Department, Fisheries Technology Department in Bangkok and the Marine Biology Department at Singapore.

Country - PHILIPPINES

Aquaculture Department, Southeast Asian Fishery Development Center (SEAFDEC)
Iloilo

This installation is potentially the major center for aquaculture research and training in the Southeastern Asia area. SEAFDEC is an international research organization devoted to the development of the aquaculture resources of Southeast Asia.

The Aquaculture Department is one of three departments organized under the SEAFDEC agreement among six nations including Japan, Malaysia, Philippines, Singapore, Thailand and Vietnam. The two others are the Fisheries Technology Department, Bangkok and the Marine Biology Department in Singapore.

Facilities include two major stations (40 and 96 hectares) with supporting laboratories, hatchery complexes, tanks, and auxiliary supporting structures. There are several other stations for specialized prawn and milkfish research. Under the SEAFDEC agreement, the Republic of the Philippines, as the host government provides project sites, physical facilities and services of local staff. The Government of Japan provides research, training and physical equipment, staff and fellowships for study in the Aquaculture Department and in Japan. Funding is provided by member governments but also support has been received from the Governments of Australia, and New Zealand as well as IDRC of Canada. This is a well-equipped research facility. It is short in trained staff but appears to be developing. It is a potential participant for collaborative research.

The Department has developed an extensive training and extension program directed to providing the appropriate research and technical manpower required for development of the aquaculture industries.

Scope of Interests

Aquaculture in the following areas: production and securing of quality seedlings of desired species from natural sources and induced breeding; increase production by means of improved design and construction of ponds, impoundments etc, improved management and pond maintenance; improvement of natural and artificial foods and feeding; biological manipulation of stocks, control of disease parasites and predators; prevention and control of pollution. Ongoing studies on the cultivation of shrimps, prawns coastal and brackish water fish and shellfish including mullet and milkfish are being conducted.

Training and Extension include a six month fishpond management program, trainor-training program, short term for fisheries technican and two year program for master level.

Country - SENEGAL

* Fishery Committee for the Eastern Atlantic (CECAF)
  Dakar

  Scope of Interests: Artisanal fishery development, establishing statistical systems, development of industrial fishing including processing, preservation, handling and marketing.

4.7 Other Country Institutions Recommended for Participation in Collaborative Research Support Programs

Among other countries, there are a number of universities, institutions and organizations that have highly qualified experienced scientific staff and excellent research facilities. Some have worked in collaboration with United States universities on various projects and programs in the past and others have a long and successful history of cooperation and assistance in the LDCs. While not all of these organizations were recently visited by members of the RDA staff, panel, or USAID advisors for this project, they are included in the list of universities and institutions suggested for participation in collaborative research programs because of their demonstrated activities in the international research and development field, and recommendations from other sources including qualified experts who have visited these institutions recently and have suggested their inclusion for CRSP.

Country - TAIWAN

Taiwan Fisheries Research Institute.
National Taiwan University, Institute of Oceanography.
Taiwan Provincial College of Marine Science and Technology.

The Taiwan Fisheries Research Inscitute is the main fishery research organizaton of the Provincial government of Taiwan, having been in active operation for over 50 years, carrying out a wide range of fishery research activities. It is organized into four departments and seven branch institutes. Activities include research in fisheries development, fisheries biology, fish processing, and fish culture. The institute has four research vessels available for use. Present research programs include an ongoing (since 1953) exploratory trawl program in southeast Asian waters and research on krill, its capture and processing. The main emphasis at the branch institutes

is as follows:

- culture of Chinese carp, eels, oysters, rainbow trout, mullets;
- hybridization of tilapia;
- milkfish and shrimp culture;
- preservation and processing of fish products, and
- gear development.

The National Taiwan University provides undergraduate training in fisheries. Its Institue of Oceanography carries out graduate training in oceanography and fisheries. The Institute is organized into the divisions of Physical Oceanography, Marine and Fisheries Biology, and Marine Geology and Physics. Current research is directed to catch production and effort statistics on a world wide basis and to the study of the biology and population dynamics of ground fish in the east and South China Sea and northwest Australian regions.

Taiwan Provincial College and Marine Science of Technology is directed to developing scientific and technical studies in marine science and technology, fisheries technology and marine food science. The objectives of the college are to:

- educate and train scientists and technologists in oceanic development, research, planning and management;
- make this institution the academic and research center of marine science and technology;
- help train government agencies, train teachers specializing in oceanography for vocational schools; and
- promote international cooperation in studies and research of marine science and technology.

Taiwanese fisheries scientists are highly regarded by the LDCs for their understanding and practical approaches to research and development problems. With their competent and experienced staff and well equipped laboratories, the Taiwanese could provide a major supporting role in a variety of collaborative research programs with United States and LDC institutions.

Country - BRAZIL

There are approximately fifteen installations throughout Brazil operated by various government departments, agencies, etc., and several universities which are conducting research on the culture of a variety of fish, crustacea and mollusks. There are also twelve aquaculture stations associated with reservoirs participating in a national program that produces fry for planting in the extensive reservoir system. Among these installations those below are recommended as possible participants which could undoubtedly provide expertise, facilities and knowledge of indigenous species that would be of considerable value in a collaborative research program.

* Federal University of Ceará, Fortaleza
  Department of Fishery Engineering

This is a graduate school offering courses in marine sciences, fishery management, population dynamics, fishery oceanography, fish processing, fishing gear and methods, fishery resource development, fishery statistics, marine and freshwater aquaculture and other fishery related subjects. The staff includes about 40 researchers, 25 of whom are teaching. Research is concerned especially with fishery biology and oceanography, fish technology of new products, especially mussels and sharks, and sedimentary geology related to fish and oil exploration on the continental shelves. There is a large single building on the coast, a collection of good fish technology equipment and a small, reasonably well-organized library. The university has a strong, solidly based program and is probably one of the leading marine laboratories in Brazil. It is recommended for consideration as a possible participant in a collaborative research program.

* Ministerio de Interior
  Departmento Nacional de Obras Contra As Secas (DNOCS)
  (National Department of Works Against the Drought)
  Pentacoste, Ceará

The National Department of Works Against the Drought (DNOCS)

has operated this experimental hatchery at Pentacoste in a cooperative program with Auburn University and some funding by USAID for many years. The facilities are excellent and are currently being enlarged to double its present size, including new ponds, laboratories, classrooms, supporting buildings, and staff homes. This institution pioneered the development of hormone injection for inducing spawning and is a leader in the spawning, hatching, and rearing of African tilapia.

The institute has pioneered in breeding and nutritional experiments utilizing non-animal protein and also conducts training courses for Brazilian fish culturists and some from abroad.

Universidade de São Paulo
Oceanographic Institute

The Oceanographic Institute with its main laboratory and headquarters in São Paulo operates two marine stations, one at Ubatuba in the north and one at Cananéia in the south. The Cananéia station has been offered as a marine sub center for UNDP/FAO Aquaculture Developement and Coordination Programs for Aquaculture. It is being developed as a mariculture center for research and training activities related to brackish and marine environments. Research interests of the Institue are directed to unrestricted research in oceanography, marine biology, fisheries biology and marine products technology. There is available a moderately complete library, research collections of Brazilian marine fishes, crustaceans, molluscs, etc; laboratories and supporting facilities are available at both north and south stations. The institute offers environmental access to the South Atlantic ocean with special emphasis on subtropical convergence sandy beaches, rock shores, brackish water bays, and mangrove vegetation.

The Institute has a well-established reputation and a qualified staff and has been recommended for consideration for CRSP Title XII support with United States universities by USAID.

Country - VENEZUELA

*Fundacion La Salle de Ciencias Naturales (FLSCN)
Isle de Margarita Marine Station
Estacion Cuidad, Guiana

The Fundacion La Salle, which operates the two research stations, is a privately financed organization supporting training, research, and development in fisheries and agriculture. It operates in cooperation with universities, government bodies, and other institutions.

The Isle de Margarita Marine Station is currently engaged in mariculture of several species of oysters.

The Estacion Cuidad Guiana, located on the Orinoco delta, is investigating fishes of the Orinoco river system suitable for culture. Professionally trained staff is limited but the facilities at both stations are good. With strengthening of the staff and some additional material support, these stations could become effective contributors to the collaborative research program. The Estacion Cuidad Guiana could be of particular significance in a CRSP research program directed toward determining new species of local fishes with possibilities for culture.

Country - ISRAEL

* Israel Oceanographic and Limnological Research, LTD (IOLR)

  ILOR Haifa Laboratories

  ILOR Kinnert Limnological Laboratories

  ILOR Aquaculture Unit

* Ministry of Aquaculture, Fisheries Division

  Fish and Aquaculture Research Station, Dor

  Sea Fisheries Research Station, Haifa

  Hebrew University of Jerusalem

  Heinz Steinmetz Marine Biology Laboratory, Elat

  University of Tel-Aviv

A considerable amount of research currently being conducted in Israel involves a number of the above groups. The Israel Oceanographic and Limnological Research LTD (IOLR) manages the activities of several of these organizations which collectively have an outstanding reservoir of aquaculture and fisheries research capabilities. Facilities and equipment at these institutions are excellent and in some fields of research the staff are probably among the best in the world.

Research projects currently under way in which Israel has outstanding research capabilities are as follows:

- Larval culture and spawning of marine fishes at Elat, ILOR Laboratory.
- Reservoir management utilizing a complex mathematical model to provide scientific basis for management of fish populations at ILOR's Lake Kinneret Laboratory. This research has important application for similar large lakes and reservoirs in the LDCs.
- On the use of brackish and alkaline waters typical of the desert areas in many LDCs.
- Cage culture of marine species as one of the few possibilities for fish production from infertile waters adjacent to arid areas.
- Intensive polyculture and hybridization research are also continuing.

There is no question that the Israeli institutions and universities could make significant contributions to selected collaborative research programs in the fields of their competence.

5.0 THE MECHANICS OF THE PLANNING PROCESS

The planning process consisted of nine major tasks derived from the seven requirements contained in the Contractor's Scope of Work. The tasks, shown in Table 13, encompass all of the activities which need to be completed to accomplish the objectives of the project.

The first task was to develop a network planning diagram which identified the sequential relationship of the major tasks and subtasks. The diagram contained in Figure 1 was used as a guide in managing and controlling the fisheries and aquaculture planning process. The numbers within the circles relate to the items listed in Table 13.

As the diagram indicates, there was a very definite critical path. Along this sequence of activities any delays had an adverse affect on completion of subsequent events. Some delays did occur, notably in obtaining permission and in scheduling LDC visits and in obtaining capability information from United States universities. While some of this time was made up in subsequent activities, the delays did contribute materially to the extension of time necessary to complete the final report.

It should be noted that one task, 8.0 Analyze Alternative Organizational Structures, was specifically omitted on instructions from the JRC. Although this was originally a requirement of the contract, the JRC felt that work on the subject would constitute a duplication of effort since a similar requirement was contained in the planning studies concerning small ruminants and sorghum and millet.

The planning process was aimed at achieving three separate but related goals:

1. defining priority areas which would be suitable for collaborative research support programs,
2. inventorying research capabilities in the United States,
3. inventorying research capabilities in developing countries.

THE PLANNING PROCESS

1.0 DEVELOP NETWORK PLANNING DIAGRAM

2.0 DEFINE MAJOR PROGRAM AREAS

- 2.1 Develop Preliminary Classification Scheme
- 2.2 Compile Baseline Date on Research
  - 2.2.1 Literature Search
  - 2.2.2 Brief Descriptions of Research Projects
  - 2.2.3 Compile Reference Material
- 2.3 Determine Current Research Status in U.S. and LDCs
  - 2.3.1 Develop Survey Instrument
  - 2.3.2 Identify Universities and Institutions to Visit
  - 2.3.3 Schedule Visits
  - 2.3.4 Make Visits
  - 2.3.5 Compile, Analyze, and Evaluate Data

3.0 SPECIFY CURRENT RESEARCH STATUS OF U.S. AND LDCs

- 3.1 Assess Research Progress
  - 3.1.1 Specify Expected Results
  - 3.1.2 Estimate Completion Requirements
- 3.2 Assess Potential Benefits of Research
  - 3.2.2 Relate Research Programs to Target Populations
  - 3.3.3 Evaluate Potential Benefits to Recipients
- 3.3 Define Status of Research with Respect to Title XII
  - 3.3.1 Develop Presentation Format
  - 3.3.2 Prepare Descriptions

4.0 DEFINE RESEARCH NEEDS IN LDCs

- 4.1 Identify Problems in Geographic Areas of Interest
  - 4.1.1 Specify Primary Recipient Regions
  - 4.1.2 Determine Differences and Similarities
- 4.2 Devise Method for Ranking Importance of Problems
- 4.3 Define Priority Needs
- 4.4 Specify Problems Susceptible to R & D Solution

Table 13 Detailed Task Outline, Fisheries and Aquaculture

5.0 SPECIFY RESEARCH PROGRAM REQUIREMENTS

- 5.1 Identify Needs Not Being Met
- 5.2 Develop Method for Ranking Research Needs
- 5.3 Prepare Research Priority Schedule

6.0 INVENTORY CAPABILITY AND INTEREST TO PERFORM PRIORITY COLLABORATIVE RESEARCH UNDER TITLE XII

- 6.1 Summarize U.S. and LDC Institution Capability
- 6.2 Identify Capability to Perform Priority Collaborative Research
- 6.3 Develop Method to Compare Capability
- 6.4 Recommend Universities/Institutions by Category
- 6.5 Recommend LDC Institutions for Collaborative Research Roles

7.0 DEVELOP PLAN FOR ALLOCATION OF FUNDS

- 7.1 Develop Method for Allocation Among Programs
- 7.2 Prepare Time-phased 5 Year Plan

8.0 ANALYZE ALTERNATIVE ORGANIZATIONAL STRUCTURES

- 8.1 Identify Alternate Methods of Organization
- 8.2 Analyze/Evaluate

9.0 PREPARE FINAL REPORT

- 9.1 Develop Report Outline
- 9.2 Write Draft
- 9.3 Review Draft and Comment
- 9.4 Prepare Final Draft

Table 13 (continued)

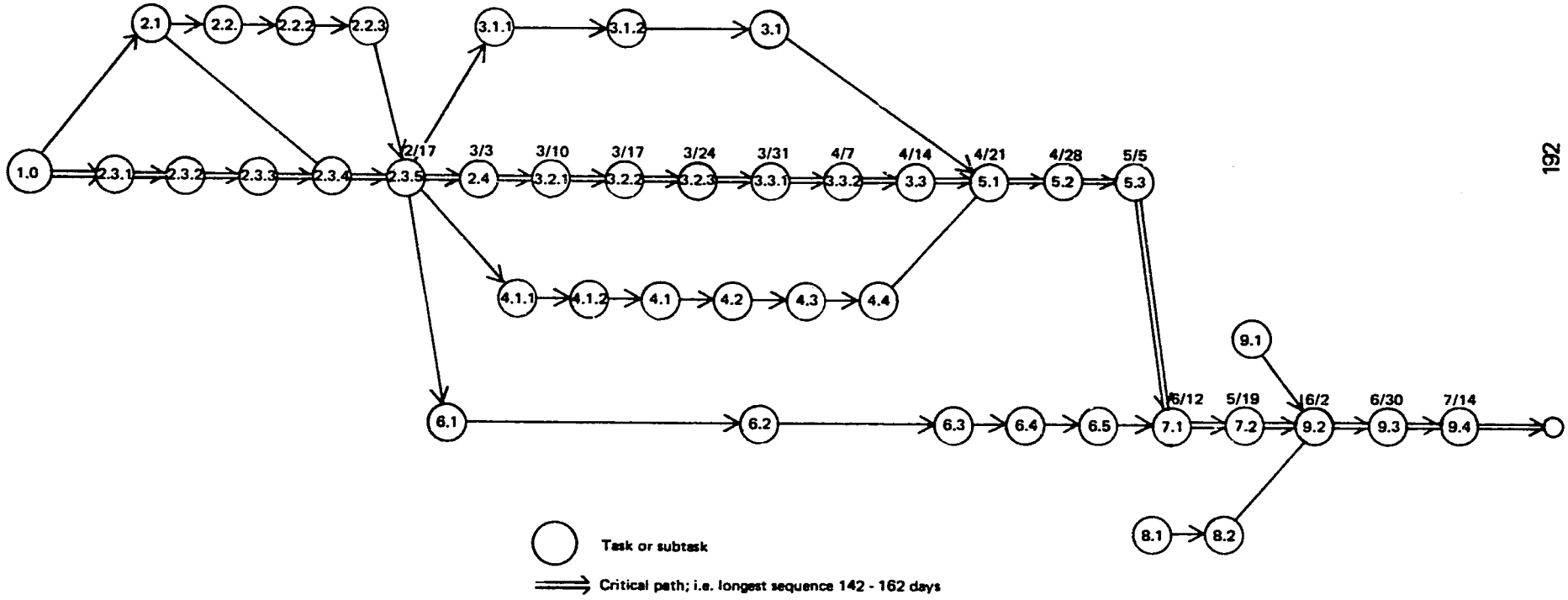

Figure 1 — Network Diagram: Fisheries and Aquaculture Planning

In pursuit of these objectives four of the items in the contract scope of work were combined. The first goal, defining collaborative research program areas, included making recommendations as to priorities, the plan for funding and a summary of research status. These were considered to be so closely related as to be inseparable.

It must be emphasized at this point that this project proved to be somewhat broader in scope than originally anticipated; i.e., was not limited to the U.S. and the LDCs. Needs and capabilities of a number of other developing countries were also included. As a result of time and budget constraints, the depth and breadth of the investigations were somewhat limited. However, in spite of those constraints, the material in the report is believed to be current, accurate, and useful. It will provide a strong base for any additional planning efforts.

5.1 Developing Collaborative Research Programs

The process of identifying potential collaborative research programs involved three major tasks:

1. evaluation of the results of past research,
2. determination of current LDC needs and,
3. specification of the research necessary to meet the unfulfilled needs.

The approach included an extensive search of the existing literature, visits to developing countries, and the application of the knowledge and the experience of a panel of experts (Delphi method).

As an aid in identifying research requirements, and to make the important aspects of fisheries and aquaculture more readily visible, the classification chart shown in Figure 2 was prepared. The classification scheme illustrated was useful in several ways; it identified all of the aspects of fisheries and aquaculture which might be subject to research, and it indicated the relationship between the two aspects and provided a framework for the literature search and site survey.

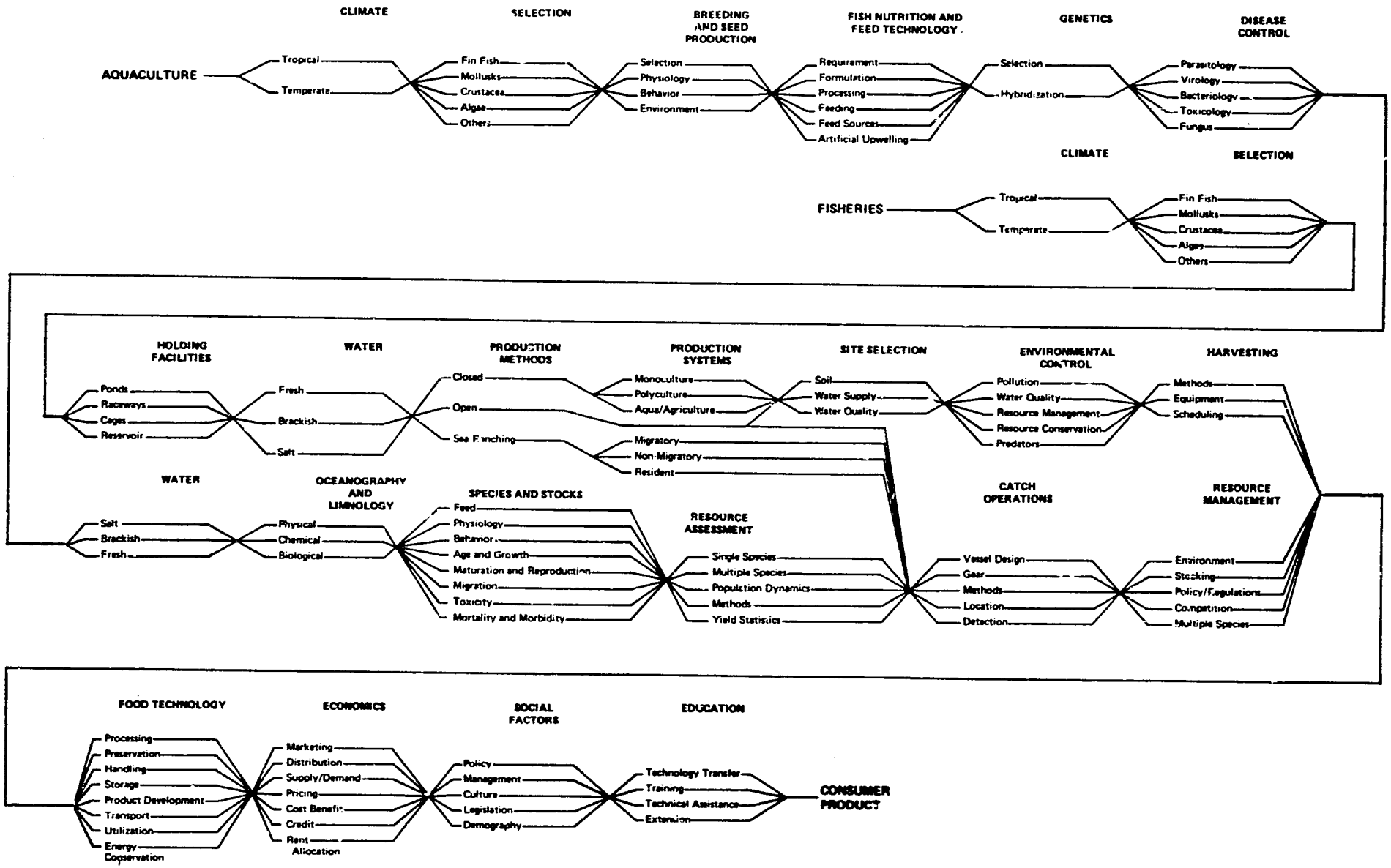

Figure 2 — Elements of Capture Fisheries and Aquaculture Production

It should be noted that capture fisheries and aquaculture are mutually exclusive except at three points: stocking, sea ranching, and food technology (beyond the food technology phase, both areas share elements in common). Thus, it is highly likely that research conducted in areas having shared elements could result in benefits accruing to both.

5.1.1 The Literature Search

An extensive literature search to determine LDC research needs for increasing aquaculture production and increasing catch and catch utilization within small-scale capture fisheries was conducted. Before making recommendations for research as designated by the Title XII Program, it was essential to know what has been done in LDCs, what is currently being done, by whom and what plans for future developments are proposed by other governments or international organizations. The purpose of this task was: (1) to avoid recommending duplication of research and, (2) to identify research areas with significant potential for the majority of developing countries.

The literature search was confined mainly to those areas of the world which would be recipients of, or participants in research under Title XII. It was designed to provide specific information for specific countries and to produce a bibliography containing useful sources of fisheries and aquaculture information. While the objective of the search was to help provide a framweork for collaborative research programs, the results also apply to country specific research and technical assistance.

Pertinent fisheries literature is voluminous; however, only part of it is found in formal publication; much of it is in the "gray literature" appearing in special documents, administrative reports, and a wide variety of similiar publications that have limited distribution. Unfortunately, the publishing process usually requires considerable time, often of the order of a year or more. Consequently, the literature can only present a partial picture of the status of research, albeit a very useful one..

Most research or technological investigations conducted by LDCs is undertaken by government agencies operating on limited budgets. Results of such investigations seldom appear in print except as brief paragraphs in "Annual Reports", or sometimes as papers at international or regional conferences.

Research or technical assistance financed and performed by specialists from more affluent countries or international organizations is reported to the sponsoring agency and appears as administrative reports with restricted distribution. University-sponsored research is normally published by the university either in an established series or as unbound separate reports. Research sponsored by international organizations such as the United Nation Food and Agricultural Organization (FAO) usually appear in the official publications of that organization in numbered series. They are available but have limited distribution. By far the majority of these publications are restricted to in-house distribution. The working papers of workshop sessions, symposia papers, and documents submitted to world-wide conferences are available only to attendees and participating organizations until such time as reports or proceedings are published, generally several years later.

Getting information directly from LDCs is more difficult. Fortunately, however, considerable information about the LDCs is collected and published by various international organizations. The literature used in this report and contained in the References was obtained from many sources. These included private individuals and foreign universities, the FAO library in Rome, and international agencies. Also particularly useful as sources were the international research and development organizations, groups, or commissions such as:

- Consultive Group on International Agricultural Research (CGIAR)
- International Center for Living Aquatic Resources (ICLARM)
- Inter-American Tropical Tuna Association (IATTIC)
- International Development Research Center (IDRC).

As a guide to directing part of the literature search, the charts shown in Figures 3 and 4 were used. These were developed from and based upon the elements of the fisheries and aquaculture production systems illustrated in Figure 2 . They provided a logical and consistent method for classifying research. A form was completed for each country included in the survey indicating its research experience. Research institutions and facilities were also listed as they were referenced in the literature. The result was a compilation of research capabilities and facilities for fifty-two countries as represented by the literature over the last ten years.

The results of the individual country searches were compiled for review by the staff and Research Advisory Panel. The material was used in helping to determine which LDCs to visit and in determining the range and depth of research activities.

To obtain information as current as possible, in addition to visits to specific countries, staff members and advisors attended the Sixth Session of the Indo-Pacific Fishery Commission Executive Committee, the Indo-Pacific Fishery Commission Symposium on Fish Utilization Technology and Marketing, the Thirtieth Gulf and Caribbean Fisheries Institute, and the First Annual Latin American Aquaculture Association Symposium.

Combined with the formal literature search, this effort resulted in a comprehensive collection of fisheries literature concerned with the LDCs, a list of LDC universities and institutions engaged in fisheires research and technology, information regarding international organizations and other funding sources assisting in fisheries development, and material for analysis of current research status.

For the LDCs, the most significant lack of published information lies in the socio-economic fields. By comparison with other fields, relatively little has been published concerning research on processing, marketing, transportation and storage of the catch in developing countries not to mention packaging, presumably because less has been done in this field than in others.

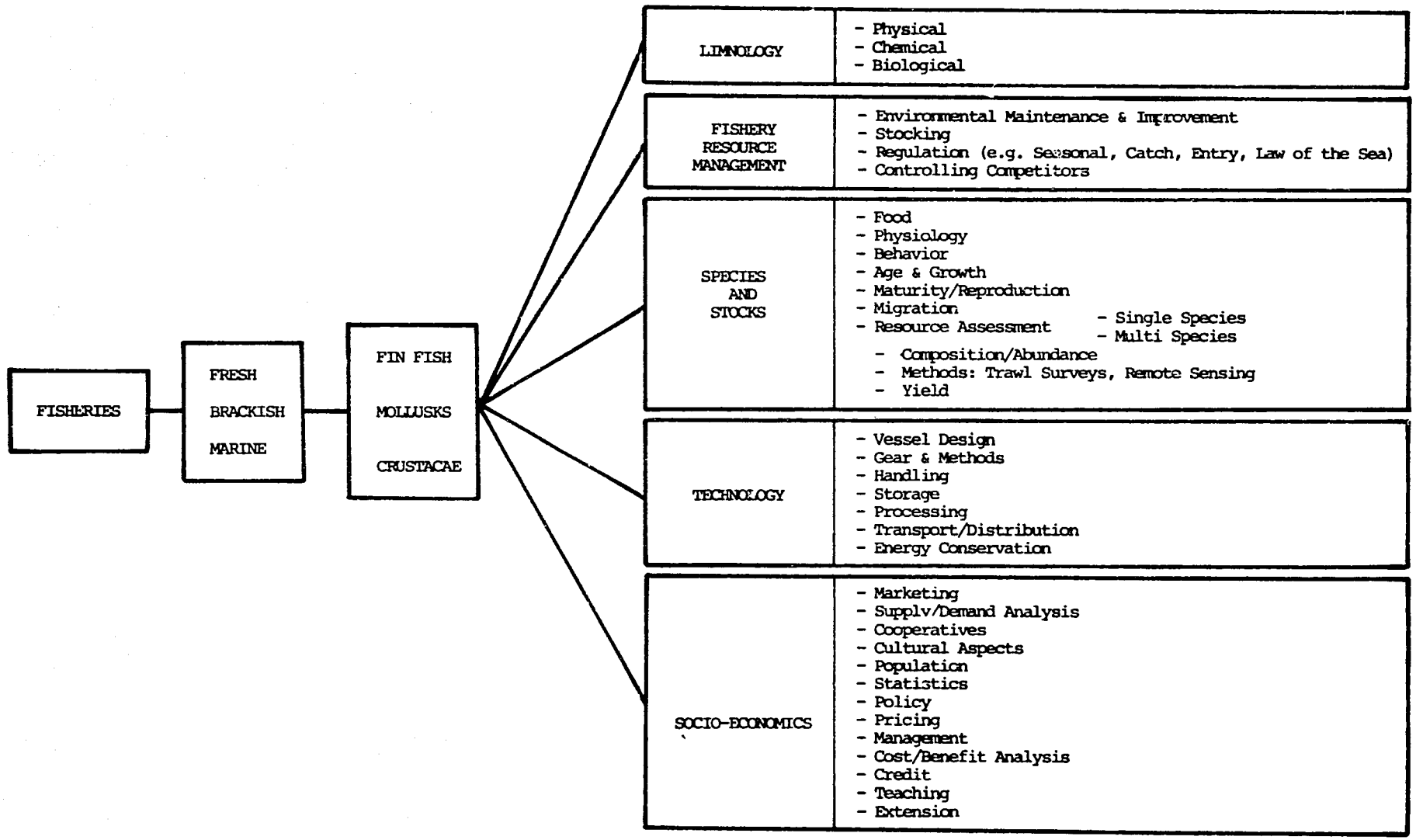

Figure 3 Elements of Fisheries

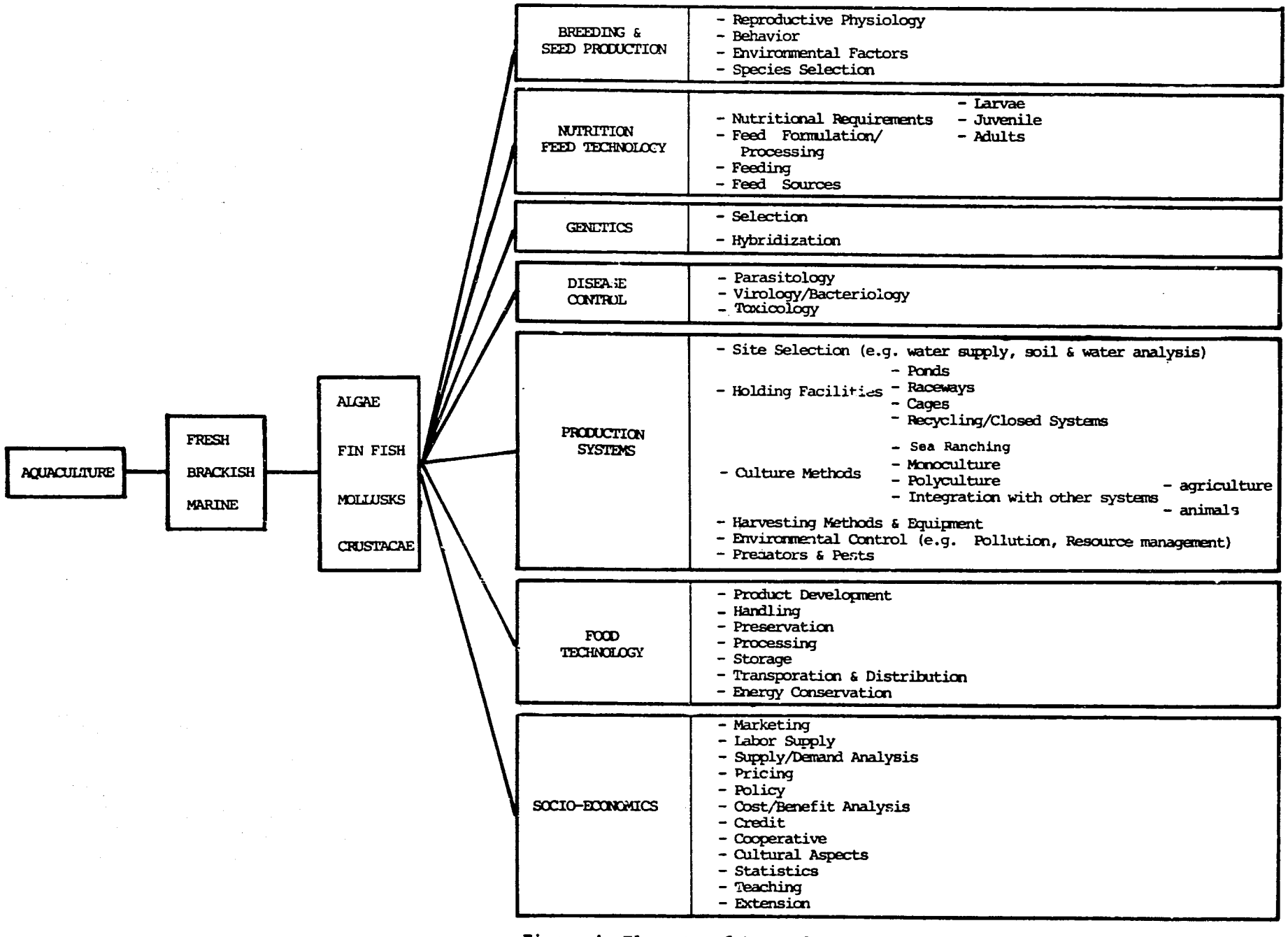

Figure 4 Elements of Aquaculture

Similiarly, little research is reported on cooperatives, cost-benefits, energy conservation or consumer demands (present or potential) training technicians, teaching or extension work and the cultural aspects of countries.

5.1.2 Determining LDC Needs

To identify priority collaborative research programs, it was necessary to determine the LDC needs for research. This was accomplished in three ways. First, the comprehensive country-by-country literature search of fifty-two developing countries discussed above was made to determine what areas of research had been receiving attention. The information from this exercise provided data on the nature of the research that had been carried out in the particular LDC, the status of the research, and at what level it had been undertaken. In addition, this search gave an indication of the priority of the research needs as it is presumed unlikely that any LDC would devote effort and funds to research projects that are not of primary importance.

Second, a number of the scientific advisory staff members have had considerable experience visiting, studying, or working in the LDCs. From their first hand experiences and knowledge, an idea of the major research needs of the LDCs was formed. This, in turn, was used as a basis for the next step.

Third, because the literature was at best two years old and was open to different interpretations, it was decided to make on-site visits to selected LDCs to gather first hand current information of research needs.

An LDC in the context of this report is a country whose gross per capita income is a little over $200 per year and has a significant involvement in capture fisheries and aquaculture. Twenty countries were selected for visits. Selection of countries for visits was based on results of the literature search, information submitted from United States universities, advice from the panel of experts and and AID guidance. The on-site visits were carried out by RDA staff

and advisors Philip M. Roedel, AID Fisheries Advisor, and Richard Neal, AID, Aquaculture Advisor. LDC personnel contacted for information included ministers, fisheries directors, fisheries scientists, policy and planning directors, technicians, and laborers.

Some of the countries surveyed in Latin America do not qualify as LDCs. However, as former LDCs, it was felt that they might provide useful information regarding what problems might be expected in LDCs and what successes had been achieved which might serve as models. In addition, they were included in the survey to determine what facilities and personnel in those countries might be suggested for participation in collaborative research programs.

After the data representing needs were collected, they were compiled in matrix form as illustrated in Table 14. The matrix grouped 25 countries into four geographic regions: Africa, Latin American and the Caribbean, Asia, and the Pacific. The countries were listed vertically on the left of the matrix and the needs expressed by the countries themselves were listed horizontally across the top. Numbers in columns indicate relative perceived priority; where countries recognized a need but had not established priorities, an x appears.

The matrix was developed to indicate which needs showed up with the greatest frequency and which were considered most important. In fact, the matrix did just that, showing resource assessment, fresh/brackish water aquaculture, and the area of fisheries management to be the most frequently cited and the most important. Geography and the level of development played a distinct role in responses to needs. Africa expressed a need for work in aquaculture; whereas Latin America had a greater interest in resource assessment. The more developed countries; e.g., Brazil and Israel have a greater need in the area of food technology.

Country	Capture Fisheries							Aquaculture						Product Utilization				Other					
	Stock Assessment	Catch & Effort Statistics, Methodologies	Population Dynamics, Basic Biology	Fisheries Admin. & Mgmt.	New or Extended Fisheries Development	Vessel/Gear Development	Fisheries Infrastructure, Facilities & Equipment	Fresh/Brackish Aquaculture	Mariculture	Feed (Fish Nutrition)	Seed Production	Genetics, Biology, Hybrid Development	Disease (Morbidity/Mortality)	Food Technology (Post-harvest losses)	Food Technology (Preservation & Processing)	Marketing/Distribution	Aquatic Weed Control	Rehabilitation/Improvement of Inland Waters	Ecology, Habitat Protection	Mangrove Studies	Socio-economic Studies	Tech Assistance	Tech Training
Africa																							
Guinea - Bissau	1	2		4										3								1	1
Ghana				1		1		1,3				2	3	1	1		4	2	x			2	2
Ivory Coast	1		2		1	1		1	1,2	1,2		1	3						4		3,4	x	2,5
Nigeria					4	x	1	1,2	x	2	1				3	3	1	1	x			x	4
Kenya	1							1	x														
Sudan	1	2	1		x			3	3								4	2	x			x	x
Senegal		2				4	1							1	1	3						1	1,4
Tunisia	1			x				1						2	2						3		2
Egypt	x			x				1	x	x	x	x	x	2	2								
Latin America/Caribbean																							
Costa Rica					x											x					x		x
El Salvador	x			x	x			x								x							x
Guatemala	x			x	x											x					x	x	x
Honduras	x			x	x											x					x		
Nicaragua	x			x	x											x					x		x
Panama	x			x	x											x					x		x
Venezuela	x		x	x	x			x				x			x	1							x
Brazil	1			1	x			2						2	2								3
Colombia					x			x						2	2	1							
Caribbean	1,2	2		2,3	1		1							2	2	3						x	
Asia																							
Thailand	3			1	1			1,2,3	1,3					1,2	1,2			2	x	x		x	
Indonesia	x			x				x						1	1	2,3					2,3	x	
Philippines				1	x			3	3		3			x	x			x	x	x	2		
Sri Lanka	x			x	x		x									x							x
India	1			1				3	x					x	x						4	3	2
Pacifica																							
Fiji, South Pacific	1			1	1	2		1(bait)								3				4			

Table Priority Assistance Needs in Fisheries and Aquaculture as Expressed by Selected Developing Countries

5.1.3 Identifying Problems to Be Solved

The needs expressed by the developing countries were, of necessity, quite general. Within the time constraints of the project it was not possible to obtain detailed descriptions of research needs. Few, if any, of the countries visited have any formally established statements of their fisheries and aquaculture research requirements. While they do know what they want, the needs are only expressed in terms of general problem areas. Well-structured specifications have simply not been developed. Consequently it was necessary to define more specific problems that might be solved by research. This task was left to the panel (RAP) of experts who served as advisors throughout the study. The experts considered the LDC needs and the material assimilated from the literature search. On the basis of their own knowledge of current research they identified a number of problem areas within the broad categories of expressed need. For example, within post-harvest food loss, one problem area was spoilage due to bacterial growth. Similarly, many specific problems were defined to form a base for the consideration of research programs.

5.1.4 Specifying Collaborative Research Programs

Quite obviously, not all problems are amenable to research, particularly the type envisioned as collaborative research in terms of the Title XII mandate. Some LDC problems can best be approached through technical assistance or training. Still other problems might benefit from research but the potential payoff would not seem to justify the effort. Consequently, before attempting to identify needed collaborative research programs, the Research Advisory Panel was asked to specify those problem areas in each of the broad categories of LDC need which were amenable to research.

After narrowing down the problems to those which were amenable to research, it became necessary to determine those which could be considered for collaborative research. The guidelines for collaborative research are contained in the BIFAD annual report

November 1977, Appendix VII (BIFAD, 1977, R-17). For purposes of this study, a set of criteria was developed from the guidelines to identify research which was collaborative in nature. To qualify as collaborative the research should:

1. represent real needs as expressed by the LDCs,
2. benefit the small-scale fishermen and/or aquatic farmers,
3. address food, income, and employment problems,
4. not be country specific,
5. be conducted by eligible institutions in the United States, having interest in continuing the research on a collaborative basis with other institutions both in the United States and in the LDCs,
6. be carried out whenever possible in the LDCs, utilizing existing or potential LDC facilities,
7. require long-term effort,
8. be of sufficient scope to warrant collaborative effort.

The identified research problems were compared with the criteria for collaborative research by the panel of experts. The resulting list of possible collaborative research programs was presented in 3.3.

Prior to recommending specific collaborative research programs, it was necessary to determine the status of related research. This was done to avoid duplication of work already completed or work well under way. Unfortunately, the status of research is seldom indicated. If reported at all, status is designated merely as planned, on-going, or completed. When completed, little indication of the degree of success may be evident. In assessing the current status of research, reliance was placed on the literature, observations, and expert opinion.

The primary method for determining the status of LDC research was a thorough literature search going back through the last ten years. This was done on a country by country basis and the same type of sources of literature were used for each successive year. By analyzing the entry and the exit of references, determination

was made as to what research had ceased (assumed completed, successful or unsuccessful), was on-going or was new. Since the most current literature is about two years old, the next step in determining research status was made from visits to specified LDCs and from opinions of experts with recent experience in a particular LDC.

The status of United States research was defined by members of the Research Advisory Panel, representing the fields of Capture Fisheries (Inland and Marine), Aquaculture, Food Technology, Economics and Administration. The experts utilized current knowledge in their respective fields, literature, site visits, and and peer discussions to develop the consensus which was expressed in the state-of-the-art descriptions addressed in Section 3.0. The analysis of the research showed where there were gaps in research that could help solve LDC needs, research areas that could use strengthening, areas that were researched to exhaustion, and areas that would benefit from an ongoing research effort.

Following the determination of the collaborative research programs, it became necessary to establish a priority listing of these programs for funding purposes. If a sufficient budget were available to fully fund all recommended research programs at the same time there would be no need for priorities. However, full simultaneous funding would cost approximately twenty million dollars a year. If the level of appropriations were below this figure, allocation should logically be made to the programs considered most important.

To obtain priorities, the matrix of Table 15 was given to the members of the Research Advisory Panel and to AID and State Department personnel concerned with the report. These individuals were cognizant of the background material represented by the rating factors and the findings of the report. They were asked to rate the various programs, using the scale indicated at the bottom of the matrix. These results were complied and a numerical value given to each program. The programs were then arranged in descending order of numerical value. It should be noted, however, that the differences in ratings among a number of the programs was quite small. Wherever this occurred, the programs were accorded

the same rating; e.g., four separate programs were designated a priority 2, three as 3 and three as 7. Within each of these priorities the programs can be regarded as of equal importance. Factors not considered or not made known during the planning effort can be used for further differentiation.

It must be noted that the programs listed in the priority matrix serve only as tentative descriptions of potential programs. They were established to determine what possible rating each would have based on the type of program they represented.

5.2 Inventorying United States University Capabilities

Another important aspect of the planning study was to develop an inventory of United States university capabilities to undertake research in capture fisheries and aquaculture in general and in the recommended research programs in particular. The initial list of universities and institutions to be considered was provided by the BIFAD. This list included United States Land and Sea Grant Universities and "others' eligible to receive Title XII grants. In the course of the study, additional institutions not presently on the list were identified through correspondence, meetings or personal contact. The objective of this part of the study was to identify the scientific capabilities and research facilities available in the United States for work in aquatic food research.

RATING FACTOR	MARKETING AND DISTRIBUTION	ENERGY CONSERVING METHODS FOR PRESERVATION AND PROCESSING OF FISHERY PRODUCTS	DEVELOP PRODUCTS AND IMPROVE PROCESSING TECHNIQUES	REDUCTION OF PRODUCT LOSS CAUSED BY INSECTS AND PESTS	CONTROL SPOILAGE OF FISHERY PRODUCTS	DETERMINE CAUSES AND RATES OF FISH AND SHELLFISH SPOILAGE IN TROPICAL WATERS	MORBIDITY AND MORTALITY	GENETICS	FEED AND NUTRITIONAL REQUIREMENTS	SEED AVAILABILITY	DETERMINE PRINCIPLES AND MECHANISMS OF POND CULTURE SYSTEMS	NATIVE SPECIES AMENABLE TO CULTURE SYSTEMS	PROCEDURES FOR CONTROL OF FISHING EFFORT	IMPROVED PROCEDURES FOR CATCH AND EFFORT STATISTICS	IMPLICATION FOR FISHERIES MGT. OF EXTENDED FISHERIES JURISDICTION (200 mi. limit)	RESOURCE ASSESSMENT
1. Number of people in target group benefiting from this report																
2. Geographical area to which this program will be beneficial (global, regional, country)																
3. Sensitivity of research to geographical selection (sited anywhere, in only certain regions, or only certain countries)																
4. Extent to which this program fits the perceived needs of LDCs																
5. When will research results become available																
6. Cost of program (low, med, high)																
7. Probability of successful completion of research i.e. are the proposed results technically achievable?																
8. Probability that research results will be applied (see rating scale)																
9. Research capabilities in LDCs and potential for expansion																
10. Research capabilities in U.S.																
11. Institutional preparedness in LDCs																
12. Institutional preparedness in U.S.																

SUMMARY RATINGS Rating Scale:

(Use numerical values for rating)

High = 3
Med = 2
Low = 1

#3 & #6 High = 1
Med = 2
Low = 3

#5 Less than 5 years = 3
6 - 10 yrs = 2
over 10 yrs = 1

#8 High = 5
Med = 3
Low = 1

Table 15. Priority Rating: Possible Research Program Areas in Fisheries and Aquaculture.

5.2.1 Data Collection

The data used in the inventory of university capabilities were obtained in a number of ways. Initially a letter was mailed to all universities on the BIFAD "Roster of Universities Having the Interest and Capability to Participate in the Title XII Activities", requesting a copy of the BIFAD questionnaire along with any updates. It was explained that this questionnaire would be helpful in gathering information for the capability inventory. The BIFAD questionnaire proved helpful for initial contact, but it proved to be very limited in content since it was primarily designed for agriculture purposes and had very little emphasis on fisheries and aquaculture.

To acquaint the university community with the project and at the same time to allow for university imput, the Fisheries Research Planning Workshop was held in Denver, Colorado, on December 14 - 15, 1977. Representatives from 47 universities and institutions attended two days of conferences and discussions. The proceedings of the Workshop were published in April 1978 and sent to the attendees and interested parties. The workshop provided the opportunity to meet with representatives from the various institutions to whom further correspondence would be addressed, to determine interest and desire for participation in collaborative research, to become acquainted with and record research activities, to allow the universities to express their ideas of LDC needs, to suggest how they could address these needs and, finally, to specify how they felt they could fit into the Title XII collaborative Research Program.

As a result of the limited scope of the BIFAD questionnaire, a survey form (Table 16) specifically aimed toward generating information in fisheries and aquaculture not previously acquired was designed. This form was sent to all universities and institutions which had expressed interest in participating in CRSPs.

SURVEY SHEET

1. What is your perception of the research needed to provide a sound scientific basis for expansion of aquaculture or small-scale fisheries in lesser developed countries?

2. Regional identification of above needs (country, region, etc.)

3. How and in what manner did the focus of these needs arise?
   a. Direct request from LDC (if so, from which level - government, institute, industry, individual)?

   b. Interest generated within your institute (department, individual).

   c. Contract or other funding group.

   d. Other

4. Do you have any specific linkages with LDC's (institutes, contracts project, industry, individuals)?

5. Have you ever had an exchange of teaching staff between LDC's and your institute? If so, when and where?

Table 16: United States University Survey Forms

6. Who on the Faculty is both willing and available to work in LDC's?

   a. Full Time

   b. Part Time

   c. Who has Foreign Language Competence?

   d. Which languages?

   e. How many have served abroad successfully? Where, with whom, when?

   f. In what research fields are the above?

7. How many graduate students, including post-doctoral, would be available?

   a. Full Time

   b. Part Time

   c. Who has Foreign Language Competence?

   d. Which languages

   e. How many have served abroad successfully? Where, with whom when?

   f. In what research fields are the above?

8. Should a problematic area show a need for an inter-disciplinary research project, would your institute have the capability of undertaking it? If so, explain?

9. List Physical facilities on campus , or available to you, pertaining to Fisheries or Aquaculture Capabilities.

a. Library

b. Computer

c. Laboratories and Equipment

d. Experimental ponds, etc.

10. If you have current research project(s) in either or both the U.S. and LDC's

a. What is/are the project(s) duration?

b. What is/are the project(s) pay off?

c. What is the target population?

11. Could your present project(s) in LDC's be expanded from country or area-specific to a more generalized geographic concept and still be viable? Explain.

12. Has the university had any experience in collaborative research with other U.S. universities in any field? Which, When?

a. In Fisheries or Aquaculture?

13. Is the university willing to recruit researchers from other institutes for a fishery program?

14. How much money might be available to the university for a collaborative research program from sources other than Title XII, USAID?

15. List of recent (5 years) publications showing specific capabilities in Fisheries and Aquaculture.

16. Is the university interested in participating and committing itself to a long term program (at least 5 years).

17. Do you have an administration set up to handle a) overseas research; b) Title XII funding mechanics?

18. Given the problem of helping the small-scale, artisanal fisherman/aquaculturist on a global or certainly broad regional basis and, after assessing your capabilities, interests, and knowledge of LDC needs, what research program(s) would you initiate?

Site visits were then arranged for the institutions showing both a strong desire and a high potential for working within the CRSP framework. A listing of these institutions is contained in Table 17. The purposes of the visits were to: support and supplement material already received, discuss the potential of the Title XII CRSP from the university viewpoint, meet with the administration, faculty, and staff interested in collaborative research; survey the facilities; discuss the survey; and review university interest in long-term collaborative research in fisheries or aquaculture, given that such research would include a commitment of university resources.

Selection of the universities to visit was made by the panel of advisors with AID concurrence. The visits were based on the BIFAD roster of eligible universities, information gathered at the Fisheries Planning Workshop and from specific requests from the institutions themselves. Visits were made to over 30 universities and institutions showing interest in the program. Every attempt was made to have as much personal contact with university research personnel as possible.

5.2.2 Data Analysis

The data collected from the various U. S. university sources were utilized in several ways. A matrix (Tables 18 and 19) was developed to show research capabilities in various aspects of fisheries and aquaculture for each university included in the study. The matrix was based on material received from the universities. Each university or institution on the list was sent a copy of its input and requested to verify and update. No response to this request was assumed to mean agreement with the contents (as was stated in the letter). Therefore it is felt that the information on the capability matrix is current and in agreement with the institution's perception of its research capabilities.

Auburn University

University of California and California State University System (Represented by University of California, Davis)

Colorado State University

Cornell University

Duke University, Marine Institute

Louisiana State University

Massachusetts Institute of Technology (MIT)

Michigan State University

North Carolina State University

Oceanic Institute (Hawaii)

Oklahoma State University

Purdue University

Rutgers, the State University of

South Carolina State University

Southern Illinois University, Carbondale

Texas A and M University

University of Alaska

University of Arkansas at Pine Bluff

University of Colorado

University of Delaware

University of Florida

University of Georgia

University of Hawaii

University of Idaho

University of Maine

University of Miami (Rosenstiel School of Marine and Atmospheric Science)

University of Michigan

University of Rhode Island

University of Washington

Woods Hole Oceanographic Institute

Table 17. United States Universities and Institutions Visited

AQUACULTURE	SOCIO-ECONOMICS												FOOD TECHNOLOGY											PRODUCTION SYSTEMS					DISEASE CONTROL				GENE-TICS		NUTRITION & FEED TECHNOLOGY				BREEDING & SEED PRODUCTION								
	EXTENSION	STATISTICS	CULTURAL ASPECTS	CO-OPERATIVES	MANAGEMENT	CREDIT	COST/BENEFIT ANALYSIS	GOVERNMENT POLICY	PRICING	SUPPLY/DEMAND ANALYSIS	LABOR SUPPLY	MARKETING	ENERGY CONSERVATION	TRANSPORTATION & DISTRIBUTION	STORAGE	PROCESSING	PRESERVATION	HANDLING	PRODUCT DEVELOPMENT	PESTS & PREDATORS	ENVIRONMENTAL CONTROL	HARVESTING METHODS	CULTURE SYSTEMS	FACILITIES	HEATING	SIZE SELECTION	TOXICOLOGY	BACTERIOLOGY	VIROLOGY/ PARASITOLOGY	HYBRIDIZATION	SELECTION	FEED SOURCES	FEEDING	FEED FORMULATION PROCESSING	NUTRITIONAL REQUIREMENTS	SPECIES SELECTION	ENVIRONMENTAL FACTORS	BEHAVIOR	REPRODUCTIVE PHYSIOLOGY	CRUSTACEA 4	MOLLUSKS 3	FIN FISH 2	ALGAE 1	MARINE c	BRACKISH b	FRESH a
Alaska																											X																	X		
ARKANSAS/PINE BLUFF																						X	X	X	X				X				X			X	X									
AUBURN	X	X				X						X									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X			X	X
CALIFORNIA SYSTEMS	X		X		X		X	X		X		X	X	X	X	X	X	X			X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
COLORADO																					X		X	X	X										X	X	X	X	X			X				X
COLORADO STATE	X		X		X																		X				X	X	X				X	X	X	X	X					X				X
COLUMBIA																																														
CONNECTICUT/STORRS	X	X		X																	X		X				X	X	X														X		X	
CORNELL	X	X	X		X		X	X	X	X		X		X	X	X	X	X	X		X		X	X				X	X			X	X	X	X	X	X	X	X		X	X	X		X	
DELAWARE													X		X	X	X	X		X	X		X	X	X				X			X	X	X			X	X		X		X	X	X	X	
DUKE																							X				X										X	X	X	X	X		X	X	X		
FLORIDA					X		X			X						X			X		X									X	X						X		X			X		X		X
FLORIDA A & M																																														
GEORGIA	X																										X	X	X															X		X
HAWAII	X				X	X			X	X		X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		
IDAHO	X		X																				X	X	X			X	X				X	X	X		X	X	X			X				X
KANSAS STATE																							X										X	X	X				X			X				X
LOUISIANA STATE			X																		X		X										X	X	X		X			X				X	X	X
MAINE			X		X							X			X													X		X	X						X	X	X	X	X	X		X	X	X
MASSASHUSETTS																X																														
MASSACHUSETTS INST. TECH	X				X		X			X	X	X			X	X	X	X	X																											
MIAMI	X			X	X								X									X	X				X	X	X			X	X			X	X	X	X	X	X	X	X	X		
MICHIGAN					X		X		X	X													X	X											X							X		X		X
MICHIGAN STATE	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X			X		X	X	X	X	X	X	X						X				X			X		X		X
MISSISSIPPI STATE					X	X	X					X				X	X	X												X	X		X	X	X						X		X		X
MURRAY STATE					X																X		X	X				X	X						X	X	X	X			X			X	X	X
NEW HAMPSHIRE	X			X	X			X				X				X	X		X				X	X	X	X	X	X	X			X	X	X	X	X	X		X		X	X	X		X
NO. CAROLINA STATE												X	X			X			X				X												X		X	X				X		X	X	X
OKLAHOMA STATE	X							X				X							X	X				X	X					X	X		X		X	X	X	X		X		X				X
OREGON STATE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PURDUE					X	X		X				X											X				X	X	X	X	X	X	X		X	X	X	X			X				X
RHODE ISLAND	X		X		X		X			X		X				X			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RUTGERS																X	X		X		X		X					X				X	X	X	X							X		X	X	X
SO. CAROLINA M.R.I.	X							X								X		X		X		X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SO. ILLINOIS/CARBONDALE																		X		X			X	X	X	X			X			X	X	X	X	X	X			X						X
TEXAS A & M	X	X			X		X		X	X	X	X			X	X		X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X
VERMONT																																														
VIRGINIA I.M.S.	X																						X				X	X	X	X	X				X			X	X		X	X		X		X
WASHINGTON			X			X			X				X			X	X	X		X		X	X	X		X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
WEST VIRGINIA																							X				X																			
HOODS HOLE INST.																																														

Table 18. Compilation of Institutional Capabilities in Aquaculture

FISHERIES	SOCIO-ECONOMICS														FOOD TECH					FISH RESOURCE MGMT						SPECIES & STOCKS							LIMNOLOGY & OCEANOGRAPHY								
	EXTENSION	CREDIT	COST/BENEFIT ANALYSIS	MANAGEMENT	PRICING	GOVERNMENT POLICY	STATISTICS	POPULATION	CULTURAL ASPECTS	CO-OPERATIVES	SUPPLY/DEMAND ANALYSIS	MARKETING	ENERGY CONSERVATION	TRANSPORTATION & DISTRIBUTION	PROCESSING	STORAGE	HANDLING	GEAR & METHOD	VESSEL DESIGN	CONTROLLING COMPETITORS	REGULATION	STOCKING	ENVIRONMENTAL MAINTENANCE & IMPROVEMENT	ASSESSMENT	RESOURCE	MIGRATION	MATURITY/ REPRODUCTION	AGE & GROWTH	BEHAVIOR	PHYSIOLOGY	FOOD	BIOLOGICAL	CHEMICAL	PHYSICAL	CRUSTACEA 4	MOLLUSKS 3	FIN FISH 2	OTHER 1	MARINE c	BRACKISH b	FRESH a
ALASKA																													X	X						X			X		
ARKANSAS/PINE BLUFF																																									
AUBURN	X																																				X				X
CALIFORNIA SYSTEMS	X		X											X	X	X							X	X				X		X	X			X		X		X		X
COLORADO																															X	X	X			X				X	
COLORADO STATE	X		X						X											X	X	X	X			X	X	X	X	X	X	X	X			X		X		X	
COLUMBIA		X	X	X	X	X	X				X	X			X								X													X		X			
CONNECTICUT/STORRS	X						X			X		X		X				X		X	X		X										X			X		X		X	
CORNELL	X		X		X	X	X		X		X	X	X	X	X	X		X		X		X	X	X	X	X	X	X	X	X	X	X			X	X		X	X	X	
DELAWARE				X	X			X			X		X		X	X	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	X		X			
DUKE																										X	X	X	X	X		X	X		X	X	X		X	X	
FLORIDA	X			X	X		X			X	X	X	X		X	X	X	X			X		X	X	X	X	X							X	X	X		X		X	
FLORIDA A & M																							X														X		X	X	X	
GEORGIA				X					X							X																										
HAWAII																																									
IDAHO				X																X			X			X	X	X	X	X	X	X	X	X			X		X	X	X	
KANSAS STATE																																									
LOUISIANA STATE																												X									X		X		
MAINE				X											X	X	X	X								X	X		X			X	X	X			X		X		X	
MASSACHUSETTS	X			X					X	X		X			X								X	X				X			X	X	X		X	X	X	X			
MASSACHUSETTS INST. TECH	X		X	X	X		X				X	X		X	X	X	X	X	X											X						X		X		X	
MIAMI	X			X		X	X						X					X					X	X	X	X	X	X	X	X	X	X	X	X	X	X		X			
MICHIGAN																								X			X	X	X					X	X	X					
MICHIGAN STATE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	
MISSISSIPPI STATE		X	X	X				X				X																		X	X						X	X		X	
MURRAY STATE																							X					X		X		X	X	X			X			X	X	
NEW HAMPSHIRE	X		X	X	X	X	X			X	X	X	X				X		X		X	X	X	X			X	X	X	X	X	X	X	X			X		X	X	X	
NO. CAROLINA STATE							X	X	X			X			X										X	X	X		X	X						X		X	X	X	
OKLAHOMA STATE	X			X											X		X			X	X	X	X	X	X	X	X	X				X	X	X			X				X	
OREGON STATE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
PURDUE		X		X		X						X																													
RHODE ISLAND	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X			X	X						X	X				X	X	X		X		
RUTGERS									X	X					X	X								X	X	X	X	X	X	X	X	X				X	X		X	X	
SO. CAROLINA M.R.I.	X			X	X	X	X					X			X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	
SO. ILLINOIS/CARBONDALE	X																					X																			
TEXAS A & M	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X								X	X	X	X		X		X	X	
VERMONT																								X	X													X	X		
VIRGINIA I.M.S.																		X						X													X		X		
WASHINGTON	X			X	X	X					X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
WEST VIRGINIA																													X								X		X		
WOODS HOLE INST.																						X	X						X	X	X				X	X	X		X		

Table 19. Compilation of Institutional Capabilities in Fisheries

To strengthen and support the inventory of capabilities, a second matrix (Table 20) was developed showing full-time equivalent faculty (FTE) engaged in fisheries and aquaculture and related research facilities and both past and current linkages with foreign countries. Again, information used in this matrix was supplied by the various institutions. Each university on the list was given an opportunity to review its input in the same manner as in the capability matrix. The material showing FTE faculty has been verified, updated or assumed acceptable (through non-response), and for the purpose of this study, can be considered current and accurate. However, it must be pointed out that there may not be a parallel determination of FTEs among universities; for instance, research assistants may be included as FTE for one university and not for another. No attempt was made to define FTE to the universities other than stressing they must be on the active faculty list.

A folder was prepared for each responding university containing all pertinent material submitted (courses, staff biographies, publication, etc.), in addition to the BIFAD questionnaire, the RDA survey, and the site visit report (where applicable). This material was then summarized on "cap" sheets which together with the aforementioned matrices were used in the final process of determining each university's overall or specific capacity to work within a collaborative research program.

5.2.3 Criteria for Participation

Before starting the final task in this section, which was the determination of institutions suitable for involvement in collaborative research programs, criteria were established to help in the selection of qualified institutions. To qualify for participation in collaborative research a university or university system must have demonstrated:

1. high performance potential as judged by commitment or willingness to participate in CRSPs,

	FACULTY (FTE) FISH-ERIES	AQUA-CULTURE	COM-BINED	FACILITIES	COUNTRY LINKAGES
ALASKA	no information sent				
ARKANSAS/PINE BLUFF	0	1	1		
AUBURN	¾	41¼	42		
CALIFORNIA SYSTEM	27	55	62		
COLORADO	2	1	3		
COLORADO STATE	16	0	16		
COLUMBIA	2	0	2		
CONNECTICUT/STORRS	10	0	10		
CORNELL	16	8	24		
DELAWARE	23	9	32		
DUKE	7	4	11		
FLORIDA	3	8	11		
FLORIDA A & M	not specified		2		
GEORGIA	13	1	14		
HAWAII	14	14	28		
IDAHO	7	7	14		
KANSAS STATE	not specified				
LOUISIANA STATE	not specified				
MAINE	9	14	23		
MASSACHUSETTS	19	0	19		
MASSACHUSETTS INST. TECH	not specified		6-13		
MIAMI	33	2	35		
MICHIGAN	11	14	25		
MICHIGAN STATE	16	14	30		
MISSISSIPPI STATE	12	0	12		
MURRAY STATE	3	1	4		
NEW HAMPSHIRE	3	4	7		
NO. CAROLINA STATE	4½	1½	6		
OKLAHOMA STATE	8	2	10		
OREGON STATE	29	12	41		
PURDUE	2	2	4		
RHODE ISLAND	18¾	7½	26		
RUTGERS	9	0	9		
SO. CAROLINA M.R.I.	4½	1½	6		
SO. ILLINOIS/CARBONDALE	2	3	5		
TEXAS A & M	35	15	50		
VERMONT	1	0	1		
VIRGINIA I.M.S.	7½	8½	16		
WASHINGTON	50	12	62		
WEST VIRGINIA	not specified				
WOODS HOLE INST.	not specified		105		

Table 20 Faculty, Facilities and Foreign Linkages in Fisheries and Aquaculture

2. high level of capability as judged by staff and past performance,

3. adequate facilities,

4. successful linkages to LDCs.

5.2.4 Determination of United States Institutional Capacity for Involvement in Collaborative Research Programs

The data collected from the universities and compiled as illustrated in Tables 18-20 of Section 5.2.2 were presented as the members of The Research Advisory Panel for review. The panel was requested to propose a classification scheme for identifying university capabilities in a logical and consistant way. The ultimate decision was to categorize the institutions using a combination of breadth and scope of research capabilities, number of FTE faculty, facilities, and foreign linkages. The resulting categories and the list of institutions within each are presented in Section 4.1

The forms used to compile university capabilities (Tables 18 and 19) classify research areas in groups and elements based on the Elements of Fisheries and Aquaculture Production illustrated earlier in Figure 2 . The elements represent the most basic level of activity identified. Related elements are combined into groups representing broader subject areas. Thus, for Capture Fisheries, the group heading of Breeding and Seed Production includes the elements: Reproductive Physiology, Behavior, Environmental Factors and Species Selection. The distinction between groups and elements was important in considering university capabilities.

In inventorying university capabilities, those included in Categories A and B (Section 4.1) generally have broad research experience identifiable by research group. The capabilities of Category C universities, on the other hand, are related to individual elements of groups and are, thus, not quite as encompassing.

5.3 Inventory of LDC Research Capabilities

An important element of the collaborative research concept is the involvement of the LDCs. To determine which ones have the necessary technical experience and facilities to contribute to such programs, an inventory of LDC research capabilities was made.

The term LDC was found to have at least four different definitions according to the source material used. Since there was wide diversity of opinion on this matter, the following guidelines were used for determining the LDCs to be studied. For the purpose of the study, an LDC is a country whose per capita income is about $200 per annum. To be included in this study, the country was also required to have significant activities or interests in capture fisheries and /or aquaculture.

5.3.1 Data Collection

The data used for the inventory of LDC research facilities came from the literature search and site visits. The literature search (References, Section 6.0) of fifty-two LDCs was made to determine what research was being conducted in fisheries and aquaculture, what type of research facilities were available at universities, government installations, and international research centers, the number of faculty and staff, and wherever possible, the linkages with United States universities. Sources for the literature search and the methods are the same as explained in the previous section and will not be repeated here.

To supplement the information gathered from the literature search and to add current information, it was decided to make on-site visits to selected countries. Determination for site visits was made on the basis of recommendations of university personnel, USAID, and a consensus of the research advisors. Those selected for visits were:

- Columbia
- Egypt

- Fiji
- Ghana
- Guinea-Bissau
- India
- Indonesia
- Ivory Coast
- Kenya
- Nigeria
- Philippines
- Senegal
- Sri Lanka
- Sudan
- Thailand
- Tunisia
- Brazil
- Costa Rica
- Israel
- Venezuela.

The site visits were made by RDA staff and RAP members, Richard Neal, AID Aquaculture Advisor, and Philip M. Roedel, AID Fisheries Advisor. A survey form was taken to each site visited similar to that taken to the United States institutions. The material obtained from these site visits was used to supplement the material gathered from the literature search, and to allow for a first-person impression of facilities and experience. These visits were not limited solely to LDCs for reasons noted earlier.

5.3.2 Analysis

Much of the material used in the capability inventory came from experts having current first hand knowledge of fishery or aquaculture activities in various LDCs. This knowledge was acquired in several ways; from expatriates who had recently lived in the particular country, current research or consulting work, and meeting with host-country nationals.

The literature and the reference search, information reqarding the nature of the research in fisheries and in aquaculture for each of the LDCs was compiled. This information was then compared on a country-by-country basis with that supplied by the visit report. Relevant data included in the staff report were utilized to assist in the analysis of LDC institutions. The information provided by the literature was helpful in providing quantitative details on the nature and the type of research as well as the relative volume. However, the most reliable estimates of the quality of the LDC institutions with regard to staff facilities and research capabilities are those provided by USAID, RDA staff and RDA advisors' visit reports

Those institutions which were not visited but have been recommended for participation in collaborative research in a supporting role were included on the basis of first-hand knowledge and information supplied by other experts not directly involved in the survey. These experts included university faculty members, State Department staff, FAO/UNDP fisheries personnel, and individuals engaged in the international fishing industry.

The list of LDC institutions recommended for participation in collaborative research with universitites is based on the most accurate and reliable information available at the time of this report. Due to restrictions of time, and funds, it was not possible to include every LDC institution. While the search was not exhaustive, the results do fairly represent the consensus of those involved.

6.0 REFERENCES

By most standards, the following list of nearly 600 references would seem unusually long for a report of this type. In this case, however, both the nature of research and development needs and the current status of research in the field of fisheries and aquaculture was required for more than 50 developing countries. This necessitated the collection and detailed review of a significant amount of material in addition to the more normal background and general state-of-the-art publications.

The references listed here are either directly cited in the body of this report or were used as a source of specific historical, current or general background information concerning the state of aquaculture and fisheries in the developing countries. The list itself would be substantially longer were it not restricted primarily to information relating directly to the LDCs. Publications reporting fisheries research specific to the United States, Europe, Japan, Australia and some Latin American countries have not been included, although they may bear in part on subjects presented and discussed here.

The listing itself is divided into five broad areas for easier reference, as: General, Africa, Asia, Near East, and Latin America and the West Indies. Many references considered General apply to some or all of these geographic divisions.

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APPENDIX A: DEFINITION OF TERMS

APPENDIX B: COMMONLY USED ACRONYMS

APPENDIX C: INTERNATIONAL FUNDING ORGANIZATIONS ACTIVE IN DEVELOPING COUNTRIES

Definition of Terms

Collaborative Research	Research whether basic, applied, or adaptive which is: 1) of sufficient scope to require multi-institutional involvement, 2) jointly supported by AID and participants, 3) aimed at common LDC problems with high pay-off potential, 4) long term (3 year minimum) 5) non-country specific. (BIFAD, 1977 R-19)
Collaborative Research Support Program (CRSP)	An arrangement which facilitates collaboration among United States universities, United States Department of Commerce, United States Department of Agriculture, International Agricultural Research Centers, other research institutions, private agencies and industry, and developing country universities and other research institutions on a problem-oriented basis in a common research and development problem to solve a food and nutrition problem. (Ibid.: R-19)
Eligible Institution	Those colleges or universities in each state, territory or possession of the United States or the District of Columbia which qualify as 1862 or 1890 Land Grant 1966 Sea Grant universities or other United States colleges or universities which: 1) are interested in exploring their potential for collaborative relationships with agricultural institutions, and with scientists working on significant programs designed to increase food production in developing countries; 2) having a capacity in the agricultural sciences;

	3) are able to maintain an appropriate balance of teaching, research, and extension facilities; 4) have the capacity, experience and commitment with respect to international agricultural aspects; 5) are able to contribute to solving problems addressed by this title. (Ibid.: R-19)
Lesser Developed Countries (LDCs)	For the purpose of this report, those countries whose per-capita annual income is about $200.
Target Population	1) Fishermen and other persons employed in cultivating and harvesting food resources from salt and fresh waters; 2) The poorest majority in agriculturally underdeveloped countries. (Ibid.: R-19)
Small-scale Fishermen	Rural inland and coastal fishermen in the poorest of the developing countries whose catch goes largely for human consumption, who are themselves poor, and who fish with relatively unsophisticated gear and vessels in nearshore marine environment (Roedel, 1978: R-147)
Aquatic Farmer (Aquaculturalist)	Those individuals involved in the farming and husbandry of fresh water and marine organisms. (Bardach et.al., 1972: R-13)
Production	Catch from wild stocks (capture fisheries) or harvest of cultured stocks (aquaculture).
Research Area	Major identifiable cultural and economic systems; e.g., capture fisheries and aquaculture
Program Area	A problem-oriented research topic representing a LDC need.

APPENDIX B

COMMONLY USED ACRONYMS

COMMONLY USED ACRONYMS

ACASTD:	Advisory Committee on the Application of Science and Technology to Development, UN (Also known as ACST or ACAST)
ACMRR:	Advisory Committee on Marine Resources Research, FAO
ADB:	Asian Development Bank
AfDB:	African Development Bank
AFS:	American Fisheries Society
AID:	Agency for International Development
AIDC:	Asian Industrial Development Council
AMSA:	Australian Marine Sciences Association
ANZAAS:	Australia and New Zealand Association for the Advancement of Science
ASEAN:	Association of South East Asian Nations
ASFIS:	Aquatic Sciences and Fisheries Information Service, FAO/IOC
ASLO:	American Society of Limnology and Oceanography
ASPAC:	Asian and Pacific Council
BCSIR:	Bangladesh Council of Scientific and Industrial Research
BIFAD:	Board International of Food and Agriculture Development, U.S.
BID:	Banco Interamericano de Desarrollo
BIRF:	Banco International de Reconstruccion y Fomento (See IBRD)
BIS:	Bank for International Settlements
CARICOM:	Caribbean Community
CARPAS:	Regional Fisheries Advisory Commission for the Southwest Atlantic (Also Comision Asesora Regional de Pesca el Sud-occudental)
CBC:	Chad Basin Commission
CBM:	Chase Manhattan Bank

CCDP: Central American Fishery Development Commission (Also Comision Centroamericana de Desarrollo Pesquero)

CCEIC: Central American Economic Committee (Also Comite de Cooperacion Economica del Itsmo Centroamericano)

CECAF: Fishery Committee for the Eastern Central Atlantic

CGIAR: Consultative Group on International Agricultural Research

CICAR: Cooperative Investigation of the Caribbean and Adjacent Regions

CIDA: Canada International Development Association

CIFA: Committee for Inland Fisheries of Africa

CIM: Cooperative Investigations of the Mediterranean, IOC/GFCM/CIESM

CIOA: Committee on International Ocean Affairs

CERBOM: Centre d'etudes et de recherches de biologie et d'oceanographic medical (Also Center for Investigations and Biological Research and Medical Oceanography)

CIFRI: Central Inland Fisheries Research Institute

CILSS: Club of the Sahel, Permanent Interstate Committee for Drought Control in the Sahel

CMFRI: Central Marine Fisheries Research Institute (India)

CODECA: Caribbean Corporation for Economic Development

CODOT: Consortium for the Development of Technology (University of Rhode Island, Washington University, University of California, University of Wisconsin, Michigan State University)

COFI: Committee on Fisheries, FAO

COMSER: Committee on Marine Science, Engineering and Resources (Stratton Commission)

CSIRO: Commonwealth Scientific and Industrial Organization (Australia)

CSK: Study on the Kuroshio, IOC

DANIDA: Danish International Development Agency

DOD: Deutsches Ozeanographisches Datenzentrum (German Oceanographic Date Centre)

DSE:	Deutsche Stiftung fur internationale Entewicklung (German Foundation for International Development)
EAC:	East African Community
EADB:	East African Development Bank (AfDB)
EAFRO:	East African Freshwater Research Organization
EAFFRO:	East African Freshwater Fisheries Research Organization
EAMFRO:	East African Marine Fisheries Research Organization
EBSA:	Estuarine and Brackish-water Sciences Association
ECA:	Economic Commission for Africa, UN
ECAFE:	Economic Commission for Asia and the Far East, UN
ECE:	Economic Commission for Europe, UN
ECLA:	Economic Commission for Latin America, UN
ECWA:	Economic Community of Western Asia
ECWAS:	Economic Community of West African States
EDF:	European Development Fund
EEC:	European Economic Community (Common Market)
EIFAC:	European Inland Fisheries Advisory Commission, FAO
ESCAP:	Economic and Social Commission for Asia and the Pacific, UN (Formerly ECAFE)
FAO:	Food and Agriculture Organization of the United Nations
FEO:	Fishmeal Exporters Organization
FRB:	Fisheries Research Board of Canada
GATT:	General Agreement on Tariffs and Trade
GCFI:	Gulf and Caribbean Fisheries Institute
GEITSPAP:	Group of Experts on Long-Term Scientific Policy and Planning, IOC
GESAMP:	Group of Experts on the Scientific Aspects of Marine Pollution (IMCO/FAO/UNESCO/WHO/WMO/IAEA/UN)
GFCM:	General Fisheries Council for the Mediterranean, FAO

IABO: International Association of Biological Oceanography, IUBS

IAEA: International Atomic Energy Agency

IAGFCC: International Association of Game, Fish and Conservation Commissioners

IAPH: International Association of Ports and Harbours

IATTIC: Inter-American Tropical Tuna Commission

IAU: International Association of Universities

IBEC: International Bank for Economic Cooperation (World Bank)

IBP: International Biological Program, ICSU

IBRD: International Bank for Reconstruction and Development (Also known as World Bank)

ICAITI: Instituto Centroamericano de Investigacion y Technologia Industrial

ICCAT: International Commission for the Conservation of Atlantic Tunas

ICES: International Council for the Exploration of the Sea

ICJ: International Court of Justice

ICLARM: International Center for Living Aquatic Resources Management

ICMARD: International Center for Marine Resources Development, University of Rhode Island

ICNAF: International Commission for the Northwest Atlantic Fisheries

ICO: Interagency Committee on Oceanography, U.S.

ICOMIA: International Council of Marine Industry Associations

ICSEM: International Commission for the Scientific Exploration of the Mediterranean

ICSPRO: Inter-Secretariat Committee on Scientific Problems Relating to Oceanography

ICSU: International Council of Scientific Unions

IDA: International Development Association (An agency of the International Bank for Reconstruction and Development, World Bank)

IDB:	Inter-American Development Bank
IDOE:	International Decade of Ocean Exploration, UN/IOC
IDRC:	International Development Research Centre (Ottawa, Canada)
IFC:	International Finance Corporation (Affiliate of World Bank)
IFCO:	International Food Policy Research Institute
IGO:	Intergovernmental Organization
IIOE:	International Indian Ocean Expedition, SCOR
ILO:	International Labor Organization
ILS:	International Limnological Society, ICSU
IMCO:	Inter-Governmental Maritime Consultive Organization, UN
IMF:	International Monetary Fund
IMPE:	Instituto Nacional de Pesca de Ecuador
INFOCOOP:	Instituto Nacional de Formento Cooperative (Costa Rica)
INFONAC:	Instituto de Fomento Nacional (Nicaragua)
INPFC:	International North Pacific Commission
IOBC:	Indian Ocean Biological Centre
IOC:	Intergovernmental Oceanographic Commission, UNESCO
IOF:	International Oceanographic Foundation, Miami University
IOFC:	Indian Ocean Commission, FAO
IOP:	International Indian Ocean Fishery Survey and Development Programme, FAO
IPFC:	Indo Pacific Fisheries Council, FAO
ISOS:	International Southern Ocean Studies, IDOE
ISR:	Institute of Seaweed Research
IUBS:	International Union of Biological Sciences, ICSU
IWS:	International Whaling Commission (London)
MAMBO:	Mediterranean Association for Marine Biology and Oceanology

MBA:	Marine Biological Association (Plymouth, England)
MTS:	Marine Technology Society
NAS:	National Academy of Sciences
NASCO:	National Academy of Sciences Committee on Oceanography
NATO:	North Atlantic Treaty Organization
NGO:	Non-governmental Organization
NMFS:	National Marine Fisheries Service, NOAA
NOAA:	National Oceanographic and Atmospheric Administration, U.S.
NORAD:	Norwegian Agency for International Development
NSF:	National Science Foundation
OAS:	Organization of American States (Also Pan American Union)
OASIS:	Oceanic and Atmospheric Scientific Information System, NOAA
ODM:	British Ministry of Overseas Development
OECD:	Organization for International Development
ORANO:	Organisme de recherches sur l'alimentation et la nutrition Africaine (African Food and Nutrition Research Organization)
OUA:	Organization for African Unity
PCSP:	Permanent Commission of the Conference on the Use and Conservation of the Marine Resources of the South Pacific
PEFU:	Panel of Experts on Fish Utilization, FAO
PSA:	Pacific Science Association
RAFE:	Regional Office for Asia and the Far East, FAO
RAFR:	Regional Fisheries Office for Africa, FAO
RFCWA:	Regional Fisheries Commission for Western Africa, FAO
RLAT:	Regional Office for Latin America, FAO
RNEA:	Regional Office for the Near East, FAO

SCIBP: Special Committee for the International Biological Program, ICSU

SCOR: Scientific Committee on Oceanographic Research, ICSU

SCSP: South China Sea Fisheries Development and Coordinating Program, FAO

SEAFDEC: Southeast Asian Fisheries Development Center

SEASCO: Science Cooperation Office for Southeast Asia, UNESCO

SEATO: Southeast Asia Treaty Organization

SIDA: Sweden International Development Association

SIECA: Secataria Permanete del Tratado General de Integracion Economica Centroamericana (Permanent Secretariat of the General Treaty on Central American Economic Integration)

SPC: South Pacific Commission

SPIFDA: South Pacific Islands Fisheries Development Agency

SUDEPE: Superintendencia de Desenolvimento de Pesca

TFRI: Taiwan Fisheries Research Institute

UNCASTD: United Nations Advisory Committee on the Application of Science and Technology to Development

UDEAC: Union covaniere et Economique de l'Africa Centrale

UDEAO: Union Dovaniere des Etats de l'Africa de l'Ouest (Upper Volta)

UEAC: Union of Central African States (Union de etats de l'Afrique Centrale)

UN: United Nations

UNCDF: German Foundation for Developing Countries

UNEP: United Nations Environmental Program

UNDP: United Nations Development Program

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNITAR: United Nations Institute for Training and Research

UNSO: United Nations Sahelian Office

USAID: United States Agency for International Development

VIMS: Virginia Institute of Marine Science

VNIRO: All-Union Research Institute of Marine Fisheries and Oceanography (USSR)

WAFR: World Appraisal of Fishery Resources, FAO

WASA: West African Science Association

WECAFC: Western Central Atlantic Fishery Commission

WFP: World Food Program, FAO/UN

WHO: World Health Organization

WMO: World Meteorological Organization, UN

APPENDIX C

INTERNATIONAL FUNDING ORGANIZATIONS

ACTIVE IN THE DEVELOPING COUNTRIES

INTERNATIONAL FUNDING ORGANIZATIONS ACTIVE IN THE DEVELOPING COUNTRIES

African Development Bank (AfDB)
BP 1385
Abidjan, Ivory Coast

Asian and Pacific Council (ASPAC)
Registry of Science and Technology Services
Canberra, Australia

Asian Development Bank (ADB)
Commercial Center
P.O.B. 126, Makati
Rizal, D-708
Philippines

Association of South East Asian Nations (ASEAN)
Bangkok, Thailand

Bank for International Settlements (BIS)
7 Zentralbahnstrasse
CH 4002
Basle, Switzerland

Canada International Development Association (CIDA)
Ottawa, Canada

Caribbean Community (CARICOM)
Bank of Guyana Building
P. O. Box 607
Georgetown, Guyana

Caribbean Organization
San Juan, Puerto Rico

Chase Manhattan Bank
New York, New York

Colombo Plan for Cooperative Economic Development in South and South-East Asia
12 Melbourne Avenue
P. 0596
Colombo, Sri Lanka

Commission for Technical Cooperation in Africa South of the Sahara
Watergate House, York Building
London, England

Consultative Group on International Agricultural Research (CGIAR)

Cooperative Investigations in the Caribbean and Adjacent Regions (CICAR)

Danish International Development Agency (DANIDA)

East African Community (EAC)
P. O. Box 343
Jinja, Uganda

East African Development Bank - 195
Res. Res. Council
P.O.B. 1003
Arusha, Tanzania

East-West Food Institute
1777 East West Road
Honolulu, Hawaii 96822

Economic and Social Commission for Asia and the Pacific (ESCA), UN

Economic Commission for Africa (ECA), UN
African Hall
Addis Ababa, Ethiopia

Economic Commission for Asia and the Far East (ECAFE), UN
Sala Santitham
Bangkok, Thailand

Economic Commission for Europe (ECE), UN
Palais de Nations
Geneva, Switzerland

Economic Commission for Latin America (ECLA), UN
Santiago, Chile

Economic Commission for West Africa (ECA), UN

Economic Commission for West African States (ECWAS)
Lagos, Nigeria

Economic Community of Western Asia (ECWA)

European Development Fund

European Economic Community (EEC), Common Market
236 Southern Building
Avenue de la Joyeuse Entree
Brussels, Belgium

Food and Agriculture Organization of the United Nations (FAO)
Via delle Terme di Caracalla
Rome, Italy

General Agreements on Trade and Tariffs (GATT)

General Fisheries Council for the Mediterranean
c/o FAO-UN
Via Delle Terme di Caracalla
Rome, Italy

German Foundation for Developing Countries (UNCDF)
Berlin, Germany

Gulf and Caribbean Fisheries Institute

Harbors Cooperation
Dar Es Salaam, Tanzania

Indo Pacific Fisheries Council
FAO Regional Office for Asia and the Far East
Bangkok 2, Thailand

Inter-American Development Bank (IDB)
808 17th Street, N.W.
Washington, D.C. 20577

Inter-American Tropical Tuna Commission (IATTC)
Scripps Institute of Oceanography
La Jolla, California

Intergovernmental Oceanographic Commission (IOC)
c/o UNESCO
Place de Fontenoy, Paris 7e, France

Inter-Governmental Maritime Consultive Organization
101 Piccadilly
London, England WIV/OAE

International Association of Biological Oceanography
c/o Institut fur Meereskunde an de Universitat Kiel
Niemannsweg 11, 23 Kiel
Federal Republic of Germany

International Association of Universities (IAU)
1 rue Miollis
Paris 15e, France

International Atomic Energy Agency
Karntnerring 11
A 1010, Vienna
Austria

International Bank for Economic Cooperation (IBEC)
15 Kuznetskiy Most
Moscos, k-31, USSR

International Bank for Reconstruction and Development (IBRD),
World Bank
1818 H Street, N.W.
Washington, D.C. 20433

International Center for Living Aquatic Resources Management (ICLARM)
P. O. Box 43
UP Kiliman Post Office
Quezon City, Philippines

International Commission for Northwest Atlantic Fisheries
Halifax, Nova Scotia, Canada

International Commission for the Scientific Exploration of the Mediterranean Sea (ICSEMS)
16 Blvd. de Suisse
Monaco, Monte Carlo

International Council for the Exploration of the Sea
Charlottenlund Slot 2920
Charlottenlund, Copenhagen, Denmark

International Council for Scientific Unions (ICSU)
51 Blvd. de Montmorency
75 Paris 16e, France

International Development Association (IDA), UN, World Bank
1818 H Street, N.W.
Washington, D.C. 20433

International Development Research Center (IDRC)
P. O. Box 8500
Ottawa, Canada, KIG 3119

International Finance Corporation (IFC), World Bank
1818 H Street, N.W.
Washington, D.C. 20433

International Monetary Fund (IMF), UN
19 and H Street, N.W.
Washington, D.C. 20431

International North Pacific Fisheries Commission (INPFC)
University of British Columbia
Vancouver, B.C.

International Union of Biological Sciences
University of Washington
Department of Zoology
Seattle, Washington 98105

International Whaling Commission
3 Whitehall Place
London, England

National Science Foundation
National Academy of Science
2101 Constitution Avenue, N.W.
Washington, D.C.

Nordic Council
Nordisk Rad Fack 102 10
Stockholm, Sweden

North Atlantic Treaty Organization (NATO)
Maison de l'Europe
67006 Strasbourg
Cedex, France

Norwegian Agency for International Development (NORAD)

Norwegian Cooperative Program

Office of the Commission of European Communities
20 Kersington
Palace Grounds
London, England W84QQ

Organization for Economic Cooperation and Development (OECD)
Chateau de la Muette
2, rue Andre Pascal, 75775
Paris, Cedex 16, France

Organization of African Unity (OUA)
Addis Ababa, Ethiopia

Organization of American States (OAS)
General Secretariat
Washington, D.C. 20006

Pacific Science Association
Bishop Museum
P. O. Box 6037
Honolulu, Hawaii 96818

Pan American Union
Organization of American States
General Secretariat
Washington, D.C. 20006

Permanent Commission for the Northeast Atlantic Fisheries
Ministry of Agriculture, Food and Fisheries
10 Whitehall Place
London, England

Permanent Interstate Committee for Drought Control in the Sahel (CILSS)
Club of the Sahel

Regional Fisheries Advisory Commission for the Southwest Atlantic (CARPAS)

Scientific Committee on Ocean Research (SCOR)
c/o UNESCO
7/9 Place de Tontenoy
Paris, 7e, France

Scientific Council for Africa South of the Sahara
Commission for Technical Cooperation in Africa South of the Sahara
Watergate House, York Building
London, England

South China Sea Fisheries (SECAF)
Development and Coordinating Programme

South Pacific Commission
P. O. Box 9
Noumea, New Caledonia

Southeast Asia Treaty Organization (SEATO)
P. O. Box 517
Bangkok, Thailand

Southeast Asian Fisheries Development Center (SEAFDEC)
Aquaculture Department
Tigbauan, Iloilo, Philippines

Special Committee for the International Biological Program (SCIBP)
7 Marylebone Road
London, N.W. 15HB, England

Sweden International Development Association (SIDA)

Union Dovaniere et Economique de l'Africa Centrale (UDEAC)
Banqui, Central African Republic

Union Dovaniere des Etats de l'Afrique de l'Quest (UDEAO)
BP 28
Ouagadougou, Upper Volta, Africa

United Nations
New York, New York 10017

United Nations Development Program (UNDP)
Food and Agriculture Organization
New York, New York 10017

United Nations Educational, Scientific and Cultural
Organization (UNESCO)
7/9 Place de Fontenoy
Paris 7e, France

United Nations Environmental Program (UNEP)

United Nations Sahelian Office (UNSO)

United States Agency for International Development (USAID)
Washington, D.C. 20523

United States Peace Corps
Washington, D.C.

World Food Program (WFP)
FAO-UN
Via delle Terme di Caracalla
Rome, Italy

World Health Organization
1211 Geneva 27
Switzerland

The following nations have also contributed to various funding projects in the LDCs:

Belgium
China
Denmark
France
Germany, F.R.
Israel
Italy
Japan
Korea
Netherlands
Poland
Saudi Arabia, NECP
Spain
USSR