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19

A Study of International Fisheries Research

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Foreword

Origin of the study

The Study of International Fisheries Research Needs for Developing Countries (SIFR) was the result of an initiative of the First Fisheries Development Donor Consultation, held in Paris in October 1986 (World Bank 1986a). The Donor Consultation was organized because of a recognition that fishery development projects that have concentrated on providing infrastructure have generally had a low rate of success. The projects have often led to the overdevelopment of harvesting capacity, which, when coupled with a lack of management, has resulted in the overexploitation of resources (World Bank 1986b). It was suggested at the Consultation that lack of research could be a contributing factor, and it was agreed that research on all aspects of fisheries was needed. This research should concentrate on alleviating constraints to development. Several donor agencies were also concerned about the lack of coordination in the provision of aid to fisheries research.

Following the consultation, the World Bank and the Food and Agriculture Organization (FAO) drafted terms of reference for a study that would focus on these two issues (annex 1). The terms of reference were finalized, following considerable informal consultation with fishery scientists and donors, by a steering committee made up of representatives from the World Bank, the United Nations Development Programme (UNDP), the Commission of the European Communities (CEC), and the FAO (annex 2).

Subsequently, the four multilateral agencies, thirteen bilateral donors, and one private industry association (the International Association of Fish Meal Manufacturers) agreed to contribute to the SIFR and provided funds and consulting services for its implementation.

Terms of reference

The study's terms of reference were extremely broad. They covered fisheries, aquaculture, the conservation of aquatic environments — both marine and freshwater — and research disciplines ranging from ecology to political science and institutions. Assessing performance in fishery and aquaculture development and management, the state of research in developing countries, and the opportunities for improvement, and preparing a strategy and plan for action were challenging tasks. They could not have been completed without the unconstrained cooperation of the many organizations and individuals consulted.

While the SIFR was under way, the Consultative Group on International Agricultural Research (CGIAR) decided to widen its consideration of international fisheries research from aquaculture to the entire spectrum of fisheries. The development of this significant new initiative in strategic fisheries research, stimulated in part by the SIFR, is documented in the text of this report.

The CGIAR initiative and the development of the SIFR strategy have been closely coordinated, which has led to some delay in the publication of the report. The SIFR strategy recognizes the need to support an international fisheries research institute under the auspices of the CGIAR. Such an institute would carry out strategic research on the

basic conditions restricting sustainable development of the sector — particularly in tropical countries. This is to complement, for the immediate future, the ultimate goal of enabling national or regional centers to conduct such research. Toward achieving that goal, the SIFR Advisory Committee has established as its first priority strengthening the national capacity for applied research to support national and regional fishery management.

Study implementation

A study team, supported by a secretariat, began work in March 1989. An advisory committee of individuals selected for their expertise in fisheries was created to guide the study (annex 3). The Advisory Committee met twice, in May 1989 and in March 1990, to review and comment on drafts of this report. The Steering Committee met periodically and finalized details in July 1991.

Following the first Advisory Committee meeting, six missions to developing regions were organized to assess the research capacities of developing countries. Missions visited India, the ASEAN region, East and West Africa, and the east and west coasts of South America, collecting information from 18 countries. The composition of these missions and the countries visited are given in annex 4. The mission reports have been published in the World Bank Technical Paper series (World Bank and others 1991a, 1991b, and 1991c).

A consultant to the study examined the problems that small island states face in fishery development and management and the constraints on the conduct of fisheries research resulting from their insularity. This work was funded and published by the International Centre for Ocean Development (ICOD) (Shepard 1991).

Four working parties with diverse members addressed international cooperation in fisheries research; tropical aquaculture development; small-scale fisheries; and small pelagic fish utilization. The membership of these working parties is contained in annex 4, and their reports have been published as World Bank Technical Papers (World Bank and others 1991d, 1991e, 1991f, and 1991g).

The final part of the documentation reviewed by the study involved evaluations of development assistance in fisheries conducted by the Danish International Development Agency (DANIDA), the FAO, the UNDP, the World Bank, the Asian Development Bank, and the CEC. Extracts of the evaluations are included in annex 5.

The conclusions of the study are drawn largely from the considerable body of information collected — that information has been published to make it available to those who may wish to review the background material in depth. A summary report of the study has been produced for the nonspecialist and published separately by the World Bank as a booklet entitled "Fish for the Future."

More than a hundred people from all regions have actively participated in the fact-finding phase (see annexes 4 and 6). The SIFR has also benefited from the experience and views of hundreds of others who met with the field missions and who contributed to the study by correspondence — fisheries researchers, university scientists, fishery administrators and senior officers in charge of national research administrations, industrialists, and representatives of the small-scale sector and of regional and international fishery and economic bodies, in both developing and developed countries. A graphic presentation of the SIFR process is given in annex 7.

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Australia	Australian International Development Assistance Bureau (AIDAB)
Canada	International Centre for Ocean Development (ICOD) International Development Research Centre (IDRC)
Denmark	Danish International Development Agency (DANIDA)
France	Ministère de la Coopération, Fonds d'Aide et de Coopération (FAC)
Germany	German Agency for Technical Cooperation (GTZ)
IAFMM	International Association of Fish Meal Manufacturers
Iceland	Icelandic International Development Agency (ICEIDA)
Italy	Ministry of Foreign Affairs, Directorate General for Development and Cooperation
Netherlands	Ministry of Development Cooperation
Norway	Ministry of Foreign Affairs Norwegian Agency for Development Cooperation (NORAD)
Sweden	Swedish International Development Authority (SIDA)
United States	U.S. Agency for International Development (USAID)
United Kingdom	Overseas Development Administration (ODA)

The contributions of the Advisory Committee and of numerous fisheries researchers and administrators consulted during the study are gratefully acknowledged.

Abbreviations

ACMRR	–	Advisory Committee on Marine Resources Research, FAO
ADB	–	Asian Development Bank
ADCP	–	Aquaculture Development and Coordination Programme
AFS	–	Asian Fisheries Society
AFSSRN	–	Asian Fisheries Social Science Research Network
AIT	–	Asian Institute of Technology (Thailand)
CEC	–	Commission of the European Communities
CGIAR	–	Consultative Group on International Agricultural Research
CRSP	–	Collaborative Research Support Programs, USAID
DANIDA	–	Danish International Development Agency
EIFAC	–	European Inland Fisheries Advisory Commission
FAO	–	Food and Agriculture Organization of the United Nations
FFA	–	South Pacific Forum Fisheries Agency
GTZ	–	German Agency for Technical Cooperation
IAFMM	–	International Association of Fish Meal Manufacturers
ICCAT	–	International Commission for the Conservation of Atlantic Tunas
ICES	–	International Council for the Exploration of the Sea (Denmark)
ICLARM	–	International Center for Living Aquatic Resources Management (Philippines)
ICOD	–	International Centre for Ocean Development (Canada)
ICSEAF	–	International Commission for the South East Atlantic Fisheries
ICSEM	–	International Council for the Scientific Exploration of the Mediterranean
IDRC	–	International Development Research Centre (Canada)

IFPRI	–	International Food Policy Research Institute
IFREMER	–	Institut français de recherche pour l'exploitation de la mer
IMO	–	International Maritime Organization
IMR	–	Institute of Marine Research (Norway)
IOC	–	Intergovernmental Oceanographic Commission
IPFC	–	Indo-Pacific Fisheries Commission
ISNAR	–	International Service for National Agricultural Research
IUCN	–	International Union for the Conservation of Nature
NACA	–	Network of Aquaculture Centers in Asia
NAS	–	U.S. National Academy of Sciences
NORAD	–	Norwegian Agency for Development Cooperation
NTFS	–	Network of Tropical Fisheries Scientists
NRI	–	Natural Resources Institute (United Kingdom)
OECD	–	Organization for Economic Cooperation and Development
ORSTOM	–	Institut français de recherche scientifique pour le développement en coopération
SEAFDEC	–	South East Asian Fisheries Development Center
SIFR	–	Study of International Fisheries Research Needs for Developing Countries
SIDA	–	Swedish International Development Authority
UNDP	–	United Nations Development Programme
UNEP	–	United Nations Environment Programme
USAID	–	U.S. Agency for International Development

Executive summary

Part 1 Diagnosis

Fish and fisheries have global importance. They make an important contribution to the world's food supply and are a source of income for more than 100 million people who depend, directly or indirectly, on fisheries for their livelihood. People in developing countries — particularly the poor — rely on fish for a large share of their animal protein requirements.

World production of fish has risen to about 100 million tons. That amount is regarded as being at, or close to, the maximum biological limit. But projected population growth over the next 10 to 15 years implies an increase in global demand of about 20 million tons if per capita consumption remains steady. The greatest gap between supply and demand will be in Asia. To satisfy the demand will require improving the management of fisheries, making better use of what is caught (reducing waste), and increasing aquaculture production.

There has been some concern that fishery development projects centered on capital investment and infrastructure have had too little success. As a result of this concern, a Fishery Development Donor's Consultation was organized in Paris in 1986 to determine ways in which fishery projects could be improved through new approaches to donor funding. The Consultation identified lack of research as one cause of the lack of projects' success. Therefore, it proposed a Study of International Fisheries Research Needs (SIFR) to be overseen by the World Bank, the United Nations Development Programme (UNDP), the Commission of the European Communities, and the Food and Agriculture Organization (FAO).

Seventeen multilateral and bilateral donors and one industry association supported the study with funds and consulting services.

The SIFR set out to:

- Determine whether lack of basic information was a cause of failure
- Identify high-priority research needs
- Assess the capacity of developing countries to undertake the research
- Recommend ways to improve the impact of international aid in fisheries research.

The study reported on the major changes in fisheries over the last 40 to 50 years, particularly developments in fishing techniques, management, and market demand. Inadequate resource management, particularly for offshore fisheries but also for inshore fisheries and, increasingly, in aquaculture, has resulted in many areas in seriously low, unbalanced, and unsustainable fish stocks. The environment has also had detrimental effects on fishing societies, especially the rural poor, and on national economies. The study targets areas of concern and opportunities to address the problems, and culminates in a plan for action for use by all major aid donors.

State of fisheries and their prospects

There have been two main changes in global fisheries since the end of World War II. First, there was a shift from rapid growth in total catch, up to 6.5 percent a year, to relative stagnation in the early 1980s, with growth at about 1 percent a year.

Second, many countries exercised their right to impose a 200-mile national jurisdiction over their fishing waters, limiting the "open access" enjoyed by large fishing industries for so long.

Improved technology

An increasing scarcity of fish was met with new technology to improve the performance of gear, fleets, and vessels, particularly for large-scale operations fishing both near and distant waters. This led to conflicts between these large fleets and the local, small-scale fishers of developing countries.

Development projects in the 1950s and 1960s promoted improved gear and vessel technology, almost to the exclusion of other, nontechnical considerations. The failure of communities to adopt the techniques was attributed to shortcomings of the fishermen themselves. By the mid-1970s the small-scale sector was not only failing to benefit from fishery development projects, in some cases it was actually being harmed.

Aquaculture

Assessing the state of and prospects for aquaculture is difficult because of the lack of accurate statistics. The FAO estimates aquaculture's growth at slightly under 5 percent a year and its production in 1987 at 13 million tons. Approximately 80 percent of reported yield comes from Asia, 12 percent from Europe, 3 percent from North America, 2 percent from South America, and less than 1 percent from Africa.

The aquaculture industry in general maintains a course toward greater intensification. Although this means greater potential supplies, it also means greater potential pollution, degradation of the aquatic environment, and upsetting of the balance in local environmental and social systems.

Postharvest

World shortages make adding value to a limited raw material strategically important. There are three main causes for concern in the postharvest sector. First, the demand from rich countries is concentrated in luxury and standard products, and there is only limited demand in these countries for low-value species, and little concern about postharvest losses. Second, the medium-term food supply of low-income consumers relies heavily on fish for protein. And third, the large- and small-scale sectors have different needs in their processing techniques.

Fishery development and management practices

Changes during the past two decades have given rise to a need for a reappraisal of the relevance of conventional fishery development and management approaches. Although past practices are being modified, they have not yet been fully adapted to the new requirements resulting from the changes.

Large-scale fisheries

Many of the reasons cited for the poor performance of large-scale fishery projects are not specific to fisheries. Those that are include the overestimates of total potential yields, despite the fact that fishery potential had been accurately assessed as early as the late 1960s; open access, allowing increased catches without appropriate management and allocation of resources; and the heavy reliance on increased mechanization, with little or no attention to the economic, social, and cultural environment of production.

Small-scale fisheries

The lack of satisfactory information on the economic and social aspects of the small-scale sector was a major constraint on its development. New technologies were expensive, and social and cultural impediments to their adoption were unforeseen by the aid and development agencies.

Immediate changes

More data are needed throughout the industry for use in developing appropriate and effective management strategies. But there are changes that could be adopted immediately to improve resource management.

Some form of property rights should be assigned to fishing grounds to encourage better allocation of resources and a more holistic approach to stock management, one that takes account of traditional and local as well as national needs and of the need for foreign currency.

Research should place more importance on the social and economic factors governing the behavior and strategies of resource users. An under-

standing of these factors and their effects is necessary to ensure that outside interventions and support programs are suitable for the local context and have a high chance of success. Research in aquaculture should similarly shift its emphasis, to take more account of the productivity of ponds in traditional extensive and semi-intensive farming systems, the dynamics of multispecies systems, and the use of locally available agricultural waste. Rights of access to stock, land, and water need to be studied.

Potential contributions of research

This report distinguishes among basic, strategic, applied, and adaptive research. Basic and strategic research is carried out largely by regional and international concerns, and applied and adaptive research largely by developing countries. The ultimate goal is to conduct basic and strategic research at national and regional levels.

Attention should also be paid to encouraging private concerns to participate in research programs, which would free public institutions to concentrate on more basic areas. The private sector could invest in areas with low risk and satisfactory returns — for example, providing technical information on equipment and markets; conducting practical experiments (boat design, aquaculture technology); and analyzing markets and trading practices.

The public sector could concentrate on conservation and management of the aquatic environment and its fishery resources; socioeconomic analyses; institutional changes; education and training; consumer health protection and inspection; and support for the small-scale sector to offset its disadvantages in competing with the large-scale sector.

There are great opportunities for an international research body. For example, the International Center for Living Aquatic Resources Management (ICLARM) could be used to develop research on fisheries and aquaculture at an international level.

Research capabilities in developing countries

Infrastructure

Most countries with important fisheries have built up the essential components — both physical and institutional — of a research infrastructure. Many have research institutes with fully trained staff, the minimum laboratory equipment, research vessels, and computer and library facilities.

Scientific equipment and facilities vary greatly among countries. In general, short-term development projects are better funded and enjoy better facilities than medium-term programs. Developing countries have acquired research vessels under bilateral assistance schemes, but many rapidly become too expensive to run without continued international financial support.

Personnel

Many countries have already recruited and trained research personnel. Some research establishments are overstaffed, and others lose staff to attractive offers from industry. The proportion of senior staff engaged in research or in supervising research programs is often low. Keeping highly qualified and experienced scientists can be difficult and affects national and regional cooperation as well as research programs. Research funds are often inadequate and wages can be low.

Policies

Clear policies to direct research and development are lacking. As a result, research tends to lag behind needs rather than anticipate emerging opportunities. That makes it difficult for industry and fishery administrations to acquire the necessary information on which to base sound decisions for changes in practice; consequently, there is no demand for changes that would lead to more pertinent research programs. Fisheries research often lacks the integration of other research disciplines, particularly economics and other social sciences.

Aid and cooperation

Basic patterns have evolved in cooperation at a regional level. The cooperation takes place through three main kinds of structure: networks, multilateral regional bodies, and regional and international research centers. Examples of multilateral bodies are the FAO, the Intergovernmental Oceanographic Commission (IOC), and the United Nations Educational, Scientific, and Cultural Organization (UNESCO). ICLARM is one of the very few regional and international research centers.

The usefulness of aid to research is mixed. Aid programs have made an important contribution to the development of fisheries research capacity in developing countries. But they have also neglected areas, often helping to create a deficient infrastructure. In countries where funds are limited, aid can generate distortions. And short-term aid projects have sometimes diverted scarce national research personnel from national programs before their completion.

Small-scale fisheries have attracted considerable attention in the last decade, but the research required to underpin them has lagged behind.

A concept for cooperation that holds great promise is the development of twinning arrangements between institutions in developing countries and ones in industrial countries.

Part 2 Opportunities for international cooperation in fisheries research

Use of existing knowledge

There are opportunities for improving fisheries that can be exploited even before improved research strategies are adopted.

At a national level, fishery laws can be changed to ensure that access to fish stocks is controlled. This will lead to better and more sustainable use of resources. Management should be adapted to include fishers in the decisionmaking process. Pilot projects can be developed to assess new management plans, and technical competence can be improved in fishery administrations. There is room for appropriate technical improvements in many cases.

At an international level, development strategies must be revised and prevailing economic and social circumstances fully understood. The dissemination of results must be improved.

A strategy for research

More funds are required to support improvements in research at national, regional, and international levels. There must be a shift in aid from investing in visible infrastructure toward strengthening research and management programs that address constraints and future opportunities.

Policies for public and private sectors, and their respective roles in research, must be clearly formulated. Research in aquaculture should be encouraged, but the extent of a country's efforts in this area should be determined by its resources.

Extension work should be evaluated and improved. Problems in the postharvest fishery sector must be addressed. An important step would be to develop an accurate quantitative picture of the real significance of losses in terms of global production.

Interactions between communities and their resources must be studied and the role of women fully recognized.

In 1991 ICLARM produced a plan for an international fisheries research institute that would undertake strategic research at an international level.

The SIFR concluded that research at the international level should be directed into four main areas: resource conservation and management, fish productivity, processing and utilization, and socioeconomics. The areas not covered by ICLARM (some strategic research and most national and regional research) will require complementary donor support, ideally through the SIFR plan for action.

Plan for action

In general terms

1. The results of the SIFR must be widely disseminated for comment among researchers and planners in developing countries and followed up with a series of regional consultations.

2. Funding should be at least doubled to support the creation of an effective international research institution under the auspices of the Consultative Group on International Agricultural Research (as recommended by ICLARM). Funds are also needed to support ICLARM through 1992 and for its transition into this new role.

3. Coordinated donor support should be provided to the research areas that the CGIAR cannot cover, including the regional and national applied research that presently attracts about 90 percent of the donor financing and some strategic research in such areas as postharvest activities.

4. Donors should also actively support the exchange of information between research programs. The FAO Fisheries Project Information System (FIPIS) could facilitate this process.

Indicative plan

5. An indicative plan for complementary support to fisheries research is recommended to direct the attention of donors. The SIFR could be used as the basis for such a plan as well as for bilateral negotiations. Key considerations for donors developing an

indicative plan should be (1) giving priority to supporting the development of fishery policy and programs and the identification of the most important research issues and (2) targeting national institutions that have regional or wider networks in place. These institutions should be selected on the basis of the significance of the associated national fishery sector, potential for returns from research investment, and evidence that the products of research are sought by government or the private sector.

6. The indicative plan should also consider support to regional institutions and should emphasize the transfer of technology. Again, the interest and involvement of the private sector must be sought.

Coordination of action

7. To ensure that the results of the SIFR translate into benefits in fisheries research, several steps are necessary:

- The communication links established during the study should be maintained, and donor consultations should be held every two years.
- A facilitator should be appointed to assist in coordinating donor activities under the guidance of a steering committee comprising the original four multilateral agencies and representatives of the bilateral donors.
- The facilitator should establish a mechanism for matching the research priorities of developing countries (including the private sector) with the interests of donors.

8. Support to research should include scientific and technical inputs. The FAO should play a leading role in providing technical advice.

9. Although multilateral agencies and the appointed facilitator can play a catalytic role in stimulating coordination of targeted donor aid to fisheries research, regular communication among donor agencies, multilateral agencies, and host governments is crucial to ensure that the support makes a positive contribution to international fisheries research.

The Study of International Fisheries Research presents donors and recipients with a challenge and a unique opportunity. The SIFR is only the beginning of a process that could, if adequately supported by donors and recipients, enable both to reap the benefits of increased collaboration at all levels of fisheries research, as well as between all levels.

1

Introduction

Recognizing that fishery development projects oriented toward capital investment and infrastructure (World Bank 1986b) have a low rate of success, the World Bank and the CEC (later joined by the UNDP, the FAO, and the African Development Bank) organized a consultation in 1986 to share experience with fishery projects and identify ways in which they might be improved (World Bank 1986a). An important recommendation of the consultation, in response to the initiative presented by the World Bank, was to undertake the Study of the International Fisheries Research Needs for Developing Countries (SIFR).

Objectives of the study

The study was assigned four main objectives:

- To determine the degree to which lack of information is an impediment to effective fisheries[1] management and development
- To assess the long-term (25-year) potential contribution of research to the economic and social progress of the sector in developing countries
- To evaluate the capabilities of the developing countries to undertake the research needed
- To propose ways and means to enhance, during the forthcoming decade, the impact of international aid on developing countries' research capacity.

Presentation of the report

This report is the most important technical output of the SIFR. It is intended for fisheries specialists in development agencies and for national and regional fisheries institutions in developing countries.

To determine the present and future requirements for fisheries research, the study team began with an examination of the historical development of aquaculture, capture fisheries, and the postharvest sector (including processing, marketing, and trade). The development of fisheries was split into three periods: *expansion*, *change*, and *adjustment*. The examination, summarized in chapter 2, was undertaken to provide a basis for identifying and characterizing the fundamental changes taking place in fisheries and the forces shaping the future.

Chapter 2 discusses in detail several critical elements affecting the future of fisheries. The most important event occurred in the early 1970s, when opportunities for further expansion from conventional resources were exhausted, leading to an increasing gap between supply and demand. The rise in the real price of fish resulting from the continually increasing demand for limited natural supplies has increased the pressure from coastal states to allocate exclusive rights of use. But although this pressure has led to a general extension of national jurisdiction over fisheries, it has not yet resulted in operationally adequate use rights in most domestic fisheries. Moreover, the rise in fish prices has significant ramifications throughout the industry, affecting consumers, patterns of trade, innovative processing technologies, and the development of aquaculture.

Important changes in the use of aquatic environments are affecting the potential for both cap-

ture fisheries and aquaculture. The problems are highly complex, in terms of both the natural and physical effects and the social and economic causes and consequences.

Chapter 2 identifies the small-scale sector as an area of increasing concern for the future, one that requires new approaches in management and development that take into account its special conditions and characteristics.

Chapter 3 examines present management and development practices. This assessment was undertaken, first, to determine the extent to which lack of information is an impediment to improved practices (the first objective of the study) and, second, to evaluate the potential capability of present practices to meet the new challenges and opportunities and, on this basis, to provide a framework for identifying research requirements. The framework attempts to provide a common understanding of the new challenges and future opportunities as a basis for improving the relevance of research programs, increasing the demand for research, and stimulating more effective use of research results.

The examination of present development practices is based largely on evaluations of fishery projects undertaken by some of the major donor agencies. Assessments and documentation of present fishery management practices are relatively limited and related mostly to industrial countries. They have been examined to elicit general principles. The shortcomings of conventional management approaches employed in the past are clear. The main difficulties are not in the limitations of stock-assessment and bioeconomic models, but in implementing the models' conclusions under the condition of open access.

Chapters 2 and 3 are designed to provide the background for the analysis of research needs and capabilities. The research needs themselves are examined in chapter 4, which begins with definitions of the different kinds of research; the roles of the private and public sectors; and the necessity for making distinctions between development and research. There are several different perspectives on the contributions that research can make to the progress of the fishery sector. These are examined in relation to the efficient utilization and conservation of aquatic ecosystems, the development of aquaculture, and the role of fishing communities within their economic and social contexts. On the basis of these examinations, the report then identifies and discusses the critically important scientific topics for research — not in terms of a "shopping list," but in terms of the main areas requiring new attention (the second objective of the study).

Chapter 5 addresses the capacity of developing countries to meet their research needs. Although there are vast disparities among countries (both industrial and developing) in the conduct and value of research, there are certain common elements useful for organizing the analysis. These include the means for research (budgets, staff, infrastructure); the relevance of the programs and policies; the quality of the research; the use of research results; and the management of research. National research capacity is also influenced by the opportunities for regional cooperation. This chapter (which deals with the third objective of the study) reviews regional and interregional cooperation in research and concludes with an examination of the role of international aid to research.

The analyses and the conclusions reached in the previous chapters provide the basis for the plan for action that makes up part 2 of the report. In keeping with the first objective of the study, chapter 6 discusses measures that can be taken by countries and donor agencies to improve fishery management and development practices on the basis of information currently available.

Chapter 7 proposes a strategy for international cooperation in fisheries research, setting forth the long-term objectives and operational targets for a program and discussing the scope of research and the appropriate location for different kinds of research at national, regional, and interregional levels.

The final objective of the study (proposing ways and means to enhance the impact of international aid in strengthening national research capabilities) is the subject of chapter 8. This plan for action contains the study's suggestions for actions that can be taken by the donor community at national, regional, and interregional levels. It proposes support for the establishment (or reinforcement) of regional structures and for the creation of interregional research units. The report refers to a number of institutions and agencies for the purposes of providing information. These references are not intended to be exhaustive.

Part 1 Diagnosis

2

The state of fisheries and their prospects

Changes in opportunities and requirements

Two major changes in global fisheries have occurred since the end of World War II. These are, first, a shift from a period of rapid growth in total catch to a period of stagnation and, second, the general extension of national jurisdictions over fisheries. Several other important developments have occurred in association with these changes as well as in response to other changes. As a result, fisheries worldwide are facing new challenges and opportunities.

This chapter examines current changes in an effort to identify prospects, to evaluate present fishery management and development practices, and to formulate research needs. The examination is divided into three parts: the period of expansion, the period of change, and the present issues and future opportunities. Some adjustments to the changes are already taking place.

The period of expansion

During the 1950s and 1960s the production of fish from capture fisheries rose rapidly (table 2.1). Total tonnage grew 6.0 to 6.5 percent a year, a doubling of production every 11 to 12 years (FAO 1981). During this period global fishing effort increased even more rapidly, as indicated by the hundreds of stock assessments conducted worldwide. For most large stocks, fishing effort exceeded the most economically efficient level and, for many high-valued stocks, led to declines in the absolute value of harvests.

The expansion of fisheries took place under the principle of the freedom of the seas. This principle emerged during the early 1600s as the Dutch fleets demanded access to areas of the North Sea claimed by the British. National limits became restricted in distance from shore and all fleets had free and open access to any waters beyond these limits, and thus to many of the most productive areas. By the 1960s large distant-water fleets had expanded their activities to almost all the resource-rich areas of the oceans. The condition of free and open access also penetrated to areas within national jurisdictions where local communities of small-scale fisherfolk had traditionally exercised exclusive use rights. National development plans for large-scale fisheries generally did not take account of local fishing rights.

Major technological changes affected fishing in both industrial and developing countries. Stern trawlers combined with on-board filleting and plate freezing allowed fishing to extend over much longer periods and over greater distances. Spillover effects from technological developments in other sectors — radar, sonar, and monofilament nets — also gave rise to changes in fishing. These changes, in combination with the development of the power block, allowed tuna fishing to extend into distant waters. Similar changes, in conjunction with increased demand for fish meal in the commercial meat industry, led to the rapid development of fisheries for small pelagic species.

Fishing techniques also improved. In developing countries this was most notable in the introduction of trawling and purse seining and the

Table 2.1 World fish production, nonfood uses, and per capita supply, 1950 and 1961-89

Year	Production (millions of tons)	Nonfood uses (millions of tons)	Population (billions)	Per capita supply (kg per year)
1950	19.8	3.0	2.5	6.7
1961	39.3	11.0	3.1	9.1
1962	42.7	13.2	3.1	9.3
1963	44.1	13.0	3.2	9.6
1964	49.5	16.6	3.3	10.0
1965	50.2	15.6	3.3	10.2
1966	54.2	18.4	3.4	10.4
1967	57.6	20.3	3.5	10.7
1968	60.9	22.2	3.5	10.9
1969	60.0	20.6	3.6	10.8
1970	65.3	24.7	3.7	10.9
1971	65.7	23.8	3.8	11.0
1972	61.5	17.7	3.9	11.4
1973	62.2	16.4	3.9	11.6
1974	65.6	18.8	4.0	11.7
1975	65.5	18.0	4.1	11.6
1976	69.0	20.5	4.2	11.7
1977	68.0	19.4	4.2	11.4
1978	70.0	20.6	4.3	11.4
1979	70.9	21.6	4.4	11.3
1980	72.1	20.9	4.4	11.3
1981	74.7	21.6	4.5	11.6
1982	76.8	23.0	4.6	11.6
1983	77.5	22.0	4.7	11.8
1984	83.9	25.7	4.8	12.2
1985	86.4	26.4	4.9	12.4
1986	92.7	29.6	4.9	12.7
1987	94.2	28.3	5.0	13.2
1988	98.7	31.1	5.1	13.3
1989	99.5	30.3	5.2	13.4

Note: Nonfood uses include production of fish meal and oil.
Source: FAO (various years) and FAO data base (FISHDAB).

modification of trawl nets to meet the rapidly growing demand for shrimp.

This period of expansion was accompanied by a philosophy that emphasized industrial growth and large-scale operations in developing country fisheries. "The modernization growth-oriented model of development, based largely on the experience of the more developed temperate-water maritime countries, became accepted. This approach primarily implied the superimposition of a modern, capital-intensive, specialized technology over the traditional base, which was largely labor-intensive and of great technical diversity. It assumed that this base was a hindrance to development and had to be either transformed or completely phased out" (Kurien and Achari 1989).

Fisheries research agendas during this period were shaped by opportunities for expanding production and the experience of industrial countries in achieving greater catches, by large-scale fleets, from the big stocks of individual species in temperate waters. Stock-assessment models developed in the late 1950s provided the tools to quantify, through analysis of commercial statistics, the size of fish stocks, and to identify the conditions for achieving maximum sustainable yields. For new fisheries, for which historical series of commercial statistics were not available, novel methods were developed based on estimation of stock biomass by direct surveys. This work led to estimates of global fishery resources in the late 1960s and early 1970s that indicated even then that the limits to natural yields were being approached.

Until the 1970s aquaculture and the conservation of aquatic environments received relatively little attention from national research institutions and development agencies even though certain traditional farming systems were economically and socially important in several countries. Like capture fisheries, these traditional aquaculture systems had a low political profile and thus a low research priority.

The period of change

Changes in capture fisheries

For capture fisheries the period of change was signaled by the collapse of the Peruvian anchoveta fishery in 1972-73. Although pelagic fish stocks had collapsed several times in the past, the demise of the anchoveta fishery took place at a time when few opportunities were left for further expansion of fisheries to unexploited stocks of conventional species. It provided dramatic evidence of the limited size of fishery stocks, evidence already substantiated by biological investigations. Globally, the rate of growth in the total tonnage of catch dropped significantly until the early 1980s, from 6.5 percent to about 1.0 percent a year.

Recently there has been a reported increase in production, much of which has come from aquaculture and from small, shoaling pelagic species (of relatively low value). There have also been large increases in certain small pelagics, notably the Japanese sardine and other Pacific sardine stocks. These stocks are subject to severe natural fluctuations, both short-term and long-term.

Total world catch expressed in tonnage is not an accurate measure of the real production from fishery resources, however. It combines on an equal basis items of vastly different value (for

example, lobsters and anchoveta) and includes double-counting. More accurate indications of the health of the fishery sector and of its contributions to human welfare would require estimates broken down by systems of production or by end use, and weighted by their economic importance.

For many countries, the reaching of the natural limits of supply has been obscured by continued, but small, increases in total catches. But these increases generally consist of faster-growing and lower-priced prey species. Consequently, in economic terms, real output has generally decreased (James and others 1991).

Extension of national jurisdiction. As the maximum sustainable yields from the most easily obtainable stocks of fish were reached, the industrial countries (as well as a few developing ones) intensified their efforts in distant waters. The presence of large foreign fleets in countries' near-shore waters stimulated a move for change in the law of the sea. By the end of the 1970s this had culminated in the extension of jurisdiction over fishery resources to 200 nautical miles off the coast.

This extension of jurisdiction had profound effects for both industrial and developing countries. Two effects are particularly important. The first of these was to redistribute fisheries wealth, by allowing the coastal states to extract benefits from the distant-water fishing states through joint ventures and user fees.

Among developing countries there is considerable disparity in the gains acquired through the extension of jurisdiction (FAO 1981). States that have gained the most are those whose exclusive economic zones include large individual stocks of fish that are of relatively high value in industrial country markets or that can be taken at relatively low cost by large-scale fishing gear. Three kinds of areas have the necessary conditions: those with major upwellings; those with extended continental shelves (predominantly in high latitudes); and those with economic zones through which oceanic tunas and billfish pass. Developing countries falling within these areas include those in northwest and southwest Africa, those in southwest and southeast Latin America, and those in several groups of island states. Although there may be potential gains in a few other areas, the number of developing states that have acquired significant wealth through the extension of jurisdiction is small.

For the states that have benefited, there are important opportunities for increasing their gains from the resources, either by extracting revenues or other benefits from foreign fishermen or by replacing foreign fleets. Examples of the first approach include Morocco, whose recent agreement with the European Economic Community (EEC) is producing revenues of about US$80 million a year, and the South Pacific island states, which, with the help of the South Pacific Forum Fisheries Agency, have negotiated an agreement with the United States.

There are few successful examples of local fishers replacing foreign fleets, which poses particular difficulties. Stocks may already be depleted by foreign fleets, with the result that average yields available to domestic craft will be low. Domestic demand may be insufficient because of low incomes, small populations, or special food habits, and, although export demand may be high, penetrating established foreign markets may be difficult. In addition, many of these countries suffer from a lack of infrastructure, distribution networks, and technical, managerial, administrative, and research competence.

Some states have sought a compromise between the two approaches, through joint ventures under which the distant-water states provide benefits (usually facilitating domestic development in exchange for access rights) or through arrangements that require the distant-water states to land a certain amount of their catch in local ports. The disparity in objectives between the two parties is often a source of difficulty.

The second important effect of the extension of jurisdiction was to allow coastal states to exercise control over the domestic use of their fishery resources and, by ending international open access, to provide an essential basis for their adoption of effective management measures. Under the principle of the freedom of the seas, multinational bodies had been necessary for the adoption and implementation of fishery management measures. Although some measures achieved moderate success in maintaining stock levels, most were unable to prevent stock depletion and none, except for the International Fur Seal Treaty of the North Pacific (implemented in 1911), was able to prevent economic waste.[2]

The extension of national jurisdiction does not always obviate the need for multinational approaches to fishery management, however. In some cases, important stocks of fish are shared by the zones of neighboring coastal states. In other cases, stocks may "straddle" economic zones and international waters outside the 200-mile limits. Oceanic tunas are both shared and straddling.

Changes in resource availability. The extension of national jurisdictions, although initiated by developing countries, also resulted because of the global scarcity of wild stocks and the increase in the value of the resources. The scarcity and the changes in value have also had other important ramifications for fishery management and development. These include increases in waste, in stock depletion, and in the severity of conflicts between different groups of fishers. Attempts to prevent these consequences through fishery management are being undertaken, but have had only limited success so far, since few deal with the basic causes: open access, whose effects are exacerbated by scarcity, and economic factors.

Although states have largely ended international open access through the extension of jurisdiction, most still allow *free and open access* to their domestic fisheries. Under this condition, capital and labor flow into the fishery as long as the anticipated total revenues are greater than the expected total costs. The equilibrium position is sometimes located at a point at which stocks are depleted. As is often said, too many fishers are chasing too few fish.[3]

For such sectors as agriculture, which are subject to property rights (with control over access), the owners use only as much capital and labor as is necessary to maximize their *net* economic revenues (where the difference between their total revenues and total costs is greatest). But in open-access fisheries, any difference between total revenues and total costs amounts to an economic rent[4] that is shared by the fishers. This provides them with an income greater than the income they could expect to receive from alternative investments in other forms of employment or in other fisheries (that is, it is greater than their opportunity costs). Where this economic rent exists in a fishery (as in one that is newly developing), the surplus income will attract additional fishers until the total costs of all fishers rise to the point at which they equal total revenues.

The equilibrium position is often beyond the point at which total costs equal total revenues, however, because it is generally easier to enter a fishery than to exit from it. Thus fishers will remain in a fishery as long as they can cover their operating costs, even though they do not receive enough income to cover depreciation and to earn a satisfactory return on their investment.

This dynamic of overfishing is particularly critical for developing states, for which economic development depends largely on the exploitation of their natural resources. Efficient development of these resources produces economic rents that provide a source of the investment finance essential for economic growth. For developing countries the loss of these rents and the waste in the production of protein necessary for their growing populations are serious problems.

Open access is also a major source of conflict between different groups of fishers. In some cases different user groups may be competing for the same stock of fish; in other cases the conflict may be over the use of the same space by different kinds of gear. The severity and pervasiveness of conflicts are increasing. They are frequently manifested in demonstrations, particularly by the small-scale fishers, and some have resulted in the destruction of vessels and even murder. These conflicts occur because, without use rights, there are no mechanisms for allocating either the fishing grounds or the resources among the competing user groups.

In these situations, technological innovations tend to have perverse effects. There is pressure to adopt innovations that allow fishers to intercept stocks at earlier stages in their life cycles, although postponing harvest to later stages and larger sizes can lead to considerable economic gains. But this is not possible without enforceable controls on the place and time of harvesting. Furthermore, the gear used to take smaller fish is generally nonselective and captures large numbers of juveniles of other valuable species before they reach maturity. In the shrimp fisheries, discards commonly exceed 80 percent of the catches.

Most coastal resources in tropical countries are affected by gross overfishing. Efforts to encourage fishing further offshore — through subsidies for large-scale vessels, for example — often fail because the economic rewards of inshore fishing outweigh those of fishing in the deeper waters.

Also having an important effect on stocks are *economic aspects — prices and rents.* Fish prices reflect the relationship between supply and demand and therefore indicate the scarcity of the resources. The prices themselves are an important determinant of development. Consumption and trade are determined by the relationships between prices for fish and prices for other food commodities and feedstuffs. Production (and overproduction) are determined by the relationships between the prices received by the producers and the costs of the inputs.

With limited natural supplies and continually growing demand, the real prices of fish products

generally rise faster than both the prices of other food commodities and the prices of fishing inputs. This has several effects, both positive and negative. It has stimulated the growth in aquaculture production of certain species, even to the point at which the increase in supplies has led to a decline in prices. It has also stimulated production of restructured protein material — through the surimi process, for example — thereby allowing low-valued species to substitute for high-valued species, again with a decline in the product's price.

Another effect of resource scarcity and rising prices is the increase in potential resource rents. Several estimates of potential rents show that *extraordinarily large economic returns — billions of dollars annually in resource-rich areas — are being wasted because of open access.* The cephalopod fishery off the west coast of the Sahara region is one example of this.

In fisheries where some control over access to the resources has been put into effect (even imperfectly), there have been dramatic results in the production of economic rents. These systems are mostly, though not entirely, restricted to a few industrial countries (notably Australia, Canada, Japan, and New Zealand; see Neher, Arnason, and Mollett 1989 and Mollett 1986).

The large economic revenues achievable through access controls is one side of the coin. The other side is the more efficient allocation of capital and labor, between fisheries and between the fishery sector and other sectors, that access controls lead to because of the economic rents they create. An example is the managed reef fishery in the Philippines described by White and Savina (1987).

In the absence of access controls, the rising "real prices" increase the value of the resources and the potential economic rents. This has two opposite consequences. On the one hand, it increases the pressures on the stocks because it becomes economically rewarding for the fishers to take smaller and smaller average catches. On the other hand, it increases the benefits of managing the fisheries through controls over access. Thus, both the necessity and the value of better management practices grow as stocks shrink.

Changes in small-scale fisheries

During the period of expansion, little attention was paid to the needs of the small-scale fisheries.

> Prior to the 1970s it was widely believed that the key to uplifting the living conditions of traditional fishermen in an expeditious way could be found in improved vessel and gear technology. Development projects of the 1950s and 1960s reflected this emphasis through their concentration on more efficient techniques, almost to the exclusion of other, nontechnical, considerations. Failures of communities to adopt the techniques made available were attributed to shortcomings in the fishermen themselves (Smith 1979).

By the mid-1970s, however, it had become increasingly clear that, in general, the small-scale sector was not only failing to benefit from fishery development projects but was in several cases actually being damaged.

The importance of small-scale fisheries. Although there are no accurate estimates of the number of small-scale fishers in developing countries, it is safe to assume that there are tens of millions. Including those engaged in ancillary activities, the small-scale sector may encompass hundreds of millions of workers. Equally important in many developing countries, where fish is a major source of protein, the sector produces a large amount of animal protein, particularly for low-income consumers. Small-scale fisheries may produce as much as half the total catches used for direct human consumption.

Although the small-scale sector is generally characterized by low incomes and poor living conditions, the poverty is not inherent. It is more likely to stem from the lack of satisfactory use rights than from inefficiency.

In developing countries, the small-scale sector may have several advantages over large-scale fisheries in contributing to the net national economic and social welfare. There are situations where large-scale operations are desirable because of economies of scale, the distances that must be traveled, the sea conditions in which the boats have to operate, processing requirements, and so on. But in many situations the comparative advantages may lie with the small-scale sector. It is labor-intensive, consumes less fuel, generally uses more selective gear, and is less dependent on imported equipment and materials. The small-scale sector's capital is owned locally, often by the fishers themselves. And because the small-scale fishers depend on resources adjacent to their communities, they have a greater self-interest than large-scale fishers in management of the fisheries (World Bank and others 1991e).

Decline of traditional management systems. This self-interest in management was a common feature of many small-scale fisheries in the past and continues today in certain communities. These communities have a concept of "sea tenure," which

> refers to any system of informal, relatively closed, communal, shared, joint, collective or even private property in fishing. Whether tenure is legal or illicit, more or less overt or covert, more or less secure, spoken or unspoken, these customs usually carry a special weight or legitimacy that can only be imposed from within, by a group on its members....Although sea tenure regimes may operate on one level to control access to fishing grounds and fish, they really amount to alternative ways of managing people (Cordell 1989).

During the past two decades, there has been a rapidly growing interest in sea tenure (and inland water tenure), traditional community systems of fishery management (Alexander 1982; Christy 1982; Ruddle and Johannes 1985; Scudder and Connelly 1985; and Cordell 1989),[5] and management of other natural resources held in common, such as forestlands, grazing lands, and irrigation water (National Academy of Sciences 1986).[6] The research on resources held in common has considerable relevance for fisheries because of its contribution to the understanding of the ways in which user groups deal with the problems of open access.

Traditional fishery tenure systems evolved as a means for preserving community stability. The systems for the allocation of access and distribution of wealth emerged as organizational rules within self-sufficient communities (more for ensuring survival of the group than for managing the resources). They were particularly well suited to situations where territories could be easily identified (lagoons, coral reefs, and inland waters); to resources that are sedentary or that tend to concentrate at certain stages in their life cycles; and to situations where fixed gear is used.

These traditional community management systems began disappearing for numerous reasons, beginning with the pressures to expand the principle of the freedom of the seas. During the era of colonialism, legislation supporting open access to fisheries "was a convenient maneuver by colonialists seeking to displace or nullify marine tenure claims of indigenous peoples" (Cordell 1989). Even today, such claims are sometimes seen as an impediment to development and, therefore, something to be eliminated.

Other reasons for the disintegration of the traditional systems include demographic pressures and the penetration of market forces. These lead to pressures for individual gain at the expense of community stability and to the encroachment of large-scale operations into waters used by communities. Despite these and other forces, there are still areas where traditional systems persist and, in some places (for example, the Solomon Islands), attempts are being made to achieve formal legal recognition of such systems. Japan in particular has preserved traditional community management structures within a broad system of overall fishery management (Ruddle 1987).

Changes in fishing technology

Since the 1970s there has been continued development of fishing technology to support the search for underexploited stocks. For distant-water fleets, a few such attempts have been successful. In the southwest Atlantic, for example, between 1978 and 1987 there was a fifteenfold increase in catches (mostly of cephalopods) by vessels from Japan, Poland, the Republic of Korea, Taiwan (China), and the USSR. Tuna fisheries are also continuing to expand to stocks that are not yet fully utilized. U.S. vessels developed the technologies for the faster-sinking, deeper purse seines necessary for the western Pacific, and French and Spanish tuna vessels have moved into the Indian Ocean. Today drift net fishing is expanding in several regions, such as the South Pacific, where extremely long drift nets (up to 30 miles) are being used to take albacore, replacing long lines and taking the stocks at an earlier stage in their life cycles.

The pace of technological innovation is increasing rapidly. The limited opportunities for expansion, together with the extensions of national jurisdiction, promote fishing technologies aimed at intensifying fishing effort, as each individual attempts to gain an advantage over others and get a greater share of the declining stock. In industrial fisheries technological innovations have taken such forms as better fish-finding devices and more effective harvesting technologies. Similar examples are found in developing countries: in Thailand the use of luring lamps led to the rapid expansion of fishing in the central part of the Gulf of Thailand. Fishing technology has also developed for small-scale fisheries, particularly in the motorization of artisanal craft and the adoption of new gear. More recently fishing technology has focused on fish aggregation devices, such as floating rafts and

artificial reefs, as a means for increasing average catches. In some cases it has been proposed that artificial reefs could serve as physical barriers to illegal trawling.

Developments in fishing technology have had mixed effects, however. Fish aggregation devices can significantly reduce search time. They could also facilitate the acquisition of exclusive territorial rights and provide a basis for effective management. But there is growing evidence suggesting that fish aggregation devices may result in the overfishing of juveniles that gather around them. And creating artificial habitats large enough to have a significant impact on productivity is likely to involve much higher costs than other means of preventing degradation of local environments (Polovina 1989). For the large-scale operations in the Gulf of Thailand, "the continuous searching and hunting process of industrial fisheries will undoubtedly lead to the overexploitation of all resources in the near future" (Hongskul 1987). Employment opportunities have also been affected by the changes in technology. In Sri Lanka, for example, the purse seiners have recently been fitted with mechanical net haulers that are increasing economic returns but also displacing labor.

Utilization, processing, and marketing

The FAO has estimated that, by the year 2000, there will be a 19 million ton increase in global demand for fish, simply to maintain per capita consumption at the present average level of 12 kilograms (kg) a year. The effect of increased incomes could expand future requirements by 10 million tons (World Bank and others 1991f). There are significant disparities in the composition of the demand, however, among both regions and consumer groups. Among developing regions the greatest gap between supply and demand will occur in Asia. Latin America is likely to have a surplus, whereas the potential supply in Africa may be only moderately less than demand (Robinson 1982).

Among consumer groups, both high-income and low-income, there will be significant shortages. The luxury market in both developing and industrial countries will continue to grow rapidly. The increase will be constrained, to some extent, for products that "price themselves out of the market." But at the same time some of the presently less-preferred species will become luxury products.

For the luxury market the rise in prices resulting from the present scarcity has stimulated rapid growth in aquaculture production of such species as shrimp and salmon to the point where prices have started to fall. Cage culture of breams, seabass, and other high-valued species is also growing, although less rapidly.

Low-income consumers will face severe shortages of fish, which will be an important problem in many developing countries. "If countries are ranked by the proportion of animal protein derived from fish, the first forty in the list are developing countries (with the exception of Japan)" (World Bank and others 1991e).

An event that is significant because it reduces the importance of species characteristics and allows supply to meet demand for high-valued products is the development of processing techniques utilizing functional (gel-forming and emulsifying) properties of fish proteins to convert low-valued raw material into high-valued products, such as crab substitutes. Other opportunities include developing new products for human consumption (textured fish protein concentrates) and better feeds for aquaculture and poultry (higher-quality fish meal).

For low-income consumers the problems are more acute. An increase in prices is important not only in itself, but also because it stimulates shifts in demand curves, as the less-preferred species move into the luxury market. That would push the "poor man's protein" out of his reach. In addition, "the strengthened demand from developed countries will have a direct effect on the supplies available in developing countries, particularly for the poor" (World Bank and others 1991f).

Although trash fish has been a source of protein for the poor, an increasing amount is being diverted to feed for aquaculture and poultry. In some Southeast Asian countries, trash fish is the main fishery target. And intercepting stocks at earlier stages in their life cycles increases the quantity of trash fish in the catch.

Better management practices should prevent such misuse of the resources. Two other approaches might also alleviate the problems of diminished supplies. The first is to improve the use of the small shoaling pelagic species as food for humans. The annual global catch of these species is about 40 million tons; of this, 24 million tons are used for fish meal. Greater utilization of these stocks is hampered by several constraints: yields are highly variable both seasonally and annually; the fish are fragile and easily crushed, and they deteriorate rapidly; and there is a rela-

tively low demand for several species because of their small size, numerous bones, and strong flavor. Another constraint is that the areas of greatest abundance are also those with the least shortfalls in supply.

The second approach is to improve postharvest utilization. Losses probably amount to about 10 percent of total food fish supplies and are particularly high in the poorest developing countries, where the need for food is greatest. The technologies for reducing such losses are generally available, but research is necessary to improve their economic viability, particularly for traditional curing and drying processes.

Low-income consumers are likely to be most seriously affected by a general price increase. For many developing countries, this will mean growing confrontation between policies aimed at increasing export earnings and those aimed at increasing food security. The trend of fishing further and further down the food chain to supply food for use in producing high-priced fish products through aquaculture may be called into question, at both national and international levels.

Aquaculture

There are three broad categories of aquaculture production:

- *Extensive systems.* Human intervention consists essentially of seeding natural environments and reducing predation. Extensive systems include seaweed and bivalve culture in coastal areas; planting of fish in rivers and lakes; and sea-ranching (salmon) in marine waters. These systems are generally associated with large marine and freshwater bodies.
- *Semi-intensive systems.* Human intervention includes the artificial enhancement of natural food production and sometimes the partial supply of artificial feeds. The relatively small size of the bodies of water in which these systems operate permits greater, but still partial, control over the stocks and their habitat.
- *Intensive systems.* Human intervention is exerted over reproduction, nutrition, the gene pool, and disease. Intensive systems exist in both freshwater and coastal environments. The systems, more independent of the natural environment, are found in small and large, fresh and marine, bodies of water. Most will remain dependent on the quality of the natural environment, however.

The present state of aquaculture and its future trends are difficult to assess accurately on the basis of currently available statistics, which suffer from two shortcomings. First, separate aquaculture data have been collected systematically (by the FAO Department of Fisheries) only since 1984; projected trends are therefore speculative. Second, data are not accurately separated by major systems of production. National statistics on culture fisheries, bivalves, and seaweeds are frequently mixed with data on the capture of wild stocks. Thus the importance of aquaculture compared with that of capture fisheries, and of production by extensive systems compared with that by more intensive modes of production, remains partly conjectural. In addition, the data series on total fishery output published by the FAO currently excludes seaweeds, so aggregate estimates of fishery and aquaculture production are not entirely comparable.

The Aquaculture Development and Coordination Programme (ADCP)[7] estimates that world aquaculture production is increasing at a rate slightly under 5 percent annually, and that it reached 12 million tons (all species and systems included) in 1987. This figure represents 13 percent, and perhaps a third of the value,[8] of the fishery sector's production.

The aggregate statistics on aquaculture mask important differences, however, in both absolute development and rate of increase, between ecosystems, geographical areas, and modes of production. Approximately 80 percent of the reported yield comes from Asia (with China, Japan, and the two Koreas alone producing 50 percent of the world total) and 12 percent from Europe. North America's share is 3 percent, South America's 2 percent, and Africa's less than 1 percent.

Although the long-term trend in aquaculture is toward intensification, the fluidity of the systems and the common property characteristics of exploitation generally explain the substantial differences that are observed between the development of aquaculture and that of agriculture. The size of bodies of water also plays a significant role in determining the possibilities for intensification.

There are three different approaches to defining the concept of intensification. The first concerns the degree to which the production variables (environment, stock, and organism) can be controlled. The second relates to the stocking density applied within a system. The third concerns the investment in capital and the labor per unit of stock or output. Clearly, there is no strict agreement among the three definitions. In this report, the first definition is generally used.

At present, progress in aquaculture development is restricted almost entirely to traditional small-scale systems in regions where they already exist and to new intensive systems, either in industrial countries (salmon culture in northwest Europe and the United States) or in developing countries (shrimp culture in Asia and Latin America). The new intensive systems have generally been developed by medium- and large-scale commercial entrepreneurs, although some have been adopted by small-scale farmers (freshwater and marine shrimp in Asia).

Quality of aquatic environments

During the past two decades aquatic environments have received increased attention, because of both their importance and the severity of the changes taking place within them. Fish stock productivity and aquaculture viability depend critically on the quality of continental and coastal aquatic ecosystems. All of the inland and about two thirds of marine fishery production come from stocks that pass the first and most vulnerable stages of their life cycle in inland waters and coastal areas (Maltby 1986). Almost all aquaculture is concentrated in the same environments.

Intensive forms of aquaculture are themselves sources of pollution. The release of excess feeds and feces in semiclosed environments has already generated eutrophication and oxygen deficiency problems. In shrimp farming the clearing of mangroves, extensive harvesting of wild larvae, and indiscriminate use of antibiotics can harm commercially important fish stocks.

Pollution problems are becoming more acute in developing countries, particularly where large and growing populations are concentrated in the coastal zones, because important habitats, such as mangroves, are not given an economic value. Several countries — Bangladesh, China, India, Indonesia (Java), and the Philippines — are facing degradation of their aquatic environments. In the Philippines, for example, an estimated 75 percent of the coral reefs have been destroyed, mainly through increased siltation associated with clearing land and building roads for forest exploitation.

Governments of developing countries, confronted by the challenge of promoting economic growth and under less political pressure than governments of more affluent societies, frequently assign a relatively low priority to environmental conservation. Because the topic generally ranks low in research programs as well, assessment of the complex environmental problems is relatively unsatisfactory. Regulations suffer from similar shortcomings. The use of certain pesticides that have been banned in many industrial countries — for example, DDT — is still legal in developing countries and is sometimes subsidized under their agricultural policies.

Alterations of environmental quality can change the recruitment, and thus the productivity, of wild stocks. Some changes are positive: the production of pelagic stocks in parts of the Mediterranean is increasing, possibly as a result of nutrient discharges in these semiclosed seas. But, more often, effects are negative (FAO 1989). Eutrophication can lead to mass mortalities in wild and cultivated stocks. The collapse of pelagic stocks that depend on outflows of the Nile or Indus is a well-known example. It has also been shown that important oyster farming activities, notably in coastal lagoons, have collapsed as a result of mass mortalities of larvae caused by the use of certain kinds of antifouling paint on the hulls of boats (Alzieu and Ravoux 1989). Pollution can also alter the growth rates and the yields of capture and culture fish stocks.

Some red tides, besides having detrimental effects on aquatic resources, contain toxins that are harmful to the consumer after they have been concentrated by filter-feeders such as mussels. In 1983, 21 Filipinos died from paralytic shellfish poisoning caused by red tides (Csavas 1988). In Japan the cost of red tides to the aquaculture industry is higher than that of oil pollution (Nose 1985). The factors involved in bloom dynamics remain largely unknown.

Although many pollution problems are local in their causes and effects, there are important exceptions. Acid rain and global warming are well-known examples. By displacing even slightly the pattern of the ocean circulation, global warming may have dramatic consequences for the distribution of important fishery resources. Already there is evidence that major upwellings are being directly enhanced by the greenhouse effect (Bakun 1990).

Present issues and future developments

The dramatic changes that have affected the fishery sector during the last two decades have given rise to three major challenges: (1) sustainable ecosystem management, (2) aquaculture development, and (3) utilization of harvests. Each has different sets of issues and opportunities, and each therefore requires specific long-term strate-

gies to ensure effective development and management of fisheries in the future.

The exploitation of natural ecosystems and open access

In capture fisheries open access to scarce resources has led to open conflict, resource depletion, economic inefficiency, and loss of employment opportunities. In open waters, whether marine or inland, the development of aquaculture is similarly dependent on the provision of satisfactory schemes of use rights. These problems are not restricted to fisheries but also affect other natural resources for which control over access is imperfect.

When there is a transformation in the use of resources, problems occur. They occur when the traditional social systems for managing collective access break down. With monetization, the incentive for individual private gain outweighs the individual's costs of violating the social rules that control access within groups.

In the past few years, however, research has shown that common property regimes (systems where resources are held collectively by a group and subject to the group's rules) continue in many areas, successfully controlling access and ensuring sustainability of resources (see, for example, Wade 1988 and White and Savina 1987). In addition, some development projects have been successful in "converting an open access regime back to common property management," as was done in the World Bank's Eastern Senegal Livestock Development Project (Bromley and Cernea 1989).

For fisheries the problems of dealing with open access are particularly difficult because the solutions that are adopted will determine the future of the sector. Under the present institutions, the mechanisms required for efficient resource allocation are not available. Administrative mechanisms do not take into account the role of economic rents in the dynamics of overfishing. If these rents are not extracted, there are no means for buying out and removing the surplus fishing effort. Market mechanisms cannot function efficiently in the absence of exclusive use rights. Similarly, traditional systems cannot operate without formal recognition of exclusive collective rights. Even with formal recognition of collective rights, a group's social structure and rules for resource allocation and wealth distribution may not withstand the progressive penetration of the market forces and the associated incentives for individual profit maximization.

Nevertheless, success in dealing with the problems offers significant opportunities. Economic rents provide the basis for efficient allocation of labor, capital, and fishery resources. The rents, presently being dissipated, are important for developing countries heavily dependent on their natural resources as the main source of investment financing. Within the fishery sector, satisfactory use rights would allow innovations in fishing technology that would increase net economic returns, rather than innovations that further deplete the stocks and contribute to conflict. In addition, research would become more relevant and the demand for it would grow. Perhaps the greatest benefit would come from the ability of the fisher groups to guide their own destiny.

A study for the World Bank pointed out that "with open access regimes the necessary precondition for any successful development assistance effort is that the property regime be *converted away from open access*" (Bromley and Cernea 1989, emphasis in original). The fundamental issue is that of developing the means to stimulate and facilitate the conversion. In this task there are great opportunities and advantages to be derived from cooperative investigations by all researchers concerned with common property resources.

The development of aquaculture techniques

The basic strategy for developing sustainable aquaculture is to reduce, through technological innovations, the natural constraints that limit the productivity of wild aquatic resources. There are different ways to respond to such a challenge, depending on the variables that can be controlled. In the intensive and semi-intensive systems that have developed, research on nutrition, genetics, reproduction, pathology, epidemiology, stock dynamics, and pond productivity will offer growing opportunities for intensification. Such opportunities are now well appreciated, particularly for the semi-intensive inland systems, which, because of their size, are relatively easy to control and which have already been mastered by some groups of farmers, and for the large-scale intensive operations, where industry has the capacity to master and optimize complex production systems.

Increasing intensification of intensive systems is, initially, not necessarily the most economically efficient option. Problems associated with the fluidity of the environment and the mobility of fish stocks in open waters are similar to those encountered in the domestication of particular species. At

the same time, the capability to master particular farming systems initially differs among rural groups, as well as among firms in large-scale industry. So in the development of aquaculture, ecological and socioeconomic aspects are as important as technological ones.

Because there has been a tendency to reduce aquaculture development to its technological aspects, opportunities for extensive forms of production in large bodies of water (continental and marine) have been somewhat neglected. Mass production systems that could be more easily assimilated by rural groups may offer important opportunities, and they could help increase both the income of rural fisher groups and the long-term global food supply.

Extensive forms of aquaculture have the potential to produce large quantities of food, for several reasons. The primary and secondary productivities in marine and continental waters are available for greater use. The cultivation of seaweeds, bivalve molluscs, and herbivorous finfish is not restricted by the supply of artificial feed because they depend directly on naturally available nutrients. Empirical observations (among which the high stock densities and yields obtained in bivalve culture are well known) and theoretical considerations suggest that wild populations are limited not so much by a lack of food as by losses (for example, by dispersion) of large numbers of organisms at very early stages in the life cycle. Aquaculture, which has developed new techniques for producing fry and spat in large quantities, may provide technological solutions (in addition to predator management) to overcome the dangers in such critical phases. This requires, however, that the reproductive strategies of populations are understood sufficiently to determine the conditions of their enhancement and that adequate use rights are available to stimulate investments. The importance of shellfish culture in certain countries and the development of salmon ranching in Alaska by fisherfolk associations after they were provided with exclusive use rights indicate the potential for such development.

The utilization of harvests

In a context of overall resource scarcity, adding value to a limited raw material is strategically important. In this respect, the challenges for technical innovations in the postharvest sector are diverse: (1) the demand in rich countries concentrates on the luxury and standard products, but is still weak for low-value species (essentially small pelagics) and for prevention of postharvest losses; (2) the medium-term food supply for low-income consumers in developing countries that rely heavily on fish for protein raises serious concerns; and (3) the small-scale and large-scale sectors have different needs with respect to processing techniques.

The large-scale sector is more directly concerned with the development of new products and processing methods and with product safety. Better utilization of small pelagic species is a clear priority for research because such resources are plentiful and similar throughout the world and conventional products have a low value. Here, technological innovations depend on greater knowledge of raw material composition (notably proteins and lipids), as well as on processes such as those involved in the spoilage of fish or in the oxidation of fatty acids. Thus, greater collaboration with basic research is needed. And because of the agro-food industry's progress in the industrialization of food production and its means available for research and development (R&D), its direct involvement in the fishery sector could help speed development. Industry associations that place a high value on research to underpin development, such as the International Association of Fish Meal Manufacturers (IAFMM), play an important role in this regard.

Developing products and methods for the small-scale production sector and for low-income consumers depends more on the adaptation of existing techniques (although there is a need for better knowledge of traditional methods), on improvements in the quality of extension work, and on the analysis of economic and social constraints.

Just as for capture fisheries and aquaculture, the importance to the postharvest sector of economic and social aspects is now widely recognized. The realization that development, because it implies profound changes in the structure and the economy of societies, is considerably broader than the transfer of technology, and that technologically driven development projects have only a small chance for success, are probably the only general conclusions applicable to all three areas.

3

Fishery development and management practices

Changes in the fishery sector over the past two decades call for a reappraisal of the relevance of conventional fishery development and management approaches. Although past practices are now being modified to a certain extent, they have not yet been fully adapted to the new requirements resulting from the changes. This chapter examines past and present fishery development and management practices, identifies some of the most pressing needs for change, and outlines a possible role for research.

Fishery development

The large-scale sector

During the 1950s and 1960s many developing countries experienced a rapid expansion of their fisheries and large increases in total catches. This occurred not only in response to growing demand, but also as a result of technology transfer. Many subsistence fisher communities gradually entered the market economy, trading their catches and buying part of their fishing equipment.

The conditions necessary for this success were unexploited or lightly exploited stocks, growing markets (both domestic and export), entrepreneurial skills, and institutions that encouraged growth in the private sector. Where these conditions were met, the development agencies played a largely catalytic role, providing moderate but significant changes in technology that were readily adopted by private entrepreneurs. Attempts to create state-owned fishing companies generally did not achieve the expected objectives (Asian Development Bank 1986).

Many development initiatives were unsuccessful, even where resources were plentiful. The fact that the extension of national jurisdiction has not been followed by a marked change in foreign fishing activities off northwest and southwest Africa, southeast Latin America, and in tropical tuna fisheries in general (Troadec 1989a) reveals constraints other than simply insufficient mechanization and capital.

The rate of success of projects and the state of fisheries in general deteriorated as the resources became fully utilized. In the early 1980s recognition of the problems associated with development projects led several agencies to undertake evaluations (annex 5). These evaluations provide a good basis for identifying past development practices and the main reasons for their low rate of success. They also give useful indications of the kinds of change needed to improve future programs and activities.

The general lack of success in fishery development projects is recognized in the statement by the World Bank (1986b) that "overall, the performance of the Bank's fisheries portfolio continues to be poor: 50 percent of 16 completed fisheries projects were adjudged at audit to have failed in their major objectives, or to offer uncertain or marginal outcome." Similarly, the Asian Development Bank (1986) noted that of eight completed projects that had received post-evaluation reports, only two appeared at the time likely to achieve economic internal rates of return of at least 10 percent.

The reasons that different evaluations gave for the poor performance were both general and specific to fisheries. The most commonly stated reason specific to fisheries was inadequate appraisal of the resources. Total potential yields had been overestimated, or it was assumed that catches would increase proportionately with effort.

But the failure is rooted more in the pressures for increased investment in fishing capacities and in development experts' lack of appreciation of the limited nature of fishery resources than in erroneous estimates of potential yields. The fact that the world fishery potential was accurately assessed as early as the late 1960s is evidence that appropriate methods were available and widely applied.

Some of the evaluations pointed to open access as a reason for failure. In the World Bank evaluation open access is referred to in a footnote to the discussion of one of the projects. For certain projects the provision of aid for vessel construction was conditioned on the government's limitation of total fishing effort or based on the assumption that older vessels would leave the fisheries. Although these examples indicate a recognition of the problems of overcapitalization, they also reveal a lack of understanding of the problems of open access and effective allocation of resources.

The evaluation by the Danish International Development Agency (DANIDA 1989) deals most directly with the problems that open access has created for fishery development projects. It emphasizes the need for more effective management, following a systems approach, and it points to the shortcomings of an uncritical application of North Atlantic management techniques to tropical fisheries.

In the past, development aid has tended to emphasize aspects in which improvement depends primarily on public initiatives — for example, mechanization; the limited nature of the resources; insufficient demand and the extra cost of underdevelopment; and the introduction of technical innovations and investment, with little attention to the economic, social, and cultural environment of production and to the constraints resulting from open access (Doucet, Pearse, and Troadec 1981). In comparison, actual development, in both the large- and small-scale sectors, often occurred without any direct public intervention, but as the result of private initiative operating within appropriate conditions.

The small-scale sector

The evaluations by DANIDA and the Commission of the European Communities (CEC) also discuss the failure to deal satisfactorily with the special needs and challenges of the small-scale sector (DANIDA 1989 and North Sea Centre Group 1988). The UNDP review (1986) noted that a major constraint in this sector was the lack of satisfactory information on the economic and social aspects. It pointed to inadequate markets, the high costs of new technologies, and social and cultural impediments to the adoption of new techniques. It also stated that "technological improvements applied to limited resources have led, in some cases, to an uneven acquisition of the technology, benefiting a few to the detriment of the many. This has also been a source of conflicts between different users of the same stock or area" (UNDP 1986).

Similar remarks are contained in a publication of the World Bank (Sfeir-Younis and Donaldson 1982), which proposes improving "small-scale fishing efficiency and productivity" through modern gear technology, improved fishing vessels, and better processing, distribution, and marketing facilities. The paper also stresses the need for both biological and sociological research "to ensure that the new technologies are relevant to their [small-scale fishermen's] needs and abilities, and to promote their understanding and acceptance of measures that may have to be introduced in the interests of resource management."

Following the sector evaluation of EC fishery cooperation, the Council of Ministers of 69 African, Caribbean, and Pacific (ACP) states and 12 EC states adopted "basic principles for fisheries" (CEC 1990). The CEC has also published guidelines for fishery projects (Spliethof, MacPherson, and Pena 1990). Independently, several development agencies are already proceeding along such lines. Development projects funded by Denmark, Germany, Norway, and Sweden are notable for their concern for the special needs of the small-scale fishing communities. Two outstanding examples are the support provided by DANIDA, the Swedish International Development Authority (SIDA), and the Overseas Development Administration (ODA) to the Bay of Bengal Program being executed by the FAO, and the support provided by the UNDP, the World Bank, and the German Agency for Technical Cooperation (GTZ) to the International Center for Living Aquatic Resources Management (ICLARM).

Many development projects continue to operate along the lines of the past, however, using the "reductionist" approach followed for large-scale fisheries and emphasizing technological innovation (improved vessels and gear) and the provision of capital to enable the fishers to adopt the technologies. This approach is supported by most, though not all, developing countries.

The consequences of these development practices, discussed in previous sections, are briefly summarized below:

- Additional pressures on stocks
- Reduction in employment opportunities as subsidized capital replaces labor
- Conflict between large- and small-scale sectors and, within small-scale fishing communities, between those who adopt the innovations and those who do not
- Damage to traditional organizational rules that governed access to resources within communities.

Fishery management

Methods for assessing the environment, fish resources, and fisheries

Immediately before and after World War II accurate methods to assess the potential yields of fish stocks were developed. According to the theory of fishing, fish production can be optimized by manipulating the age at first capture (for example, through the enforcement of mesh size regulations) and the overall rate of fishing (fishing effort) for individual fish stocks. These tools were largely satisfactory for evaluating investment opportunities for the development of latent resources during the expansion phase. They were utilized by the large-scale sector, which enjoyed a high degree of mobility in deploying capital and labor.

Sometime after World War II bioeconomic models based on these stock-assessment models were developed to analyze efficiency in the use of fishery resources. These models showed that, because of the limits to stock yields, maximum average production is not an adequate development objective. It fails to take into account the cost of fishing, and leads to excessive use of labor and capital. In the long run net economic benefits are achieved at a level of fishing effort lower than maximum average yields. These bioeconomic models can be used to analyze the economic and social implications of exploitation at different levels of capital and labor inputs and to evaluate potential gains.

Economic models are also available to quantify potential rents and producers' and consumers' surpluses (Copes 1970). Fully appropriate tools are available for sector analysis (for a general presentation, see Panayotou 1989; for an application to a national fishery sector, see Doucet, Pearse, and Troadec 1981). The FAO has developed interactive computer simulation models to analyze interactions (for example, between the capture and processing sectors or between small-scale and industrial fisheries). Yield, costs, revenues, employment, foreign exchange, and other parameters can be considered. The software BEAM I to BEAM IV has been widely applied at national levels and used in training courses.

Where fishery resources have been fully exploited, however, conventional biological models have important shortcomings. They are usually single-species models that are inappropriate for taking into account environmental changes or one species's interactions with others in the food web. That is because they are based on assumptions of average environmental and recruitment stability and consider fishing the factor that determines stock abundance and production. In fact, these models have probably led to an exaggeration of the role of fishing in stock collapses, at least in environmentally driven ecosystems such as upwellings. In addition, current applications neglect the effects of predation on the early stages of trophically related species in multispecies resources. In theory, these effects can be modified by manipulating the distribution of fishing effort over the exploited predatory species. The main practical conclusion of recent investigations in this field, however, has been that the potential long-term benefits of mesh size regulation are probably overestimated (Daan 1990).

The two most important factors in fishery management are the interspecific predation and the relation between recruitment and the environment. Because of the current lack of attention to management, fishery science is unable to explain stock collapses, to provide objective advice for minimizing their occurrence, or to give rules for optimizing stock recovery (assuming that fishing plays a role in stock collapses). The issue could be resolved, at least in part, if specific scientific investigations were undertaken.

Environmental assessment methodology and the economics of natural resource systems are

other areas where the state-of-the-art research falls far short of meeting current and future needs. Models are needed for the principal aquatic ecosystems that would combine information on the physical and natural environment and the ecology of species with the socioeconomics of human intervention in exploiting and managing such systems. General models featuring the principal production systems could be adapted to particular cases of local interest, such as algal blooms (ciguatera) and contaminant flow through the food web. This type of modeling would also be crucial for analyzing the effects of global warming.

The important changes in fisheries necessitate a change in data analysis. The present systems were developed during the period of expansion and provided the basis for assessing the resources and for monitoring the performance of the large-scale sector. But full utilization has led to a change in the nature of problems and an increase in the need for information on fisheries and fishers. Three kinds of data are needed: (1) data collected occasionally for specific research purposes; (2) biological, economic, and social data for assessing and monitoring managed unit fisheries; and (3) national data on output by major production systems (by large- and small-scale capture fisheries, by different kinds of gear, and by large extensive, semi-intensive, and intensive aquaculture systems). The lack of knowledge about development processes makes it important to acquire information about the progress of different production systems — about which ones are developing and why. National and global production statistics have little meaning if they cannot be sorted by production system. Producing such data should be an important objective for the FAO *Yearbook of Fishery Statistics*.

The conventional management approach

Faced with stock depletion, administrators have conventionally responded by addressing the symptom rather than the cause. They have followed three general approaches: (1) restricting the kinds of gear, vessels, or engines that can be used; (2) instituting controls on age of first capture; and (3) limiting total catch.

The first approach is, in some cases, eminently desirable, such as prohibitions against the use of dynamite or poison. In many instances, however, this approach is adopted more as a means for reducing the competition from efficient gear than as a means for conserving the stocks. And, like other conventional approaches, restrictions on gear do not prevent excessive use of capital and labor. Rather, they stimulate investments in inputs that substitute for the one that is controlled, thereby artificially distorting the combination of inputs. Moreover, by preventing technological innovations, they place the fishing industry at a disadvantage relative to other industries, and perpetuate inefficiency.

The second approach, controls on the age of first capture, includes limits on the size of fish that can be landed and on the size of mesh in trawl codends or drift nets; closed seasons when small fish are available; and closed areas (nursery grounds or prohibitions against trawling in inshore waters). These techniques can enhance resource productivity: a one-month extension of the closed season in Cyprus produced dramatic increases in the total tonnage of catches (Garcia and Demetropolous 1986). But without additional controls they cannot prevent waste in capital and labor. The economic forces that drive fishers to overinvest in open access fisheries are just as strong, if not stronger, for stocks made up of large fish as they are for stocks of all sizes.

In the third approach, limits on total catch are imposed through total quotas on the stock as a whole, through quotas on catches in subareas of the stock's range, or, indirectly, through closed seasons. In multinational fisheries, such as in the northeast Atlantic, total quotas may be broken up into national shares. These techniques have not always been successful in preventing further depletion (in the case of Antarctic whales, for example) and do not, and cannot (without other controls), prevent economic waste. There are numerous examples of failure (FAO 1983).

Limits on total catch cannot by themselves prevent economic waste for very simple reasons. In a total quota system, every fisher has an incentive to increase his effort as much as possible to get the greatest share for himself before the total quota is reached and the season closes. Seasonal closures produce the same effect.

In all cases, enforcement is a difficult task as long as access is not effectively regulated. With total or national quotas, there is a tendency for the fishing industry and national administrations to underreport catches. Regulations against large-scale vessels in inshore waters are widely violated, and fishers show considerable ingenuity in

effectively reducing mesh size in the codends of trawls.

As long as open access remains in effect, conventional management approaches may be able to prevent stock depletion if they are effectively implemented and enforced, but they can do nothing to prevent excessive numbers of fishers from entering a fishery. The more effective they are in increasing total catches, the greater will be the pressures to enter the fishery. The only way to prevent these consequences is to limit access to the resources directly or indirectly, a solution that would require some form of exclusive use rights.

The conventional management measures have been adopted for a variety of reasons. In part, they reveal a lack of appreciation for the basic cause of the problem. To a larger extent, perhaps, they reflect the real difficulties associated with the necessary institutional changes (discussed below in the section on capture fisheries).

The strongest stimulus to change comes from crisis, whether conflict, a severe depletion of stocks, or significant declines in income. As opportunities for expansion to new fisheries decline and pressures on present fisheries increase, such crises are becoming increasingly apparent and creating forces for change. The total ban on trawling in the western part of Indonesia is an example (Bailey 1987).

Aquaculture development

Evaluations of aquaculture development projects in developing countries (see in particular UNDP, NORAD, and FAO 1987) have generally justified the priority given to aquaculture by the scarcity of wild resources and by the need to generate employment and income, notably among the rural poor, and to acquire foreign currency. Multilateral aid has focused on aquaculture development for small-scale farmers. In Africa, for example, 90 percent of the aid went to projects aimed at helping subsistence farmers (Huisman 1988).

The overall impact of development projects cannot be quantitatively assessed. Initiatives by development agencies have helped to raise awareness of opportunities in aquaculture, promote its takeoff, and disseminate technical aspects of aquaculture development. But although global aquaculture production is assumed to be growing at a rate of 5 percent annually, this growth does not necessarily meet the development objectives. Production increases are still restricted to regions where economically significant activities existed before the initiation of aid programs and to large-scale operations undertaken independently by the private sector. Production has not taken off in rural areas of Africa and Latin America. Despite the aid for aquaculture development in Africa, US$150 million in 1972-85, Huisman (1988) suggests that production declined in this period.

Many aquaculture programs and projects were inspired by the Kyoto strategy,[9] which was based on a zoological and technical approach and emphasized cultivated organisms and the design of the grow-out structures. The strategy assumed that technical solutions were known or could be rapidly developed through R&D and applied from the top down. It included little assessment of systems that would be socially acceptable, economically profitable, and environmentally sustainable (World Bank and others 1991g).

Intensification and the development of new systems were emphasized despite the dominance of extensive and semi-intensive systems in aquaculture in developing countries. Technological solutions, such as intensification in the culture of high-valued species, were seen as the way to achieve profitability. Little attention was devoted to ways of achieving better yields at lower costs. The long-term contribution of extensive systems remains to be assessed (World Bank and others 1991g).

With respect to bilateral aid, "few donors have a well-articulated policy for their technical assistance in aquaculture. This is reflected, on occasion, in hasty and uncritical attempts to transfer technology often not suitable to the needs of the recipient country" (UNDP, NORAD, and FAO 1987). Support for exports of national services and equipment was also an underlying motivation.

The need for change in development and management practices

The first objective of the SIFR is to "determine the degree to which the lack of information is an impediment to effective fisheries management and development." The analyses in this and the previous chapter indicate that considerable improvements can be made on the basis of information presently available but that, in the long term, new and innovative research will be essential to ensure the full realization of the opportunities that exist.

There are clearly major gaps and deficiencies in the basic data on fisheries. Statistics on output are not available by systems of production. Basic data

on social and economic aspects of fisheries are scarce and, where available, of dubious validity.

To a large extent the deficiencies stem from the difficulties of collecting basic data in an industry with large numbers of disparate products and vastly different kinds of gear. The difficulties also reflect the inadequate incentives for fishers to provide the data and for administrators to acquire them. In the absence of satisfactory use rights, providing accurate data will not benefit fishers and may even disadvantage them if it reveals secrets on the magnitude and location of their catches. Similarly, administrators see no advantage in data that cannot be used to develop the resources. Even if the basic data were fully available, they could not be used to improve fisheries unless fundamental changes were made in institutions.

Conversely, improvements can be made without having more or better information. In most cases, the information presently available is sufficient to undertake the necessary changes in institutions and to increase the benefits from the resources. Furthermore, having improved institutions in place would enhance the ability to use information and increase both the relevance of research and the demand for it. The development of new models of major aquatic systems and their application in specific countries would allow better use of existing data as well as the elaboration of cost-efficient strategies to collect the most pertinent data for understanding and managing these systems.

Capture fisheries

Present improvements. The most significant improvements in capture fisheries can be achieved by national governments adopting new fishery management mechanisms.

It is simplistic to assume that effective fishery management can be achieved without assigning some form of property rights. The essential requirement is to control access to the resources. The theory and practice of the different techniques have been fully discussed in many publications (see, for example, Hamlisch 1962; FAO 1983; IPFC 1987; Campbell, Menz, and Waugh 1989; and Neher, Arnason, and Mollett 1989).

The most publicized experiences in the use of access controls are in industrial countries. But several fisheries in developing countries also operate under restricted access systems — for example, in Egypt (Awadallah 1982), Malaysia (Sulaiman and Ch'ng 1987), Mozambique and Madagascar (Sanders 1988), and Papua New Guinea (Vonole 1989). Territorial use rights in fisheries that have been adopted (as against those that have evolved) are in use in Indonesia (Martosubroto 1987) and in the Philippines (Flores and Silvestre 1987; Pastoral 1987; and Smith and Panayotou 1984). Although these systems face a number of difficulties, they indicate an awareness of the need for such controls and a willingness to take the necessary steps.

Adopting access controls can lead to several kinds of problems. One is that the administrative allocation of exclusive use rights benefits one set of users at the expense of another set. The wealth distribution decisions required are generally not within the mandate of fishery administrators but must be made at a political level. Another difficulty is in determining where the management functions are best fulfilled and what the role of the government (at whatever level) should be relative to the role of the group of fishers. Many fishery administrators are reluctant to relinquish their authority (or even part of it).

The short-term effects of closed access on employment present a particular difficulty, depending on the situation of the fishery and the system used. The overall employment effects need to be considered in a long-term context, however. Maintaining open access will itself lead to the eventual diminution of employment in fisheries. But closing access will increase net economic revenues, which can be invested in other employment-generating activities.

The adoption of access controls is technically easier for large-scale fisheries than for small-scale ones (IPFC 1984). Large-scale fisheries are in a better position to work within allocation schemes based on economic mechanisms, which they already routinely use for mobilizing capital and labor. Small-scale fishing communities, on the other hand, are marked by restricted mobility, including a high dependence on adjacent resources, and by social rules of organization within their communities. Systems based on exclusive collective rights may be initially more suitable for them than those based on market mechanisms (World Bank and others 1991e).

The allocation of exclusive use rights, either individual or collective, does not imply that fishery resources have to be privatized or that public management will become unnecessary. Because of the fluidity and extensiveness of aquatic ecosystems, there are strong arguments in favor of combining public property rights with exclusive (individual or collective) use rights. The relative

roles of public administrations and individual producers will depend on the level at which controls over the resources and their environment can best be exerted.

Implications for research. Adopting the kinds of management measures discussed above requires that biological resources be understood within the context of their environment. It also requires much more attention to the social and economic factors governing the behavior and strategies of resource users. This, in turn, implies a new focus for research, with greatly increased emphasis on the social sciences relative to biological and technological studies. The same shift in emphasis is required for other common property resources (Peters 1986).

Untangling the relationships among uses, users, and the varying influences on use, equity, and gender issues requires innovative research at several levels. It requires involving the fisher groups and communities, to gain a better understanding of their needs and constraints and the unwritten rules within which they operate. This understanding is necessary to ensure that outside interventions and support programs suit the local context and have a high chance of success.

National research institutes need to broaden their competence to include social and economic research and to undertake studies of both the organization of user groups and the influences on them of local and national institutions and government agencies.

Although fisher groups vary widely in organizational rules, institutions, and influences, there is a commonality in research methodologies that invites international efforts. In addition, the broadly shared interest in all common property resources and their management suggests that there are significant opportunities for cooperation at the international level among those concerned with natural resources.

Aquaculture: The need for a systems approach

Present improvements. There is a need to widen the scope of development strategies in aquaculture, to take account of important factors that have been neglected. The development constraints involved in improving existing systems differ substantially from those involved in introducing new ones among rural groups. There are also important differences between promoting small-scale and large-scale operations.

Small- and large-scale commercial operations differ significantly in the mobility of the means of production and access to them. How they dispose of products is another area where they differ. Economies of scale may work against small producers, so a well-developed fishery sector can be an important asset for aquaculture. Economic and social constraints are likely to be particularly tight among rural groups living on the edge of poverty.

Under these circumstances it is not surprising that projects aimed at developing technological packages, particularly for rural development, have been the most unsuccessful (UNDP, NORAD, and FAO 1987). In the exploitation of living resources by small-scale farmers, the ecology of the resource and the sociology of modes of production dominate the choice of technical solutions, not the reverse.

To improve the relevance of aquaculture development strategies requires analyses of development prospects. The links between controllable and noncontrollable variables should be investigated at four levels: (1) the farming systems; (2) the production units; (3) the social organization of producers; and (4) the relationships among these three structural layers.

1. *Aquaculture farming systems.* Farming systems are technically feasible and economically viable when specific combinations of environmental, stock, and organism variables are mastered simultaneously at the micro and macro levels.

An important step in passing from extensive to semi-intensive integrated systems is the artificial enhancement of primary production in the culture environment and the supplementing of feed with waste from other crops within the same production units. The ability to derive benefits from progress in genetics depends on the farming practices. Only when the systems are sufficiently developed and managed can the genetic characteristics of cultivated strains be effectively controlled.

This concept of farming systems stresses the importance of a global and integrated approach for successful development — that is, the importance of relevant and comprehensive research agendas and development approaches, rather than the "reductionist" and disjointed approach frequently encountered in development initiatives and research programs.

2. *Production units.* The same concept can be applied to the different economic contexts within which the present farming systems exist or for

which new farming systems are proposed. Prevailing economic forces not only determine the different combinations of agriculture, livestock, and aquaculture crops viable in polyculture, but also influence such factors as optimal feeding, investment costs, size of production units, and harvesting and rotation rates (World Bank and others 1991g).

Literature is now beginning to appear on the technical and economic factors that determine the polyculture combination at the level of the production unit. Economic models are available for optimizing the production function, although they are not yet used systematically in aquaculture development (World Bank and others 1991g).

Production systems are also dependent on the characteristics of local demand. Development plans do not always give adequate attention to demand as a critical condition for development; confusion between need and demand is common. Because demand distribution is mixed, a global demand for food, income, and employment does not imply that there is a local demand, especially in those communities on which international aid focuses.

3. *Social organization.* Rural communities in the developing world are being increasingly incorporated within the general economy. The degree of their incorporation depends on their productive relationships with available natural resources. Agricultural production systems in developing countries differ widely in their social organization, use of economic mechanisms, and requirements for technical skills. These differences affect the opportunities and paths for aquaculture development. Although the global tendency is clearly toward greater commoditization, the use of economic mechanisms, and the formalization and individualization of use rights, it is still important to understand the situation of each community to ensure that the development or modification of aquaculture systems is in accord with local conditions.

4. *Relationships among the elements.* A systems approach would comprehend all three elements: farming systems, production units, and social organization. It would begin with the community and seek to understand its specific economic and social characteristics as well as the environment within which it operates. This would determine the constraints and opportunities for the development or improvement of aquaculture systems.

Implications for research. Research in tropical aquaculture has made significant contributions to its development. It has concentrated on the biological functions of organisms. Relatively less work has been devoted to the productivity of ponds in traditional inland farming systems; to enhancing their productivity by using locally available agricultural waste and offal; and to the dynamics of multispecies stocks (World Bank and others 1991g). Similarly, the potential importance of extensive systems for the development of living resources in open coastal and continental waters and the promotion of small-scale fisher communities has been neglected in research programs centered on species physiology.

Little attention has been given to economics, sociology, or the shortcomings of prevailing use rights in access to stocks, water, and land. There are several reasons for this. One is that research has often been confined to an operational role (short-term and disjointed adaptation of zoological techniques). The different requirements for the transfer and adaptation of existing techniques, technological experimentation, and scientific research have not been adequately distinguished.

Awareness of the importance of social organization is commonly expressed in development circles in the call for appropriate technology, with an emphasis on the importance of traditional know-how and the need to distinguish among expanding aquaculture, increasing intensification (Asia), and introducing aquaculture (Africa and Latin America). But this appreciation generally remains too superficial to be effective. Original research is required to determine which aquaculture systems would fit best with existing agricultural and forestry practices and socioeconomic organizations.

The confusion between development and research, and the reliance on research capacities for development operations, have hindered both development and research. Development agencies have not been provided with the kinds of information they need, and appropriate new techniques or methods have not been produced. The development of research skills and the establishment of adequate working conditions have also suffered.

4

The potential contributions of research

Scientific and technological research is defined as the intellectual investigations and practical experiments conducted to develop new theories, laws, and techniques. Different kinds of research can be identified — in the progression from acquiring knowledge to applying it — by both their objectives and their mode of operation.

The Consultative Group for International Agricultural Research (CGIAR) has identified four types of research:

- *Basic research* is designed to generate new understanding. It has a long time frame and no certainty of success.
- *Strategic research* is designed to solve specific research problems and is thus less speculative.
- *Applied research* is designed to create new technology.
- *Adaptive research* adjusts the technology to local conditions.

These four types together form a research continuum.

At present most of the research carried out in developing countries is applied and adaptive, making use of basic and strategic research results from industrial countries. The ultimate objective, to conduct basic and strategic research at national and regional levels, is still some way off. But there are no clear-cut boundaries between the different kinds of research. It is probably more important to ensure that the research being conducted is good and relevant science than to be overconcerned with whether it is basic or applied.

In this report the two terms generally used are strategic research and applied research, to which the following definitions apply:

- *Strategic research* involves the investigation of basic scientific problems of practical importance that cannot be solved with existing knowledge.
- *Applied research* applies existing scientific knowledge to specific technical problems. As used here, the term includes adaptive research, which adjusts known technology to local conditions.

The roles of the public and private sectors

Differences in the scale of technological and institutional innovations are critical in determining the respective roles of the private and public sectors. Combining production systems into technologically viable and economically profitable activities is generally the responsibility of the private sector. Consequently, technological changes are generally implemented by producers, as is primarily the case in large-scale fishing, aquaculture, and processing activities. Major developments have come out of research in nonfishery sectors and been imported into developing countries — for example, electronic equipment and outboard engines.

The private sector contributes significantly to training and to the diffusion of technological innovations in developing countries, as it needs personnel with adequate skills for expansion.

For R&D programs the private sector generally relies on public institutions, such as universities and sectoral research institutes. But because it has no mandate for development in developing countries, it conducts very little research there, getting most of its scientific inputs from industrial countries. Aquaculture may be an exception.

Involvement of the public sector in fisheries research can be justified by a number of considerations. Among the most important are the shared resources and their diverse use by competing interests. Because controlling resources and their uses is beyond the ability of producers, the management of fisheries and the protection of aquatic ecosystems require public intervention and research.

Social objectives that cannot be met by private interests provide another rationale for public support of research, as does work with long time horizons. Public institutions can be more cost-effective than numerous small private laboratories. Innovative research is not only costly, it is also risky and amortized only in the medium term. And because there is no incentive for private investment in research if the investors cannot acquire a proprietary interest in the results, research on the state of the resources and the aquatic environment also requires public support.

Areas in which the public sector should concentrate its investments are:

- Conservation and management of the aquatic environment and its fishery resources
- Consumer health protection and inspection (where quality controls are imposed, however, the private sector has incentives to undertake the research)
- Support for the small-scale sector to counter its disadvantages in competing with the large-scale sector
- Socioeconomic analyses and research on policy and global issues for the formulation of government policies
- Institutional changes
- Education and training.

The research areas in which the private sector is likely to invest are those that allow satisfactory returns with low risks:

- Technical information on equipment and markets
- Technical services, for example, quality control
- Practical experimentation and adaptation in boat design, fishing equipment, and aquaculture technology
- Market analyses and trading practices.

Several SIFR missions (see, for example, Troadec and others 1991) have shown that the distinctions between public and private research interests are not always clear. The heavy involvement of governments in fishery management and economic development is often accompanied by the provision of free services to the industry. The bureaucracy that provides those services tends to become entrenched and may view private sector research as a threat to its role rather than as an opportunity to enhance efficiency. There is therefore a general need for clear-cut national policies that take into account opportunities in research and the comparative advantages of the public and private sectors in supporting and carrying out different components. Encouraging private sector contributions to research should be seen as a way to concentrate limited public means in areas of public concern. In countries where the large-scale fishery and aquaculture sectors are developed, there are advantages for the governments in stimulating the collective involvement of the industry in technical and R&D activities and encouraging small-scale producer associations to play an active role in extension.

Development and research

The review of past aquaculture development approaches in chapter 3 showed that an insufficient distinction between research and development can be detrimental to both activities. Although research can prove its usefulness only through application, research policies that are restricted to immediate development concerns are ultimately doomed, for three reasons.

First, research is only one component of development and management. Public development agencies do not operate under conditions of economic efficiency and can therefore be only partially effective in demonstrating the economic profitability of innovations. And not being bound to achieving economic profitability, they have difficulty terminating demonstrations that have failed, unless strict, periodic evaluations are the rule.

Second, innovative research requires more time to materialize than adaptive research. Research policies focused only on application risk failing to anticipate the need for new knowledge.

Third, different kinds of research require different professional qualifications and working conditions. The confusion between repetitive applications to development and management, and the development of new approaches and methods, is a major cause of stagnation and poor performance in research.

Maintaining a clear distinction between development and research requires effective mechanisms and structures for communication between public research and its potential users, public and

private. The dissemination of public research outputs to fishery administrations and the production and postharvest sectors requires particular mechanisms and structures (see below). And the capacity to assimilate research outputs depends on conditions — such as access to credit or security of tenure — that can be more important for economic growth than technological innovations.

Priority research areas

Since the SIFR has been under way there has been a substantial change in the approach to international fisheries research. For some time the Consultative Group for International Agricultural Research (CGIAR), which funds and manages a number of international agricultural research centers, considered establishing a center for aquaculture research. The International Center for Living Aquatic Resources Management (ICLARM) was a candidate for this role. On the recommendation of its Technical Advisory Committee, the CGIAR decided to widen its coverage to other areas of fisheries research (but excluding intensive aquaculture and deep-sea fisheries) and in November 1990 recommended in principle that a reoriented ICLARM should join the CGIAR as an international institute for fisheries research. (In May 1992 the Technical Advisory Committee is expected to recommend the immediate admission of ICLARM as the fisheries research institute of the CGIAR). Because of the overlap between this initiative and the SIFR, the two have been closely coordinated, and each has benefited from the other.

During 1991 ICLARM developed a strategic plan for an international fisheries research institute (ICLARM 1991). The plan identifies strategic research areas in which an international research center would have a comparative advantage. A long-term program for strategic research has been drawn up in accord with CGIAR criteria, and the resources and collaborating institutions identified. It is hoped that these steps will eventually lead to an internationally funded strategic research program in fisheries. The program would maintain links with institutes in developing countries, but it would not extend to cover the wide area of applied research required there; the bulk of present development assistance to fisheries research is directed to meeting those needs. ICLARM's strategic research program is considered in more detail in part 2 of this report. It should not be assumed that strategic research at an international level is the exclusive preserve of a single institute; a number of universities and other institutions run such programs (annex 8).

The SIFR Advisory Committee, while acknowledging the need for strategic research, gave highest priority to strengthening national research capacity and encouraging regional research initiatives. As noted earlier, at least for the time being research programs in developing countries will generally concentrate on applied research. International-level research is necessarily limited to relatively few topics of broad application and tends to be at the strategic end of the research continuum.

The broad strategic research topics that have emerged from ICLARM's deliberations — choices supported by earlier sections of this report — are as follows:

RESOURCE CONSERVATION AND MANAGEMENT. The objective of research in this broad area is to develop tools that will enable fishery resource managers and policymakers to manage resources so as to ensure sustainable development in both capture fisheries and farming systems. Consideration of human linkages is essential for sustainable resource management.

FISH PRODUCTIVITY (AQUACULTURE AND CULTURE-BASED FISHERIES). Research in this area seeks to improve the biological and technical basis of developing country aquaculture in order to allow optimization of small-scale aquaculture systems and increased production from culture-based fisheries. To achieve full impact, the results of this research must be combined with relevant socioeconomic information.

COMMODITY CONVERSION AND UTILIZATION. This area comprises research on the conversion of fishery resources into food for human consumption and includes efforts to improve capture, handling, and processing technologies. Because this area has a large applied research component, it will not be taken up by the international institute. The important gap that this will leave in the strategic research agenda will have to be filled through other means.

HUMAN LINKAGES, SOCIOECONOMICS, AND POLICY. The term *fisheries* implies productive human activities. The human linkages — the socioeconomic aspects of the fishery sector — play a critical role in maintaining the productivity of the sector. And productivity, as well as issues of equity, gender, and access, play key roles in improving the welfare of the poor.

Box 4.1 Summary of applied research requirements

RESOURCE CONSERVATION AND MANAGEMENT

- Maintaining environmental quality
- Impact of man's activities on the environment and on fish production
- Assessment and monitoring of resources
- Modeling of ecosystems supporting exploitable resources
- Effect of pollution on aquatic resources
- Human health risks posed by consumption of fish from altered environments

FISH PRODUCTIVITY

- Fry and fingerling production
- Enhanced recruitment and habitat management
- Economic analysis of application of improved technology
- Conservation of ecosystems and genetic diversity
- Impact of nonindigenous species and stock enhancement
- Choice of species and farming systems
- Epidemiology and pathology of major diseases

COMMODITY CONVERSION AND UTILIZATION

- Selection of relevant technology for small-scale fisheries
- Improved vessel design and selective gear development
- Reduction of postharvest losses
- Utilization of small pelagic species
- Development of low-cost products
- Biotechnology and fish utilization

HUMAN LINKAGES, SOCIOECONOMICS, AND POLICY

- Assessment and monitoring of the economic and social state of fisheries
- Regulation of access, use rights, and resource rents
- Technical aspects of enforcement
- Social mechanisms in management of small-scale fisheries
- Social organization, gender, and equity issues in small-scale fishery communities

Although applied research objectives have been linked to economic activities rather than to scientific disciplines, it is still possible to classify the applied research needs identified in earlier sections under the same four topics. But that would make the coverage under each topic too broad to allow the setting of priorities. A further complication arises from the fact that the applied research would be carried out at a national or regional level. Differences among regions and countries in geography, resources, culture, and stages of development would make setting global priorities impossible. The process of elaborating agendas for applied research will therefore differ from that for international strategic research. In the list of applied research requirements in the appendix box (and in the summary in box 4.1), no attempt has been made to establish priorities. But there has been an attempt to identify the types of project under each objective to which, depending on the conditions, national institutes might assign priority. An attempt has also been made to separate fishery development issues that require the application of known science from issues that might require specific scientific investigations.

Appendix box Applied research requirements

RESOURCE CONSERVATION AND MANAGEMENT

Application of known science

- Monitoring and maintaining environmental quality for fisheries and recreational purposes
- Assessing the effect of urban, industrial, and agricultural effluents on the environment in terms of eutrophication, oil pollution, chemical contaminants (pesticide residues and heavy metals), and bacteria and viruses of public health significance
- Impacts on recruitment
  - Reduction of spawning or nursery areas as a result of mangrove cutting, global warming, land reclamation, siltation following deforestation, and reduced river flow caused by use of fresh water for agriculture or industry
  - Mass mortalities of eggs and larvae as a result of pollution
- Decline in production from adult stocks
  - Changes in growth or mortality as a result of pollution
  - Mass mortalities caused by oxygen deficits stemming from eutrophication, red tides, and other causes
  - Entanglement or entrapment of nontarget animals and ghost fishing by abandoned nets, traps, and pots
- Assessing and monitoring resources
  - The relationship between fishing capacity, production, biomass, and catch rates (population dynamics of recruits)
  - Variability of stock abundance and its effects on assessments, and impact of gear interactions
  - Effects on wild and enhanced fish populations of wild larvae capture for aquaculture and stocking programs
  - Multispecies resource assessments and simplified methods of routine stock monitoring

New scientific investigations

- Modeling of ecosystems for sustainable resource management, taking into account the impact of human settlement
- Modeling of hydrodynamic flows, especially in lakes and coastal areas, to determine dispersion of contaminants and the carrying capacity of productive areas
- Primary productivity modeling, causes of red tides and other abnormal plankton blooms, and eutrophication processes
- Ecology of altered ecosystems and fish communities, effects of such stresses as pollution, biodiversity, and introduction of new strains or species, and impact of stocking programs on biodiversity
- Toxicological effect of pollutants on aquatic organisms or ecosystems
- Human epidemiology of diseases transmitted by or through aquatic organisms or environments: bacteria and viruses, particularly in molluscs, and accumulated toxins — ciguatera, paralytic shellfish poisoning, and diarrhetic shellfish poisoning caused by red tides and chemical contamination of the food chain
- Age-specific natural mortality of commercially dominant fish species, including predation on early stages and the effect of changing the fishing patterns for major predator species on the recruitment of major prey stocks

FISH PRODUCTIVITY (AQUACULTURE AND CULTURE-BASED FISHERIES)

Application of known science

- Fry and fingerling production through improved hatchery technology and disease control
- Development of culture-based fisheries and extensive means of production through such methods as enhancing recruitment and habitat management, species diversification, and biomass regulation
- Cost-benefit analysis of production integrated with improved demand analysis
- Investigation of the assimilation of technological innovations through training and extension
- Economic analysis of production, investment, markets, and optimization of production units
- Conservation of natural ecosystems, indigenous species, and genetic diversity
  - Effects of the introduction of nonindigenous species and the escape of cultured species from aquaculture establishments
  - Effects of stock enhancement programs on natural ecological associations of species
  - Impact of overfishing, escapes, and introductions on genetic diversity

New scientific investigations

- Choice of species farming systems and potential farmer groups related to site-specific economic constraints and socioeconomic structures
- Investigation of the prospects and conditions for developing extensive aquaculture in relation to (1) strategies to regulate fish populations, (2) the effects of larval behavior and predation in the early life stages, and (3) parental biomass related to fecundity and recruitment
- Ecologically oriented investigations of ways to optimize stock density and species composition in extensive systems; pond productivity, fish feeding, and ecosystem modeling to improve production from semi-intensive systems; and limitation of the adverse environmental impact of aquaculture on cultivated stocks
- Stock assessment and management in ponds and extensive systems; and dynamics of single-species and multispecies management and the optimum mix of herbivorous and carnivorous species
- Epidemiology and pathology of major diseases
- Biotechnology in relation to genetic selection, manipulation, and gene transfer[10] (These will be very important areas of applied research in the future, but for the time being research in these areas will be basic and strategic.)

Appendix box (continued)

COMMODITY CONVERSION AND UTILIZATION

Application of known science

- Fishing technology — selection of relevant technology for small-scale fisheries — particularly for use in developing countries, where private sector interest is limited
  - Improved fishing boat design, reduction of energy consumption in fishing, and investigation of alternative building materials
  - Development of more selective fishing gear
  - Fish detection and ancillary fishing equipment
- Estimation of postharvest losses, in both physical and economic terms, and improved utilization through selection and improvement of technology, including in transport, infrastructure, on-board handling, chilling systems, and cost-effective use of insulation (includes investigation of collection methods and utilization opportunities for by-catches)
- Utilization of small pelagic species
- Improvement of on-board preservation and handling methods to increase fish quality by reducing spoilage caused by oxidation, bacterial growth, and autolytic deterioration and by controlling biogenic amines
- Development of new products to satisfy the demands of both domestic low-income consumers and higher-value export markets
- Investigation of processing methods for both food products and higher-quality fish meal products for animal feed (for example, for fish feed)
- Investigation of improved handling and processing methods for the small-scale fishery sector
  - Requirements for landing sites
  - Saving fuel in smoking and drying
  - Control of insect infestation in cured products
  - Fermentation as a preservation technique
- Economic aspects of fish utilization and marketing, including market and trade analyses, economic optimization of processes, and the socioeconomic aspects of development projects in fish utilization

New scientific investigations

Because commodity conversion and utilization is not considered a priority research area for a CGIAR institute, it is important that consideration be given to ensuring that the necessary research is carried out at the strategic research level in order to provide the basis for applied research. The projects outlined below have strong elements of strategic research.

- Basic composition and deterioration processes affecting the quality and safety of fish as food
  - Analysis and prevention of spoilage through study of oxidation, muscle biochemistry, bacterial growth, and so on
  - Investigation of the functional properties of proteins (gel-forming or emulsifying) and lipids from tropical species
- Application of biotechnology to fish utilization
  - Use of enzymes and bacteria as agents in preserving and processing fish
  - Identification, extraction, and purification of pharmacologically active or otherwise high-value products from aquatic animals and plants (including enzymes, hormones, lipids)
  - Use of compounds or raw material from the aquatic environment in the food industry
- Investigation of preservation methods and new products
  - Low-cost sterilizable flexible packs as an alternative to metal cans
  - Reformulated products as ingredients (meat extenders) in fish or other food products, or converted through surimi-style processes, as novel fish products

HUMAN LINKAGES, SOCIOECONOMICS, AND POLICY

Application of known science

- Assessing and monitoring the economic and social state of fisheries
  - Relationship between the intensity of inputs (labor, capital) and economic and social outputs (gross and net)
  - Development of simplified methods to monitor fisheries through such indices as fish prices, fishing costs, benefits, employment, and incomes
- Methods of regulating access
  - Investigation of the advantages and limitations of allocation mechanisms — administrative, economic, or collective — in relation to the features of the fishery
  - Advantages and limitations of different systems of use rights (individual catch quotas, licenses, site leases) in relation to the biological, socioeconomic, and administrative characteristics of the fishery
- Technical aspects of enforcement, including monitoring technology and operational research for control and surveillance
- The roles of women and children in small-scale production

New scientific investigations

- Mechanisms for regulating access that concern the applicability of use rights and resource rents in allocating resources
- The role of social mechanisms in small-scale fishery management, including comanagement structures between fisherfolk groups and fishery administrations
- The economics and social organization of small-scale fishing communities, their effects on labor and capital mobility, and their response to technological changes
- Gender and equity issues as they relate to institutional and technological change and its impact (for example, through selective impoverishment) on women and the family, nutritional and health status, and access to education

5

Research capabilities in developing countries

This chapter concentrates on current fisheries and aquaculture research in developing countries. By necessity, it emphasizes gaps, but this should not be interpreted as a general criticism of performance. Rather, identifying current constraints and shortcomings provides a basis for determining opportunities for improvement.

Research capabilities differ widely among developing countries. The greatest differences are observed between regions and reflect differences in their stage of development. Within regions differences are generally less marked, indicating that improvements are possible in all cases. Among the factors explaining differences within regions are levels of expenditure and governments' research priorities. These factors depend on the economic significance of the fishery sector, the size of national economies, and the priority that government development policies give to the sector and to research.

Despite these differences, similar patterns of achievements and shortcomings occur in almost all countries, reflecting common difficulties in managing research and in using its outputs for development.

The chapter examines the means available for research, the relevance of research programs, the quality of research, and the use of research, which, together determine the effectiveness of research. It then considers important aspects of research management. Finally, it reviews the development of regional cooperation in fisheries research and the contribution of international aid to the development of research. Relationships between these two aspects make this articulation partly artificial.

The chapter also gives an integrated interpretation of the six missions to developing regions undertaken by the study and a commissioned report (see Christy and others 1991; Griffiths, Gumy, and Lupin 1991; James and others 1991; Pauly and others 1991; Poinsard and others 1991; Troadec and others 1991; and Shepard 1991).

Research means

Infrastructure

Most countries with important fisheries have built up the essential physical and institutional components of a research infrastructure. They have acquired fisheries research institutes with the minimum laboratory equipment, research vessels, and computer and library facilities. They have recruited staff trained in different disciplines and in applied methods. Although many developing countries still rely on foreign universities for the advanced specialization of their researchers, most can provide training in their own universities in the basics of fisheries and aquaculture research.

In the field of fishery resource assessment and management, research institutes were often created separately from existing national research systems. Later, fishing technology laboratories were added, either within or outside the fisheries research institutes, but still apart from the national research system. More recently, however, research programs on aquaculture and the environment have been initiated within univer-

sities. Thus, two different solutions have been adopted for the three major fields of research, each with its own advantages and disadvantages.

The location of fishery administrations within government organizations varies greatly from country to country. A few countries have a specialized ministry for fishery and marine affairs. In most, fishery administration is part of the ministry of agriculture. In some, it is attached to less directly related ministries. Where fishery administrations are located within the government can have important consequences for the choice of fishery policies and research.

Almost all countries have a horizontal administration in charge of organizing and planning research. The administrations' responsibility for sectoral research institutions varies greatly among the countries, however. Some countries have established parastatal "organisms" in fields related to fishery and aquaculture development — for example, aquaculture, product development and marketing, and extension services for the small-scale sector. Their mandates and activities also differ substantially among countries. And some countries have established administrative mechanisms linking fisheries research institutions and fishery administrations.

This research infrastructure represents a substantial investment of human and capital resources, particularly in countries that gained their independence after World War II. Over the past three decades, several developing countries have made remarkable efforts to assimilate new knowledge and concepts from research and to apply them in their fishery sectors.

International aid has played an important role in the acquisition of this basic infrastructure. In the 1960s and 1970s multilateral aid concentrated on creating fisheries research institutes. Since then, these institutes have regularly provided specialized and on-the-spot training in applied research. Research projects aimed at assessing local fishery resources were conducted in almost all countries. Bilateral aid contributed to the creation of specialized research laboratories and to the provision of research vessels and equipment, as well as to thousands of fellowships for training abroad. Both bilateral and multilateral organizations provided on-the-spot support to national research teams. Thus, international cooperation, which has been extended and intensified over the past three decades, played a significant role in the diffusion of knowledge.

All these achievements should be assessed when analyzing fisheries research capabilities. Although fisheries research is far from effective, a physical and intellectual framework has been established and put into action.

Scientific equipment and facilities

Scientific equipment and facilities vary greatly, both among countries and, within countries, among institutions. In general, short-term, development-oriented projects are better funded than medium-term research programs.

Funding to support the acquisition of scientific information has been much less satisfactory. Library facilities and information services are frequently insufficient, and few scientific journals of regional and international significance are published.

Despite their considerably higher cost, research vessels have generally benefited from greater attention. Developing countries have acquired research vessels, sometimes at no cost, under bilateral assistance schemes. But many of the vessels rapidly became too expensive to run; neither the donors nor the recipient countries had adequately considered the burden that such vessels would impose on research budgets.

Staff

Some countries are still building up their core research staff, but many have already recruited and trained a corps of research workers. In some countries the number of staff is relatively large compared with the number of research programs that are conducted and with the research outputs. This indicates that there are serious constraints undermining the use of human resources.

The academic qualifications of researchers are on average much lower in sectoral research institutes than in universities. The proportion of senior staff actively engaged in research, or in supervising research, is often low. These findings reflect the lower priority that is assigned to scientific and innovative targeted research compared with that given to more operational research.

Finally, national research programs generally do not reflect the need for adjustment in the distribution of research disciplines to keep up with changing priorities. Most sectoral institutes are still heavily engaged in the kinds of programs that

were designed when they were established, when assessing the fishery resources available for development was the priority. The development of research on the biological and physical aspects of aquaculture has been an important exception.

Wages

In many countries researchers' salaries are low, often lower than those they would receive in the industry or in comparable administrative positions. In several countries researchers have second jobs to supplement their incomes. Low wages make it difficult to retain staff or to recruit specialists (economists, computer specialists, master fishermen) in high demand in the private sector or in certain nonfishery public sectors. A few countries have raised the salary scales for research, but they are an exception.

Operating funds

Insufficient funds, together with the low wages, are the most important constraints on fisheries research in developing countries. In some countries funds are so short that after fixed expenses are covered, little is left for undertaking research. Some funding is provided through research loans from international aid agencies. And some institutes and universities earn revenue through commercial production (shrimp larvae, fish products), but this is at best a temporary solution.

Some countries are encouraging the industry to assist in funding public institutions. Although this approach may improve the private sector's use of national research capacity, it seldom takes into account the relative responsibilities of the public and private sectors or the mechanisms for setting priorities and allocating funds for different kinds of research.

The relevance of research programs

Policies

Ideally, research policies should reflect the priorities of national development policies, as well as the potential contributions of the more innovative forms of research to sector development and management. But national policies for the fishery sector are seldom detailed enough to provide useful goals for planning research. As a consequence, research programs are determined largely by scientists, who rely on broad development needs to justify their proposals. But as there are few quantitative and comprehensive analyses of the potential contributions of research, research proposals are seldom integrated into coherent strategies for development. This autonomy may be justifiable for basic academic research, but it is inappropriate for research programs intended to produce results relevant to industrial production systems.

When a sector's progress depends on major structural adjustments, as fisheries and aquaculture do today, a lack of explicit development and research policies has several negative effects:

- Rather than anticipating emerging opportunities and needs, research programs lag behind, responding to past needs.
- Research cannot produce for fishery administrations and the industry the information necessary to increase awareness of the need for change, and thus fails to promote the demand for more pertinent research programs.
- As low-priority research programs continue to be carried out, the effectiveness of research declines and its funding becomes increasingly inadequate.

Lack of balance

Developing countries' research programs tend to concentrate on immediate applications of existing methods and techniques. In several countries and in some regions fisheries research is restricted solely to such applications (James and others 1991). This emphasis is justified by the need to address emerging issues and opportunities in the sector. But because present programs are restricted almost entirely to the biological and technical dimensions of existing production systems, or to the introduction of new intensive systems for raising exotic, high-value species, they fail to address the fishery sector's most important issues, which are economic and sociological.

Developing countries' research programs, because they are not designed to address broad development and management issues, are frequently imitative and repetitive, consisting of uncritical local applications of methods learned abroad. Although this was unavoidable during the initial development of national capabilities, continued emphasis on local application leads to research agendas that are too narrow.

Adopting new paradigms that enhance the capacity to conceive new programs is a slow, gradual process. Today, progress in fisheries research de-

pends on the adoption of paradigms that better match the conditions in developing countries in general, and in fisheries in particular.

In countries that have built up a research infrastructure and acquired researchers who have mastered basic scientific methods, attention should be given to upgrading research programs.

Lack of integration

The effectiveness of research programs can be reduced if they fail to integrate research from different disciplines. For example, research programs in fishery management concentrate largely on assessing stocks or developing boats and gear technology. But improvement of fishery management schemes depends on inputs from economics and other social sciences.

Similarly, research to develop aquaculture will be effective only if the suitability of different farming systems for the socioeconomic organization of potential farmer groups and for the available markets is properly assessed and if the programs in biology and technology are tailored to the needs of farming systems at their successive stages of development.

Improving the integration of research requires strategic planning, and mechanisms and procedures for mobilizing different disciplines and expertise in institutes and universities at national, regional, and interregional levels.

The quality of research

The quality of research varies considerably between and within regions and, to a lesser extent, among research institutions and universities within countries. The most important determinant of the quality of research is the quality of research personnel (Pauly and others 1991). This in turn depends on training and education, selection of qualified personnel, and adequate working conditions. The financial, intellectual, and other incentives vital for recruiting and maintaining high-quality researchers are unsatisfactory in many developing countries. Moreover, the working conditions necessary to support high-quality research are often difficult to establish.

Other factors and conditions also affect research quality:

- Fishery administrators are inclined to maintain the status quo in fishery management practices and to restrict their demands for information to justifications for political decisions.
- Special relationships between sectoral research institutes and fishery administrations tend to suppress innovation and support bureaucratization.
- Inadequate procedures for evaluating programs and staff lead to a lack of accountability and a likelihood that promotions will be based on considerations other than professional qualifications.
- Research institutions' weak scientific capabilities and excessive bureaucracy impede research programs that involve different departments within and between institutions.

The use of research

Relationships between sectoral institutes and fishery administrations differ significantly among the countries visited by the SIFR missions. In several countries research has made important contributions to conventional fishery management and to negotiations of fishing agreements with foreign parties. And in a few countries research has played a critical role in the dissemination of modern concepts within fishery administrations and in the elaboration of sound fishery policies (Poinsard and others 1991).

But many sectoral research institutes are just starting to investigate the economic aspects of fishery management, and therefore have not yet made any basic revisions to management and development approaches. Thus, in nearly all countries fishery administrators have not been provided with adequate management tools, which may justify their skepticism about the feasibility of managing the fisheries. Administrators may also be reluctant to adopt the necessary changes in management because of the implications for their decisionmaking authority. For the same reason, they may be unwilling to support research that could strengthen demands for change.

The use of research by the industry and the small-scale sector is even less satisfactory. The most common observation made during SIFR missions is that the private sector fails to take advantage of the technical knowledge available from public research institutions.

There are four main reasons for the current misunderstandings and ineffectiveness in the use of research. First, there are diverging views on the roles that research, the private sector, and the administration play in development. These ambiguities persist because industry has invested very little in research in developing countries and because administrations are heavily involved in rou-

tine fishery management, making associated demands on public research institutions.

Second, there is little participation by the private sector in discussions concerning research priorities and programs. Furthermore, few countries have set up structures that link public research bodies and the production sector and allow the industry to select, fund, and evaluate research projects of direct interest to it.

Third, when the private sector is not stimulated by competition to adopt innovations, there is little demand for them. The situation is changing in aquaculture, however, because of the greater availability of use rights, which allow the private sector to capture the research benefits.

Fourth, communication gaps impede the use of available research infrastructure and findings.

The relationship between the public and the private sector, particularly the small-scale sector, tends to be from the top down, a relationship that does not stimulate a positive attitude among potential users toward innovations. The adoption of more participatory cooperative mechanisms could improve this situation.

The management of research

The management of research is another area where substantial improvements are needed globally. In developing countries the opportunities for improvements in the management of adaptive research differ from those in the management of innovative targeted research. Generally, adaptive research can be managed efficiently through economic mechanisms. Innovative research, however, requires scientific mechanisms and debate on research agendas. It also requires periodic evaluation by leading scientists in the field.

Generally, these mechanisms are not being used adequately in the management of applied research institutes, or in the management of targeted research at national levels. This results in the misallocation of funds and other resources.

Management of research institutions

The management of research institutions needs strengthening in several areas. Program planning in some sectoral research institutes is conducted in part through hierarchical mechanisms, both within the research body and between user administrations and institutes. Research institutes are sometimes directed by senior civil servants with limited professional experience in research. Because of this lack of experience, they tend to give all demands the same attention, and to give more weight to political considerations than to achieving effectiveness. Moreover, bureaucratic management affects cooperation between the administrative and the research divisions of institutions.

In conducting research, sectoral institutes in some countries use procedures inspired largely by basic research, although their research is essentially adaptive. This also impedes institutes' ability to meet new research needs.

Procedures for selecting and promoting staff need to match program selection and evaluation mechanisms. Criteria for staff selection should be explicitly stated. Promotion should be based on performance and should reflect a balance among the different kinds of research activities.

The inadequate operational mechanisms of some research institutes are another source of problems. Public institutes may offer employment security, but they do not always have an operational structure that motivates effective performance and accountability. Those who use the research output of such institutes commonly criticize them for their lack of achievement and accountability. Development activities would benefit from systematic recourse to economic mechanisms for allocating development funds and evaluating performance.

Management of national targeted research

Because of the position of fisheries research institutes outside national research systems, there is generally little cooperation between them and other national research organizations (Pauly and others 1991 and Troadec and others 1991). To develop the methods that are now required, researchers in fisheries and aquaculture need to collaborate with researchers in basic science.

The planning of national research programs is an area that urgently needs attention. Mechanisms and structures are needed to formulate and implement national programs on research problems of common concern to basic and applied research. A number of countries have designed methods to direct basic and adaptive research. But few have adopted mechanisms for formulating comprehensive national programs on important development and management issues that require inputs from faculties and sectoral research institutions. These mechanisms must meet the requirements of technical and scientific investigations.

Few countries have a national scientific literature with peer review. More often, institutions publish their own journals. This is appropriate for disseminating the results of adaptive research to the private sector and the administration, but not for disseminating the results of scientific research.

Regional cooperation

There are probably more than a hundred mechanisms and structures used for regional cooperation. Their number makes reviewing all of them impossible. Even classifying them is difficult, as the distinctions between types are not always clear. But basic patterns can be discerned. These include:

- *Networks.* These can involve individual scientists, research institutes, or working parties, established under regional fishery or economic organizations, in different fields. They differ greatly in type of institution, disciplines covered, and geographic coverage.
- *Multilateral regional bodies.* These include regional economic bodies not generally involved in cooperative fisheries research, and fishery development and management bodies only partly engaged in cooperative research, such as the FAO fishery commissions, independent bodies, and bodies established by UNESCO and the Intergovernmental Oceanographic Commission (IOC) in environmental studies and management. These bodies are listed in annex 9.
- *Regional or international research centers.* There are few regional institutes involved in research, despite the potential advantages of a regional approach. The South East Asian Fisheries Development Center (SEAFDEC) and the Asian Institute of Technology (AIT) are two examples of regional institutes; both are in Asia, both have research facilities, and both play significant roles in training and education. International institutes are even rarer; ICLARM is the only example of a center specializing in fisheries. But there are a number of advanced scientific institutes that could make a contribution if they were encouraged. Annex 8 gives a tentative list of institutes and donors whose research programs include international components.

Regional research bodies, networks, and international or regional research centers respond to different needs and fulfill different, though complementary, functions. Networks, the most common kind of cooperative scheme, have an excellent record in organizing cooperative research efforts among national institutions, in promoting on-the-spot training in many fields, and in transferring knowledge. Although networks will always be necessary to facilitate scientific exchange and to disseminate research results, they are not suitable for scientific investigations of wide relevance. That is because research to develop new methods does not initially require the involvement of a large number of institutions.

All schemes are potentially useful, however, depending on the circumstances. Regional structures are needed not only for the exchange of views and findings, but also for organizing, and initially funding, concerted programs of regional interest. Without active regional cooperation, much work is repetitious or too narrow to lead to significant achievements. Cooperative programs can significantly increase the efficiency of the use of existing means. The mission reports indicate that regional cooperation in research, where active, has had visible effects on national research programs (James and others 1991; Griffiths, Gumy, and Lupin 1991; and World Bank and others 1991d). This indicates that regional cooperation enhances and complements — not hinders — national efforts. In regions where most countries are small (Shepard 1991), joint approaches are the only way to achieve self-reliance. Regional cooperation accelerates the exchange of information, experience, and methods. It offsets dispersion, combats scientific isolation, and stimulates thinking. And it reduces the risks of national efforts moving in unproductive directions.

Regional cooperation also facilitates the elaboration of research strategies that can be implemented at a national level and that provide priorities for aid programs. Moreover, regional arrangements can circumvent the entanglements of national bureaucracies.

Along with the potential benefits of regional cooperation, there are some drawbacks. To an even greater extent than national research programs, regional cooperative and international aid programs focus almost exclusively on adaptive research. Development and management bodies, as well as economic institutions, have not yet shown a marked interest in the kind of research necessary to help the sector adjust to new conditions. But despite the drawbacks, researchers have expressed strong interest in more active cooperation.

The difficulties in expanding regional cooperation should not be underestimated. With some exceptions, multilateral and bilateral organiza-

tions are not bringing to regional cooperation in research the support they provide to development. Furthermore, regional cooperation does not enjoy a high priority in the administrations of developing countries. The most important constraints on cooperation are the lack of means (notably for travel), insufficient national support, and inadequate research structures. With their own research institutions short of operating funds, governments may not see regional cooperation as a way to improve the cost-effectiveness of their investment in research (James and others 1991 and Poinsard and others 1991). The effective research cooperation between Argentina and Uruguay is an exception worth noting (Griffiths, Gumy, and Lupin 1991).

Opportunities for cooperation in research are not restricted to the public sector. There are also possibilities for private sector collaboration in regional research activities, through such industry associations as the International Association of Fish Meal Manufacturers (IAFMM).

International aid

The usefulness of aid to research is mixed. Aid programs have made an important contribution to the development of fisheries research capacities in developing countries. But they are affected by several of the gaps that also characterize national programs, and they share in the responsibility for the present shortcomings.

In the 1960s and the early 1970s, in line with the policy of the time, multilateral and bilateral agencies assisted developing countries in building their fisheries research capabilities. In several countries research institutes were established with the technical and financial support of the FAO, the UNDP, and bilateral agencies. Hundreds of researchers were trained. At the instigation of the FAO, fishery development and management bodies were created in most developing regions. The FAO also formulated a global scheme for the collection of fishery statistics. Using its own resources, the FAO was able to draw on advanced scientific expertise in industrial countries to deal with tropical fishery issues.

Resource surveys and stock assessments were conducted throughout the tropical belt with the support of multilateral and bilateral aid programs. This work culminated in the late 1960s in the publication of comprehensive and scientifically based estimates of potential world fishery resources (Gulland 1971 and Moiseev 1971). Since then the FAO has regularly updated reviews of regional and national resources. The FAO and others have continued to disseminate basic stock-assessment methods among newly trained teams of fishery biologists in developing countries. ICLARM has successfully followed a similar approach.

The stock-assessment studies were useful, and they demonstrated unambiguously that the resources were under stress and that controlling fishing capacity was a necessary condition both for economic profitability and for fishery development in general. But this finding was not reflected in the support of banks and development agencies. Although the FAO fishery bodies repeatedly emphasized the critical importance of adequate institutional arrangements (use rights and national fishery management structures), the need for area-based user rights is only beginning to be recognized, as exclusive economic zones are established. Much remains to be done, for instance, in monitoring, control, and surveillance.

The FAO continues to assemble and disseminate valuable information on the conditions for effective development and on fishery management methods. Recently, however, its external support has been reduced, as some donors shift their emphasis from multilateral to bilateral assistance.

In practice, fishery development and management are still opposed in many countries, and the demand for research tends to shift toward immediate support of development operations. Governments give little attention to the specific requirements for basic research, and the results of research are often used without regard to their quality. Similarly, in aquaculture the distinction between development and research has not always been clear.

Small-scale fisheries have attracted considerable attention from donors in the last decade, but the research required to underpin them has lagged behind. Beginning with a seminal paper by Smith (1979), however, ICLARM has devoted considerable attention to the problems of small-scale fisheries, in particular to open access and resource scarcity. And the FAO has produced a number of case studies in order to develop an information base on small-scale fisheries, for which little empirical knowledge has been available.

Aid to research frequently suffered from a lack of coherence and continuity. The supply of infrastructure and equipment was sometimes emphasized without assessing whether it could be used

effectively after aid projects were terminated (Poinsard and others 1991 and Troadec and others 1991).

In countries where research funds are tight, aid can generate distortions. Sometimes short-term aid projects have diverted scarce national research personnel from ongoing national programs before the programs were completed (World Bank and others 1991g). With the strong pressure for immediate development activities, research programs became narrow.

In selecting research programs to support, development agencies do not systematically involve experts competent to assess the scientific relevance of the programs. Even when development agencies do mobilize scientific expertise for that purpose, the reviewers are not necessarily familiar with local conditions and with the constraints that underdevelopment imposes on the selection of programs and equipment. Sometimes the investigations promote the particular interests of certain scientific teams in donor countries.

A top-down approach to the conception and provision of aid to research is common. This approach tends to maintain dependence rather than promote self-reliance. Many countries receive excessive amounts of aid — both financial and technical. And when foreign inputs are poorly matched to local conditions, they divert national researchers from identifying and giving priority to the research topics likely to contribute most to local development. When the concern for a product's scientific excellence is allowed to take precedence over promoting local researchers to whom the management of research can be transferred, aid schemes tend to perpetuate themselves and slow the growth of cooperative efforts.

Building up national capacities for self-reliance in research requires national commitment and the active participation of national research institutions and personnel in the formulation of research policies. The assimilation of aid depends on the involvement of national researchers and research institutes and on a concern with the relevance of aid, even if this leads to initial losses in terms of product excellence (Poinsard and others 1991). Some international research bodies in developed regions — for example, the International Council for the Exploration of the Sea (ICES) and the European Inland Fisheries Advisory Commission (EIFAC) — are effectively pursuing this approach (World Bank and others 1991d). Without such permanent structures, the much-needed continuity and coherence in research, and in aid to research, will not be achieved.

The adjustments that the fishery and aquaculture sectors have to achieve imply changes of similar magnitude in research programs. At the same time, once the institutional arrangements needed to ensure progress in the sector are adopted, they will generate a considerably larger demand for research. But these new arrangements would call for a change in the way research is funded and used. The contribution of research to development is basically strategic in nature, not operational. Thus, development agencies have a direct interest in investing in research to open new development opportunities and to redress current development policies.

A promising concept for research cooperation between developing and industrial countries is the twinning of institutions. This could be a relationship between an institute in a developing country and a partner in an industrial country, or it could involve several institutes from both developing and industrial countries. The advantages of twinning lie in the extensive, well-organized, and potentially long-lasting exchange of information and personnel and in the sharing of facilities that the concept envisions.

Part 2 Opportunities for international cooperation in fisheries research

6

Use of existing knowledge for the political, economic, and social development of the sector

The following discussion addresses the actions that could be taken, based on presently available information and methodologies, to improve the management and development of fisheries. It focuses, first, on the actions that could be taken at national levels. Assuming that such actions are taken, it then suggests how technological innovations could be used to improve economic returns. Finally, the discussion turns to actions that could be taken by development and aid agencies.

Actions at the national level

At the national level considerable improvements could be achieved by changing institutions, revising sector development and food policies, and increasing technical competence in the relevant fields.

Institutional changes

Fishery laws. Institutional changes will require revisions in national laws. Earlier revisions concentrated on the implications of the new ocean regime for resource allocation at the international level. The revisions now required have to do with allocation at the producers' level. They will require societal decisions on the adoption of exclusive (individual or collective) rights schemes and the respective roles of market and administrative mechanisms in allocating the rights. Because of the strong interaction between uses of the aquatic ecosystems and the similarity of issues relating to them, the new legal arrangements should address all the different uses — fisheries, aquaculture, pollution, recreation, and so on. Four aspects have to be addressed:

- The ownership of the resources
- The surrogates (for example, sites, stocks, harvests, waste emission levels, fishing or aquaculture capacities) that can be used in each production system to support exclusive quantitative rights of use
- The mechanisms (economic, administrative, and collective) and the structures required for allocating such rights at appropriate scales (for example, fishery management units, broader geographical areas) to optimize uses and to ensure conservation of resources
- The means and procedures for enforcement.

Administrations can deal with the last three aspects if there is a comprehensive legal framework. The framework should make a distinction between large-scale activities, in which resource allocation may be better achieved by economic (market) mechanisms, and small-scale user groups, in which resource allocation relies to a varying extent on social mechanisms (membership). The compatibility of social mechanisms with the national legal framework also deserves attention.

Information on the basic concepts (notably on allocation mechanisms) and on recent initiatives taken by other countries is not readily available to lawyers and administrators. Therefore, inputs from researchers with theoretical knowledge and practical experience of new schemes, including environmental and stock-assessment experts, resource economists, economic anthropologists, and social and political scientists, will be needed to prepare technical background for the legal revisions.

Since the adoption of appropriate institutions can determine whether development projects suc-

ceed or fail, national administrations and development agencies planning new investments in fishing capacity should determine whether the required legal frameworks are in place, as well as adequate means for controlling foreign fishing and allocating resources between small- and large-scale interests.

Fishery comanagement structures. It is essential to involve fisher groups in the formulation and implementation of management measures, particularly for small-scale fisheries where national administrations alone cannot exert adequate control over access. National administrations should determine how best to involve fisher groups and associations so as to facilitate the operational management of discrete fisheries — fisheries explicitly delimited on the basis of resources, boats, gear, or fisher groups. Tasks in which fisher groups could be directly involved include:

- Collecting and analyzing data for monitoring stocks and ensuring optimal economic and social utilization of unit fisheries
- Developing methods for adjusting the rate of fishing and investment to the desired levels
- Establishing the forms of cooperation and the distribution of responsibilities between fisherfolk associations and the fishery administration regarding access controls within comanagement structures
- Adopting and enforcing regulatory measures.

Fishery management pilot projects. Decisions to adopt management schemes and methods at a national level may be difficult to make because of their novelty. To acquire some practical evidence of the merits of the schemes that are envisaged, administrations could consider implementing, for a fixed period, pilot projects for one or a few fishery units. The coastal lagoon fishery at Ayvalik-Haylazli in Turkey (Berkes 1986) and the Balicasag Island experience in the Philippines (Flores and Silvestre 1987) are examples of pilot management projects involving fisher communities. Other experiences, such as the management of the Cyprus demersal fisheries (Garcia and Demetropoulos 1986), illustrate how quick responses to unanticipated events can produce good results.

Such pilot projects should consist of four phases: (1) discussions with potentially interested fisher groups; (2) design of the management scheme; (3) implementation; and (4) final evaluation. Phases 2 and 4, and possibly 1, would require research. Phase 3 would require a fishery administrator to work as secretary of the pilot project, with the assistance of technicians in collecting and processing data. The pilot project would finish with extensive discussions of the project outcomes with the fisher groups concerned. It would provide objective evaluation of new fishery management techniques.

Preparation for crises. The long-term benefits of new institutions can be expected to be considerably greater than their immediate costs. But when the changes involve such matters as use rights and appropriation, political opposition is always strong. At the same time, the frequency and acuteness of crises will increase as a result of the present institutional weaknesses. By temporarily relaxing political constraints, crises open up opportunities for action. To ensure that such opportunities are well utilized, fishery administrations and research institutes need to analyze in advance the institutional changes that are required.

Sector development and food policies

Most national fishery and aquaculture policies, whether explicit or implicit, have serious inadequacies. Sector policies do not satisfactorily take account of the special characteristics of the sector or of the internal organization of small-scale user groups. This is important both because of the consequences it may have for the groups' ability to adopt innovations and because of the negative effects that may result from interventions that are not properly assessed.

Fishery management and development may also be negatively affected by inappropriate national food policies and policies outside the fishery sector. For example, policies aimed at increasing export earnings can lead to reduced domestic food supplies or reduced opportunities for small-scale fishers. Consequently, economic and social analyses of fishery and aquaculture opportunities and options need to be conducted in the broader context of the national economy.

Economic analyses can provide the quantitative information needed to judge the suitability for national circumstances of different development strategies and, thus, the priority that different research programs should receive. Because opportunities and constraints are similar among countries within regions, and even among larger groups of countries, a range of issues can be covered through a few selected national case studies. Such case studies would also help disseminate the methodologies for undertaking similar studies.

Strengthening of technical competence

Given the need for a change in management and development approaches, national fishery administrations and fisherfolk associations should consider increasing the range of their technical competence. This could take several forms, including:

- Creating economic units within national fishery administrations (as some countries, such as Mauritania and Malaysia, have already done) to prepare management schemes, development and management plans, and analyses of cooperative schemes with foreign fleets, and to collaborate in the preparation of nationwide macroeconomic analyses
- Fishery management organizations' acquiring technical expertise in data collection, resource monitoring, economic analyses, market studies, and other activities conducted when new schemes involving fishers in comanagement are set up.

These changes do not imply withdrawing public research from these duties, but shifting its role toward providing analytical tools, supporting users, and undertaking analyses of a more strategic nature.

To an appreciable extent, increasing the effectiveness of research will depend on strengthening users' capacity to assimilate it. This should improve communication between researchers and administrations, allow better use of research findings, and enhance the demand for research.

Economically efficient use of knowledge and technology under appropriate conditions

When the appropriate institutions for access controls are effectively in place (and only then), all the information and techniques that help increase harvesting efficiency can be transformed into gains in economic efficiency. Such gains can be considerable, as demonstrated by fisheries that are managed (the Australian shrimp fishery).

Gains that can be expected as a result of adopting innovative capture technology include:

- Maximization of the resource productivity by optimizing the time and space distribution of fishing effort — for example, the physical output of the Moroccan cephalopod fishery could almost double if the juveniles were effectively protected (Bertignac, Cunningham, and Zouiri 1989)
- Effective reduction of the unit costs of harvesting
- Use of static gear to reduce costs as well as to facilitate the acquisition and enforcement of exclusive use rights
- Improvements in the safety of fishing operations, making technological or administrative measures considerably more effective
- Promotion of coastal aquaculture development, as in Japan, where exclusive use rights are available or, more recently, in Alaska, through the development of salmon ranching by associations of fishermen who have acquired exclusive catch rights
- Greatly reduced costs of enforcement because of incentives for the use of technological devices supported by the great majority of those holding resource rights
- An enhanced demand for research in general.

Actions for development and aid agencies

Revision of development strategies

Development strategies for the fishery sector based implicitly on industrial and agricultural models must be revised so that they adequately comprehend the sector's special characteristics (analyzed in part 1 of this report). Development and aid agencies should identify projects based on an overall understanding of the structure and dynamics of major production systems operating under different economic and social circumstances (small- as against large-scale, Asian as against African aquaculture, semi-intensive as against extensive systems).

Two sets of actions would help achieve the required change: (1) preparing sector development policies and analyses of major national unit fisheries and (2) increasing the technical competence of development agencies. Because of the financial and conceptual influence that international development agencies and technical organizations have on national fishery sectors, their taking these steps would have a significant and relatively rapid effect on national policies.

The identification of development projects has been largely the task of specialists in certain components of the production systems (biologists, technologists), of industrialists, who often have experience in different economic and social contexts, and of generalists with field experience. In formulating agency policies, it is critical to draw on experts trained in sector analysis, such as renewable resource economists with practical experience in the fishery and aquaculture sector and sociologists with similar experience in small-scale activities.[11] The contributions of biologists, technologists, and other specialists will continue to be

necessary in multidisciplinary evaluations and in formulating and implementing projects.

Dissemination of concepts, methods, and experiences

Achieving the necessary institutional innovations will first require wide dissemination of the theoretical concepts underlying the innovations, the methods to implement them, and accounts of new experiences. A majority of actors in the sector — including national fishery administrations, investment banks, aid and development agencies, the fishing industry, and the small-scale sector — need to share a new understanding of the necessity for and the modes of change before the proper actions can be taken. Different media and languages will be needed to reach these targets.

Several organizations (the FAO, ICLARM, SEAFDEC) have a long and excellent record in this kind of dissemination effort. Their programs should give high priority to institutional change for fishery management and development. Because of the variety of audiences, materials should be rewritten, translated, and distributed through different communication systems. The basic contents should be prepared by regional and international organizations, since they have better access to the original information, and then adapted to specific national purposes.

7

A strategy for international fisheries research

International collaboration in fisheries research will make possible more efficient and sustainable use of living aquatic resources. This in turn will help provide food and income for the people of developing countries, particularly the poor. The diagnosis presented in part 1 of this report demonstrates that there are many opportunities for pursuing this goal through research programs. This chapter presents a strategy to provide developing countries and interested donor agencies with a basis for cooperation in exploiting these opportunities.

The diagnosis makes clear that there are needs for national research, by individual developing countries; regional research, with collaboration among countries sharing fishery production systems and aquatic resource systems; and international research, on topics relevant to large parts of the developing world.

When considering research strategies at these three levels, it is useful to bear in mind the different categories of research. As described in chapter 4, research is broken down into two broad categories for purposes of the study: strategic research (investigating basic scientific relationships to solve specific practical problems that cannot be handled with existing knowledge) and applied research (applying existing scientific knowledge to specific problems). In this study applied research includes what is often called adaptive research—adjusting a successful research methodology or result to fit a specific case that is related but somewhat different.

National research

Donor agencies and developing countries agree that the highest priority in assistance to fisheries research is to strengthen the capacity of research institutions in developing countries, and thus to help increase the countries' self-reliance. A large proportion of donor assistance is presently devoted to this goal. That priority has been applied in this study, and was reflected in guidance from its Advisory Committee. With regard to marine research, the terms of the United Nations Convention for the Law of the SEA (UNCLOS) further justify the focus on national research. The Convention places most weight on improving national competence (as part of the technical support that countries need to manage the renewable resources in their exclusive economic zones). It also emphasizes the need for regional cooperation, for which it identifies fishery commissions as the appropriate management mechanism.

For these reasons, the SIFR strategy emphasizes strengthening research capacity and conducting research at the local and national levels. The need to accord priority to research at the national level as a matter of development policy is reinforced for fisheries by the fact that much of the research required in this field is location-specific. This is true, for example, of research on particular species of fish, production systems, and economic and policy issues. Because the opportunities for earning a livelihood from fisheries depend very narrowly on local habitats and species and on characteristics of the population, local research is

required to identify resource potential, define appropriate management measures, and monitor resources. In practice, research on such subjects can only be carried out by agencies on the ground, and it is done more effectively by local institutions with the necessary scientific skills than by international agencies that are only temporarily present. Moreover, actually conducting research is perhaps the best capacity-building exercise. The detailed discussion of strategy for research areas below and in chapter 4 therefore focuses most heavily on strategy at the national level. A study of this kind can only give indications of types of national strategies, however; specific research goals must be worked out at the country level.

Regional research

The diagnosis in part 1 shows that there are important research issues best addressed cooperatively by institutions that are located in more than one country and that share fish production systems or knowledge of aquatic resources and could also share equipment. This is particularly true for smaller countries with relatively large fishery interests, such as island nations. Thus, for some research issues, there is a comparative advantage in either working through a regional institution or involving scientists from more than one country, working in collaboration, with an explicit division of labor and a shared interest in the results. The word *regional* is used in this report to mean this kind of international collaboration among neighboring countries.

International research

The diagnosis also identified important research topics that could be usefully addressed at an international level. Examples include the development of new theories and methodologies that could be widely applied, the study of basic relationships among resources and their users, the implications for fisheries of global environmental trends, and problems that require innovative and risky research and thus are not likely to gain priority attention at the national level. Strategic research constitutes a large part of the research that is appropriate for international collaboration. Collaborative efforts at the international level can play an important role in energizing the entire research effort as well as in generating support for related research at national and regional levels. By transferring the results of international research to national efforts, regional activities can have an important multiplier effect.

As this study reaches completion, a strategy for international fisheries research is evolving simultaneously through a parallel mechanism — the Consultative Group on International Agricultural Research (CGIAR). This group comprises some 40 national, international, and private donor agencies that have supported a number of international agricultural research centers since 1971. Aquaculture has been on the agenda of the CGIAR and its Technical Advisory Committee for many years, but at the time this study began, that interest appeared to be limited and had not extended to capture fisheries. But after a Technical Advisory Committee meeting in which the SIFR played an instrumental role, the CGIAR decided to reconsider fisheries research with a view toward expanding its scope to include coastal capture fisheries. It asked the International Center for Living Aquatic Resources (ICLARM) in the Philippines to prepare a strategic plan for international fisheries research for consideration for CGIAR support.

The scope of international fisheries research outlined by the CGIAR's Technical Advisory Committee as guidance to ICLARM, and approved by the CGIAR in October 1990, differs little from that in this study. The Technical Advisory Committee specified one major limitation: research on deep-sea or ocean capture fisheries and on capital-intensive aquaculture is to be excluded from CGIAR support. For many countries, however, such research may be given a high priority at either a national or a regional level and will therefore still fall within the framework of the SIFR.

Part 1 of the report and its supporting documentation was an important input for the Technical Advisory Committee in its deliberations and for ICLARM in drafting its strategy. The exercises were closely related, and a number of individuals were involved in all three. The completion of the SIFR strategy and plan for action was delayed to allow consideration of the ICLARM strategy. What follows takes account of the ICLARM strategy as prepared for submission to the Technical Advisory Committee in June 1991. It is now assumed that CGIAR support for fisheries will be forthcoming. To give a complete picture, this report therefore focuses primarily on research at the national and regional levels but also notes the strategy prepared by ICLARM for the international level, as well as strategic research areas that will not be covered in the program of the new CGIAR institute.

ICLARM was started by the Rockefeller Foundation in 1974 as an international coordinating and facilitating mechanism for fisheries research, largely in the Asian Pacific area. It is incorporated in the Philippines and governed by an international board of trustees, most serving in an individual capacity. Its host country, the Philippines, accords it some of the privileges that normally accrue to international status.

ICLARM has grown since it was founded, reaching an annual budget of $4 million. The center has research projects in Asia and programs in Latin America and Africa. Its programs are generally recognized as of very high quality. It has been particularly effective as a center for generating and distributing information to fisheries researchers in the developing world.

As requested by the CGIAR, ICLARM has prepared a strategy that represents a new direction in its range of research and supporting activities (ICLARM 1991). The approved funding level will be determined later and will depend largely on the willingness of donors to provide the needed support. The most important change foreseen, however, is not so much in the total budget as in the security of core financing for a program that would contain a significant amount of strategic research.

The strategy outlines a long-term program focused on methodologies for the management of capture fisheries; improvement in the adoption of integrated aquaculture and agriculture systems; enhancement of capture fisheries; and the social, economic, and policy aspects of the entire spectrum of fisheries, with the exceptions mentioned above. At its June 1991 meeting the Technical Advisory Committee requested that ICLARM narrow the strategy by reducing the number of resource system activities, and it is anticipated that as the strategy is further refined, the resources will be focused on a limited number of priority issues. Much of the research will be on the modeling of aquatic resources, breeding methodologies for captive species, and the sociological aspects of fish production and consumption. A pervading focus will be the management of aquatic ecosystems. Research on production will be based primarily on such a systems approach, with less emphasis on individual components. The strategy's priorities are constructed on a matrix combining aquatic systems with fields of research. The latter fit conveniently with the structure of research topics used in this report.

Like other CGIAR-sponsored centers, the new institute proposed by ICLARM will devote considerable attention to strengthening national research programs in developing countries in the research areas where its programs are concentrated. Much of its research will be conducted in collaboration with national institutions. ICLARM also plans to continue developing research networks. It will undertake training in fields related to its research program and conduct an information program to disseminate its research results and those of its collaborators. It will also support the research programs of national and regional institutions.

The opportunity to elaborate a program of fisheries research for developing countries through the CGIAR is a significant breakthrough, one that is long overdue. It offers the possibility of strong support for research focused on key aspects of fisheries and managed through the proven CGIAR system. Collaboration with other centers working in agriculture and other aspects of natural resource management will be facilitated through the CGIAR. But the initiative will cover only some of the many applied fisheries research issues outlined in the appendix box in chapter 4. Alternative means will be required to strengthen national capacities to undertake research on other issues.

The following discussion focuses principally on these short- and medium-term research needs at the national level, with reference to regional and international needs. Where appropriate, distinctions are made between strategic and applied research. The material is divided according to the objectives set forth in chapter 4, but provides only a summary perspective (see the appendix box and box 4.1 for more detail).

Main areas of research

Resource conservation and management

Resource conservation and management covers the management of environmental influences on the production of fish and fishery products, the environmental impacts of fishery activities (including those on human health), the conservation of ecosystems and genetic diversity, and the management and sustainable exploitation of aquatic resources.

Global trends. Although research on global trends in the environment and related scientific issues is the responsibility of agencies beyond the scope of this study, the results of that research will be very important for fisheries. Increasing knowledge of ocean dynamics, for example, should have signifi-

cant payoffs for research on aquatic resource management.

Clearly, national research agencies need the capacity to gather and analyze data both for their use and for the use of international agencies, to monitor analysis produced internationally and interpret its implications for their country, and to perform research in areas of local importance. They also need the capacity to identify, study, and suggest remedies for instances in which domestic fishery activities have an international impact.

The substantial research required on environmental management issues that affect fisheries calls for collaboration with institutions not primarily concerned with fisheries. Understanding the causes and processes of different forms of pollution and their impacts on stock recruitment and the production of adult stocks will be essential in developing measures to mitigate these impacts.

Perhaps the most complex issues concern the interaction of fishery and nonfishery economic activities, particularly in coastal zones. Research on the relationships among, for example, forestry, agriculture, recreation, hydrology and water use, industrial and human waste disposal, and fisheries within a particular coastal ecology is critical in determining the best policies for managing economic development. This research requires the ability to assemble and analyze large amounts of data with spatial dimensions, and to relate social and economic factors to physical ones.

Another national issue in which fishery interests interact with a wide range of other economic activities is land use management. Protecting against health risks from the consumption of fish products and from the environmental effects of fish production also requires attention.

Genetic diversity. The preservation of germ plasm in captivity or *in vitro* is difficult and expensive. Thus ICLARM will classify and conserve germ plasm only for the very small number of species on which it will undertake genetic improvement research, which requires preserving germ plasm in captivity. To conserve the genetic diversity of living aquatic resources, priority must therefore be given to monitoring natural environments and to protecting natural ecosystems through integrated management of coastal areas and inland waters. Important aspects are the effects of environmental change, of different levels of fishing effort, and of the release or escape of nonindigenous or cultivated species.

Rather than attempt to centralize living germ plasm, ICLARM, the FAO, and a number of other organizations are developing a data base on all known aquatic species (FISHBASE) that will be widely available as a research, teaching, and reference tool in CD ROM. This should enable national and regional programs to make maximum use of otherwise inaccessible knowledge and to identify gaps in knowledge for future research, including issues related to genetic diversity. Inputs from national research institutes will be needed to create and maintain the data base.

At the national level an initial step should be to appraise trends in genetic diversity, primarily among species of economic importance, to determine whether interventions may be needed. Where necessary and practical, steps could be taken to conserve germ plasm of such species through the preservation of habitat and the maintenance of cryopreserved sperm or brood stock of captive species.

Capture fisheries. In most countries with strong fishery interests, coastal capture fisheries yield by far the largest production. They also have the greatest scope for making gains in production (or preventing losses) over the short and medium term. For these reasons, managing the resources in the exclusive economic zone and developing national institutional capacity to appraise and monitor these resources are matters of highest priority. Where freshwater fish resources are relatively important, these also merit priority.

To develop effective management policies and practices for capture fisheries, national research institutions need access to multispecies models for tropical resource systems that are adapted to local conditions. Developing models of this kind is a high priority for research at the international level. As this research progresses, developing country institutions could be involved in the biological and ecological research required to calibrate, test, and adapt the models. The same institutions could then serve as training and dissemination centers to help other national research systems learn, adapt, and apply the new technology.

Once the tools are available, national institutions will need to evolve routine, low-cost methods of collecting and analyzing the data required to monitor changes and environmental influences. The human dimension of capture fisheries also needs to be studied and monitored. This subject has a number of levels, ranging from local, national, and international production and consump-

tion (and markets), to the firm and other fishing and fish-consuming organizations, to the community and the family.

The goal of research on capture fisheries should be to develop a package of policies and programs that would make it possible to achieve a high sustainable yield from aquatic resources in ways consistent with other national policies and purposes. This package might include ways of regulating access, through such related mechanisms as gear design, restrictions on physical access, and administrative, economic, or organizational measures. Research is needed to understand how such mechanisms would operate in the community and what their impact on aquatic resources would be, in both the short and the long run. Although such research can draw on generally applicable models and theories, and benefit from similar studies elsewhere, it is largely location-specific. The research combines biology, ecology, economics, engineering, and social sciences.

Private sector. The private sector could play an important role in managing fishery resources not only by contributing financial and intellectual support to research, which may be crucial in assuring its quality and continuity, but perhaps also by performing research. In some areas, such as designing vessels and gear for commercial use and investigating low-cost ways of meeting environmental or access requirements, the potential returns might well motivate private companies to undertake or finance the needed studies. But often there is no incentive for private investment in such activities in developing countries and the research burden will continue to fall on national institutes.

International collaboration. International-level research should give high priority to developing, for each of the principal aquatic resource systems, a generic model incorporating specific features of the systems. The models would consider the interaction among economic activities, demographic factors, and ecological processes. Their outputs would help decisionmakers in formulating policy guidelines, resource management strategies, and management actions. This multidisciplinary work could be done in collaboration with institutions in both industrial and developing countries. As these models are developed, they could be distributed, with training and technical support as required, to national institutions for testing, adaptation, and implementation. Another appropriate activity would be drawing together experience over the range of resource management issues, and helping international agencies to place them before the international community. This would draw increased attention to the research needs at all three levels — national, regional, and international — and to the broader implications of research results.

Regional collaboration. Because resource management issues tend not to be confined to national boundaries, they are logical candidates for research collaboration among the countries affected. The issues are also often sensitive, involving questions of financial or moral responsibility across borders. Opportunities for regional research may therefore be hard to seize, but may be a first step toward regional collaboration on action programs.

Although not among CGIAR priorities for international fisheries research, high-seas fisheries producing such species as sharks, tunas, other large pelagics, krill, and cephalopods are of vital importance to many countries and require management based on scientific analysis. Research and data collection on the high seas are therefore necessary, and regional collaboration in these activities offers obvious benefits.

Fish productivity

Fish productivity covers research topics concerning the farming of aquatic organisms, including enhancement of fisheries, and focuses on aquaculture systems.

Aquaculture. At the national level, aquaculture research priorities should be based on the country's resource endowment, entrepreneurial and research capability, market opportunities or home consumption, and the level of aquaculture development. In countries where aquaculture does not have a solid base, the strategy for short- and medium-term development-oriented research should concentrate on the selection of simple, easily acceptable forms of aquaculture with the highest chance of being successfully adopted by local large- and small-scale producers. This strategy would require an initial investigation of the potential for aquaculture development, which should lead to the identification of simple, economical aquaculture technologies and the research required to adapt the technologies to local conditions. The initial stage of investigation of the po-

tential should include social and economic research in addition to research on the physical and biological potential.

For countries in which aquaculture is well established, the objectives of short- and medium-term development-oriented research should be to increase the economic effectiveness of existing aquaculture practices; remove constraints to spreading aquaculture to new farmers and new areas; and develop techniques for diversifying cultured species, which may lead to expanded market opportunities for the producers. The most effective approach would probably be multidisciplinary research on three broad categories of aquaculture systems — extensive, semi-intensive, and intensive — analyzing their comparative advantages and providing guidelines for development of the aquaculture subsector.

For countries whose aquaculture practices are traditional and very diverse, such a comprehensive research program may be difficult to implement fully because of resource constraints. A shortage of resources may require the ranking of research issues by priority to concentrate efforts on the most important. Another way to achieve rapid results would be to upgrade, from national to international research needs, topics and practices that are common to a number of countries and for which a collaborative research program could be devised. Collaborative programs involving a network of institutions working on agreed-on protocols and assigned tasks have a record of success in aquaculture and agricultural research and could be an attractive alternative.

The strategy to follow for short- and medium-term development-oriented research would be to create a mechanism to organize and assist networks of national institutions, supplemented by external assistance when required. The ICLARM strategy will concentrate on improving a small number of breeds for aquaculture, with the principal goal of producing fish-breeding methodologies applicable to other species in national programs. There are several other institutions with active networks of aquaculture research that could be integrated into this program.

Enhancement. Fisheries enhancement is the improvement of capture fisheries production by stocking, supplementing recruitment, and manipulating the physical or biotic environment to favor exploited species. Considerable progress has been made in developing such techniques in a variety of geographic zones and aquatic systems, and well-established and tested methods are available for most economically important species. These techniques have some environmental costs, however, in terms of their impact on host communities.

At the international level, the priorities for research in fisheries enhancement are (1) to assemble data on technologies that have proved successful, to examine and improve their cost-effectiveness, and to minimize their environmental impact; and (2) to elaborate new or improved technologies for particular types of systems or species. At the national level, efforts should be directed at introducing or extending such technologies. Much of this work has been initiated through the FAO's regional bodies, Regular Program, and field projects, but ICLARM programs and those of other international or national institutions could take it further — for example, by documenting the technologies available, studying their economic and social effectiveness, and investigating means for their further intensification.

Commodity conversion and utilization

Commodity conversion and utilization concerns all aspects of the conversion of a fishery resource into food, including capture, handling, distribution, processing, and marketing.

On the capture side, research on the technology of fishing, particularly at the small-scale level, should avoid efforts aimed only at increasing efficiency. Because small-scale fishermen are generally competing to catch heavily exploited stocks, increased efficiency inevitably leads to increased effort and eventual impoverishment. More important to the small-scale fishing community is improving the design and fuel efficiency of their boats to contain costs, improving fish-detection methods to reduce search time, and increasing the selectivity of their fishing gear to reduce unwanted by-catches and thus to conserve resources. Improving safety at sea is also a vital concern.

In the postharvest sector, efforts requiring application of technology include improving fish handling and reducing the substantial postharvest losses that result from ignorance or lack of infrastructure. Other efforts are improving the quality and safety of fish products and developing new processing techniques and products.

One of the most important needs is for better utilization for direct human consumption of the portion of the world's harvest, principally the small pelagic species, that is now processed as oil

and fish meal for animal feed. In view of the size of the pelagic resources and the failure of present technology to produce major changes in their use in developing countries, improving the utilization of small pelagics is an appropriate area for international research. The diagnosis suggests that, although the principal stumbling block is the purchasing power of the consumers, a market-led strategy is required to deal with this issue, rather than the technology-led efforts of the past. This suggests, in turn, that private enterprise should play a prominent role. As ICLARM will not undertake research in the postharvest sector, there is scope in this area for a major international initiative.

Postharvest research issues abound in the analysis of artisanal and small-scale fisheries. These typically raise economic and cultural — rather than primarily technical — questions, and are quite location-specific. Relevant research is therefore closely linked with the activities under the research area *human linkages, socioeconomics, and policy.*

Because most of the research issues in the postharvest area are highly location-specific, they are suitable for combined technical and economic research at the national level. Regional cooperation in such research would also have much to commend it.

Human linkages, socioeconomics, and policy

Human linkages, socioeconomics, and policy addresses the interaction between aquatic resources and people, a critical aspect of many fishery issues and one that tends to be overlooked. It also covers economic and social analysis of fisheries, gender and equity issues, enterprise and industrial organization, and market and policy research.

No topic in fisheries research is more important, and studied less, than the interactions between people and the resources they use. Research on this topic requires strength at the national level in the social sciences — sociology, economics, and related fields — which may be found in the formal fisheries research structure or in the universities. An important challenge is to link social science research with biological and technological research in a mutually supporting union.

It is important to study the culture and institutions of people involved in fishery production, and the basic values, skills, and tools they use to interact with their environment. A subject often neglected is the role of women, who frequently play a distinct role; if their separate function is not recognized, conclusions about the dynamics of a production system may be faulty and thus lead to mistaken policies. And because important differences can be concealed behind statistics based on average values, equity considerations require looking at the experiences of different groups — men, women, and children, for example.

National research institutions must look at all elements involved in going from production to consumption, in both fisheries and aquaculture, from a systems perspective. Account must be taken of the wide variety of activities undertaken, both inside and outside the production system, to gain income or reduce risk. It is also necessary to look at the interactions of aquaculture with agriculture and forestry, at both the family and the community level. Links with other sectors of the economy are important for aquaculture. They are even more important for capture fisheries, for which the availability of labor and the labor market implications of reduced employment in fisheries can be critical to the viability of their production system.

The specific institutional and organizational context of fishery production must be understood before technological change, regulatory changes, or market incentives can be successfully introduced. For example, small-scale fishers are often at a significant disadvantage relative to those who buy their products or supply their inputs. Organizations developed to overcome these problems often fail because they are based on a poor understanding of the institutions and relationships within the community and between it and outside entities. One of the most important institution-related issues is the management of common property resources. Although this issue arises in agriculture and forestry as well, the frequent lack of any individual or collective owner of wild fish stocks or the waters in which they swim makes the issue especially difficult in the fishery sector.

What happens to the product is an important part of the fisheries research agenda at the national level in several ways. Markets inside and outside the country play an important role in determining the choices that exist both for those in the industry and for government authorities. Infrastructure, both physical and institutional, is closely related to markets and production systems. The role of fish products in the diets of poor people in developing countries, whether or not they are producers, is another topic for research; the potential nutritional impact of proposed policies and interventions should be considered before action is taken, and should be monitored afterward.

To conduct research on fishery policy, national institutions will need to collect and analyze extensive data at the individual, family, and community levels. Special skill is needed in selecting the data to be collected and in analyzing these data to discern policy implications. Fisheries researchers should make use of the experience in similar research in other fields, including agricultural policy.

Researchers should be sufficiently involved in the decisionmaking process of government to address policy issues directly and to have their results taken seriously. They can then be fully aware of the factors that enter into policy decisions and the tradeoffs taken into account. Linkages between the fishery sector and the rest of the economy, for example, play an important part in determining fishery policies. Identifying negative impacts on fisheries of policy decisions made outside the sector can be as important as work within the sector. Evaluating not only the economic and social status of fishery enterprises, but also the impact of government policies — if recognized as desirable by the competent authorities — can be very influential research.

Although social science research involves many location-specific issues, there is also a need for a social science initiative at the international level. The new CGIAR institute and other international institutions will give prominence to research aimed at extending the understanding of human interactions within aquatic systems. Much of this work will be done in collaboration with national systems, and conducted so as to increase the capacity of developing country institutions. Drawing together the results of research projects carried out in cooperation with developing country researchers, the CGIAR institute will try to synthesize principles and methodologies of broad application. In policy research, the CGIAR intends to work closely with institutions that have expertise in fishery policy issues, or institutions that have expertise in related issues, such as the International Food Policy Research Institute (IFPRI).

Priorities for national research

It is impossible to give generalized priorities for national fisheries research because of differences among countries. But the above discussion and the more detailed presentation in the appendix box and box 4.1 in chapter 4 may provide an outline against which a first approximation of national priorities can be made. Given the relatively high cost of research, it is critical for developing countries contemplating significant investments in fisheries research to define their goals for the sector and then to relate research objectives to those goals. Countries already deeply engaged in fisheries research would be well advised to do the same thing periodically.

The research strategy should cover the work of research institutions. And it should cover the related technical functions that this report recommends (in the section in chapter 6 on revising development strategies) be conducted not by research institutions, but by adding technical expertise to development institutions and agencies.

The need for a framework of objectives for planning research (and development programs) in developing countries reinforces the need for research on fishery policy — to help provide a basis for defining realistic goals. It also suggests that attention should be given to the organization and management of fisheries research itself. Present knowledge may not be adequate for advising countries on how to organize their programs efficiently or on how to relate research to national objectives. Several actions could be taken to improve this knowledge. First, a number of national programs with varying degrees of success could be studied to see what determined the different outcomes. Second, the impact of the programs could be appraised to help in deciding how much should be invested in research. And third, the relationship of fisheries research to agricultural research and other development research functions could be examined. The same general range of services is performed in the field of national agricultural research systems by the International Service for National Agricultural Research (ISNAR).

Priorities for regional research

Like national research priorities, regional priorities cannot be specified in general, but only for a specific region. In all fields of development research, there are powerful arguments for regional cooperation based on the logic of efficiency. But despite the large number of regional research initiatives, success is rare. Regional initiatives that depend heavily on donor support are particularly vulnerable, rarely surviving the inevitable phasing down of that support. Regional activities have been successful in addressing common issues as a route to promoting global understanding and col-

laboration, as well as to developing common data bases. They have not worked well in building national capacity, however, as this was often not among their goals. Conditions for successful regional cooperation in research include strong national commitment to the research goals; recognition that the value of collaboration exceeds the loss of national control; and demonstration that research results will be equitably shared by participating countries.

Arguments for the efficiency of regional collaboration in fisheries research are strong, as the diagnosis portion of this report makes clear. And there have been successful regional efforts among developing countries, mainly in Asia. In general, however, national commitment to fisheries research is low, which is not a favorable sign for the success of expanded regional cooperation. From the strategic point of view, therefore, this suggests caution in starting at the regional level, except where circumstances make this the only choice (small island states with shared interests, for example) or where national commitment is evident.

Consultative frameworks concerned with fisheries, which exist in almost all developing regions under the auspices of the FAO's regional fishery bodies, can play a valuable role in identifying research needs and priorities and in promoting cooperative research. In other regions intergovernmental bodies serve as forums for exchanging information and elaborating, or even imposing, management measures.

One form of research collaboration among institutions in different countries that has had some success is the collaborative research network. Studies of agriculture research networks have identified several criteria for success:

- Choosing research topics of genuine mutual interest, through a process that engages the network members
- Allocating by joint decision leadership roles in particular areas of specialization to member institutions that have the necessary capacity
- Holding periodic meetings among the scientists conducting the research, including tours to observe and comment on their work in the field
- Adopting agreed-on mechanisms for ensuring scientific quality
- Having a network coordinator with research skills sufficient for participating in research programs, but not in a dominating role
- Having some resources available for network functions, but also resources committed by members to meet at least the bulk of their own research expenses. (There are networks that also manage donor support for members' institutional development, but they have difficulty achieving both an efficient allocation of resources and the style of open collaboration required for effective research.)

Networks, still at an early stage of development in the fisheries field, should be adopted in the future to promote international collaboration on research because they can do so without some of the problems inherent in mounting new, formal regional research institutions. The involvement of existing regional institutions and regional fishery bodies in such networks should be encouraged.

The role of the private sector

Governments generally support research to encourage private enterprise in areas of national importance, but leave research that can be clearly justified by the expected market returns, including innovative research, to the private sector. Drawing the line between what should be given public support and what should be left to the private sector is a contentious matter and best left to national governments.

One clear need for publicly supported research related to the private sector is in developing policies for private sector development, not only to encourage investment, but also to define roles for large- and small-scale operations and to regulate participation. Another area where much of the research will be a public sector responsibility is support for small-scale fishing. That is because those responsible for vessel, gear, and processing developments in the private sector do not generally view the small-scale fishery sector in developing countries as a profitable area for investment.

But there are a number of research areas that should attract significant private sector involvement. These include fish processing, the future direction of markets, technology for high-value aquaculture production, the development and design of fishing equipment (including boats), and ways of meeting standards for international trade in fish products — but not, of course, establishing standards.

Research does not have to reside entirely in the public sector or in the private sector, however. Close collaboration between the two sectors is indispensable in resource management, for example. And nongovernmental organizations can make a valuable contribution to socioeconomic research.

8

A plan for action

This chapter suggests courses of action and modes of implementation that donors may wish to consider in order to implement the strategy emerging from this study.

Action points

Communicate study results

Although the study was prepared at the initiative of the donors, it is also relevant for those planning and managing fisheries research programs in developing countries. Many fisheries specialists from industrial and developing countries were involved in its preparation through their participation on the Advisory Committee and in missions and working groups. The final document will be widely circulated among fisheries researchers and planners to seek their comments. A series of regional consultations is proposed as a means of elaborating follow-up action.

Provide support to CGIAR fisheries research

Creating a CGIAR international institution for fisheries research will not guarantee adequate support for its programs. ICLARM's budget in 1990 was US$4 million, less than 10 percent of the average annual amount of aid to fisheries research in 1986-90, as estimated by the FAO Fisheries Project Information System (FIPIS). Implementation of the new strategy clearly requires that the budget be at least doubled. Donors interested in fisheries are encouraged to contribute to the institute within the CGIAR framework. The principal needs will be funding for existing ICLARM activities through the end of 1992 to ensure a smooth transition into the new role, and core support for a CGIAR-approved program beginning in 1993. The CGIAR program does not, and is not intended to, meet requirements for national and regional research; in fact, it will neglect some strategic research areas. Donor support to fisheries research outside the CGIAR will be vital to cover these areas, which will continue to account for most of the funding required.

Provide complementary support to fisheries research

Donors may wish to use the series of Fisheries Development Donor Consultations as a forum to review the progress that has been made relative to the strategy suggested in this report, and to prepare a new indicative fisheries research plan for their own use. An indicative plan is outlined below to illustrate how it might serve as a guide to increasing the impact of fisheries research through coordination of donor support.

Additional research-related activities associated with the Donor Consultations might include interactions with representatives of developing country fisheries research institutions. These discussions could perhaps be built around evaluations of donor-supported projects that have conclusions of potentially broad relevance. Discussions could be held with members of international and regional research institutions to exchange views on research priorities and identify opportu-

nities for program actions arising from recent research results. Also helpful would be talks with private industry on common research interests. The discussions with these parties might, in turn, result in elements that could be included in the plan, or in actions to be taken in its support.

Fishery donors' indicative plan for complementary support to research

As the report's analysis clearly shows, strengthened national research institutions with focused programs of development and management-oriented research can make an important contribution to the development of national economies by helping to improve the use of fishery resources. Donors should provide assistance to countries in developing their *fishery policies and programs* and determining their research priorities. These priorities should be drawn from the research areas identified in the study (the appendix box and box 4.1 in chapter 4) but adapted to the needs of particular countries and to the state of development of their fisheries research institutions.

National institutions linked to a regional or wider network are particularly good candidates for such assistance for two reasons. First, they are in a position to draw from, and contribute to, international research activities, and second, they have engaged in joint research planning to ensure an efficient allocation of effort in the research fields covered by the network. Membership in such a network does not ensure funding or other support for the participating institutions, since network funding usually does not extend beyond the costs of network operation and, possibly, modest amounts of seed money to facilitate collaborative research. National institutions that have the immediate potential to play an effective role in such collaborative networks should also receive special attention.

Criteria for selecting national institutions to support include location in countries in which there is a significant fishery sector or the potential to develop one and in which a feasible level of investment in fisheries research can make an important contribution. Institutions would need to have evidence that their research products are sought by producers and government authorities and that the government is committed to providing sustained budgetary and political support. They should also have the potential to acquire, with the contemplated donor assistance, an effective administration and a trained research staff large enough to undertake a meaningful program, as well as sufficient equipment and access to information. A framework of constructive interaction with related research institutions within and outside the country is also important.

Since a fundamental prerequisite for research is access to information, donors should be particularly open to ensuring that national institutions can obtain scientific information through books, journals, and abstracting and indexing services. Such support should cover the necessary hardware and the ongoing acquisition of publications to keep the resources current. Networks could be set up among established information centers of national and international fishery organizations to provide key references, photocopies, and access to wider resources. It should be understood that the costs of information need to be built into the budgets of national institutions and given a priority equal to that of other essential inputs. The Aquatic Sciences and Fisheries Abstracts (ASFA) provide access to a valuable central core of information. This and an increasing number of relevant data bases are now available on CD ROM, which enables researchers to gain direct access to fisheries information in regions where it had previously been impossible. Micro CDS/ISIS, developed by UNESCO and distributed free of charge to developing countries, is becoming a standard information retrieval software package. It allows not only the creation of national or regional data bases of fisheries literature, but also the exchange of this information, thus providing greater opportunities for the sharing of resources. The FAO, ICLARM, and a number of other organizations also provide information services that should be coordinated. FISHBASE, with its broad range of standardized and fully referenced information, is another valuable central data bank that could reach developing country institutions at low cost. A comprehensive review of fisheries research information needs in developing countries, and proposals to meet the needs, could be an important initiative.

Donors should also be prepared to consider *regional initiatives* in research, whether in the form of networks or other arrangements with the necessary elements of identified common interests and commitment.

Donors should also, individually or jointly, provide comprehensive assistance to promote the *transfer and adaptation of technology resulting from research.* Efforts should focus on reaching policy-

makers and the fishing community, using the FAO and other implementing agencies. In some cases major programs of technical and organizational support may be needed to facilitate the adoption of important new technology; in other cases discussions at the policy level to call attention to the implications of technical developments or of policy research may be all that is needed.

Since a CGIAR-supported institute will necessarily meet only part of the needs in fisheries research at the international level, donors may be open to providing support for *additional research conducted by universities and advanced scientific institutions,* in appropriate collaboration with developing country laboratories, or to stimulating research in the private sector. Such research would include work in the postharvest sector and research on the management of natural resources — for example, research in coastal zones, which is focused primarily on nonfishery resources but has an important fishery component.

It will be important for donors to support and contribute to the *exchange of information about fisheries research activities,* including research results, projects undertaken, evaluations of programs, and other matters of common interest. The FAO Fishery Project Information System (FIPIS) should greatly facilitate donor coordination, and can be selectively and progressively expanded in relation to research activities as required.

The indicative plan would be very effective if donors and recipient organizations in fisheries research discussed progress and problems and brought issues needing attention to the notice of the broader development community.

Means of implementation

Action is needed at a number of different levels to follow up on the SIFR findings and to contribute to a sustained strengthening of fisheries research in developing countries. A full response to these findings in the form of a refocusing of donor funding for fisheries research will take some time. The time required will be reduced, however, if communication among donors can be maintained and improved.

The series of Fisheries Development Donor Consultations provides a good forum to maintain communication and build support to fisheries research. It is suggested that these consultations should be held every two years, and that a steering committee consisting of the four multilateral agencies that have guided the SIFR should provide support for the fisheries research aspects of the donor consultations.

It will be necessary to establish a mechanism for consultation between the donors and fisheries research personnel in developing countries.

Some support to the steering committee will be required but, particularly during the early stages, as interest is being built up, it is important that funding be held at a modest level, with any future increases justified by concrete accomplishments. Two sorts of support can be identified: direct staff work to promote donor coordination, and technical and scientific inputs and initiatives.

To ensure coordination of donor inputs and support the periodic donor consultations, a consultant or full-time staff member working out of the World Bank in Washington, D.C., but reporting to the steering committee, should undertake the following activities:

- Draw up and assist the steering committee in disseminating periodic revisions of an indicative plan to support fisheries research at national and regional levels in developing countries
- Consult with donors and recipients, and monitor progress on the implementation of the indicative plan, reporting back to the steering committee and the consultations
- Match national and regional research priorities and funding requirements to donors' interests and resources
- Maintain a close working relationship with the CGIAR's fisheries research activities to promote and facilitate the exchange of information between the fisheries program supported by the CGIAR and activities under the donors' indicative plan for fisheries research
- Seek cooperation with private sector research interests.

Support to adaptive research also requires scientific and technical inputs. These should include the following:

- Assisting in the preparation of national research strategies and plans to strengthen national research capacities
- Consulting with donors and recipients, and monitoring progress on the implementation of the indicative plan, reporting back to the steering committee and the consultations
- Supporting regional research networks, twinning, and other arrangements to promote closer collaboration between institutes and individual scientists

- Providing an active interface between research results and development programs, with the goal of promoting the rapid transfer of technology
- Providing a channel to bring the results of strategic research to developing countries and ensure that they are adapted and applied.

Although many of these inputs can be made available through bilateral and multilateral programs and projects, there is a comparative advantage in having the FAO Department of Fisheries play a leading role because of its technical advisory capabilities. The FAO has offered to take on this role.

Annexes

Annex 1 Terms of reference

The output (of the Study) shall be a comprehensive report in two parts.

Part 1 provides the background information, specifying, for the appropriate types of fishery and areas of research involved:

(1) the specific constraints to fisheries development and management posed by lack of information and the ways in which these can be overcome by research

(2) background information including a brief summary on the current status of research and the roles of individuals and institutions involved

(3) the most important specific areas in need of research

(4) measures needed to overcome those constraints, detailing the role of international support efforts

(5) how these measures are expected to improve fisheries development and management with particular attention to the interpretation and application of research results to fisheries, including fisheries policy.

Part 2 contains the specific recommendations for an appropriate international plan of action to the year 2000 to improve fisheries research and its contribution to fisheries development and management, including:

(1) the types of research involved

(2) the institutions which would be appropriate for, or which should be involved in, the implementation of that research

(3) the new institutional or other arrangements needed to accomplish or facilitate the necessary national and international support

(4) the approximate funding required

(5) an approximate timetable for implementation of the proposed plan

(6) an evaluation mechanism to assess the effectiveness of the resultant program and to provide guidance for future developments including necessary changes

(7) the role of the donor community.

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Annex 5 Extracts from fishery development project evaluations

Asian Development Bank: An impact evaluation study on bank assistance to the fisheries sector (presented at the Fishery Development Donor Consultation, October 13-15, 1986)

Despite past difficulties in lending to the fisheries sector the Impact Evaluation Mission (IEM) considers that the Bank can play an important and useful future role, particularly to assist DMCs [developing member countries] in developing institutional capability for fisheries resource planning and management and in identifying viable approaches to improve small-scale fisheries. It is considered that the Bank's major role in the future will be to assist governments in improving the performance of private sector fishing operations.

Although measures can be taken to improve the performance of public sector enterprises, the inherent weaknesses of such firms, particularly in DMCs where private enterprise dominates the fisheries sector, tend to raise basic questions regarding the suitability of the public enterprise approach. In any event present thinking in many DMCs does not appear to favor providing additional vessels for operation by public enterprises. Consistent with recent trends in the Bank, it is considered that the Bank should stand ready to assist if requested in government measures to privatize state-owned fisheries enterprises.

There is a need for governments and the Bank to focus more intensively than in the past on conditions conducive to the economic viability of fisheries investments. The starting point would be an understanding of the common property nature of the resource and of the market failure which leads to overinvestment in fisheries capture and to depletion of fisheries resources. The present situation is roughly equivalent to complete free enterprise in several countries, since, despite incurring the administrative costs of fisheries departments, resources have been depleted. The measures adopted by the Bank in the past to prevent project vessels from contributing to overfishing have been largely ineffective.

A summary of the major specific recommendations related to fisheries resource planning and management and project planning and implementation are as follows:

(1) In order to internalize sector externalities it is suggested that when programming and projecting sector development governments should adopt a comprehensive approach involving both artisanal and commercial marine fisheries (para. 114).

(2) For the same reason it is preferable that a single agency should have responsibility for all marine fisheries beyond municipal limits (para. 114).

(3) A key aspect of the planning and regulatory process should be regular periodic dialogues between the fisheries agency on the one hand and on the other hand all concerned groups in the private sector and major institutions involved in financing fisheries-related activities (para. 114).

(4) Also vitally important would be improved statistical monitoring of marine fish stocks, effort, production and profit rates (para. 115).

(5) Fisheries policies and programs should be focused on a concept of overfishing that reflects both economic and biological aspects, such as Maximum Economic Yield (MEY). Despite high profit rates MEY may already have been reached if catch rates on fish prices have fallen or production costs have risen. The concept of overfishing invoked in the past is based on the Maximum Sustainable Yield (MSY) which takes no account of economic factors, and is of doubtful validity in terms of biological theory (paras. 108 and 116).

(6) It is believed that governments can do considerably more than in the past to prevent overfishing. Measures include repeal of fishing legislation which provides subsidies for the sector, active programs to identify and devise effective technologies to catch less exploited species and to enhance resources and outright regulation (paras. 112-122).

(7) Individual investment proposals should be considered within the context of an integrated plan which projects overall sector effort, and catch rates. This reflects the fact that economic viability of marine fisheries projects depends as much on the catch and number of non-project vessels as on project vessels (para. 117).

(8) If in the Bank's terminology a "project" approach is adopted, a policy dialogue on sector performance and issues is as vital as under a "sector" loan. Consistent with this point, review missions for marine fisheries projects should necessarily consider sector as well as project performance (para. 117).

(9) Substantial flexibility in project scope and vessel design is appropriate for fisheries projects, since in the context of a rapidly changing private sector dominated fishery, projections are difficult (para. 117).

(10) Preference should be given to fisheries port proposals justified on the basis of cost saving to ongoing fishing operations; proposals whose justification depends on generated fish production

would preferably satisfy several specific criteria (para. 118).

(11) Although planning of port and post-harvest facilities could be based on a medium term time horizon, construction should be phased, and the initial establishment based on a relatively short period in which there might be some risk that the facilities would prove inadequate (para. 119).

(12) Fish marketing, processing and transport components should be based on studies which specifically consider existing marketing arrangements and/or transport economics (para. 120).

All except one post-evaluated fisheries project involved provision of medium to large scale commercial vessels, yet the majority of fishermen in DMCs are engaged in artisanal fisheries using unsophisticated technology and thus can be adversely affected by introduction of large, modern craft. The fisheries project that directly assisted small-scale fisheries provided vessels at the top of the local technology scale, and these vessels were financed on very concessional terms. This and several projects approved subsequently to assist small-scale fisheries involved a "quantum leap" in the sense that the value of project-financed assets was large relative to the initial wealth levels of the beneficiaries. In such cases, even if small-scale fishermen learn the new technology involved, the financial management burden can pose a serious obstacle to sustainability. Although two ongoing projects involve smaller "leaps" in the sense that power and gear will be provided for use on existing artisanal vessels, the Bank has never, in regard to small-scale fisheries development, attempted an "incremental" approach by which is meant a step-by-step process, integrated in the sense that each level of technology and wealth is linked to the next higher level through multiple incentives and institutional support. A basic recommendation of this Study is that the Bank should move toward increasing assistance to small-scale fisheries following an "incremental" approach.

DANIDA: A strategy for fisheries development

(These guidelines, prepared by a DANIDA working group and submitted for review at an external hearing with interested agencies, research institutions, and organizations in Denmark, constitute part of DANIDA's policy on program and project identification and planning in the fisheries sector.)

Section 3: Operational guidelines for integrating environment aspects into Danish development assistance within the fisheries sector

1. Background

The fisheries sector includes capture fishery, aquaculture, handling, processing and marketing. Capture fishery refers to all kinds of harvesting of naturally occurring living resources in both marine and freshwater environments. Aquaculture normally refers to production of living resources such as fish, molluscs and algae in an aquatic environment.

In both developed and developing countries, changes in the socioeconomic structure behind the fishing industry, and technological changes within the sector itself have implied intensified exploitation of the living resources.

Increased demand for investments in the sector has created surplus capacity in fishing fleets, which has hampered efficient control of the fisheries. Development of advanced equipment has increased the efficiency. The lack of appropriate equipment has caused increasing amounts of by-catches. In general, technological development of the sector has implied increased stress on the ecosystem with possible damage of the natural resource as a consequence.

Investments in advanced technology in the fishery industry, such as industrialized processing facilities, cold stores etc., is often followed by political pressure to increase catches beyond sustainable yield.

Involvement by donor agencies in development of the fisheries sector may therefore support an undesirable development, and participation in such activities should only be undertaken after careful consideration of the environmental aspects.

Development of aquaculture activities may supplement capture fishery in covering the growing need for fish protein in the developing countries, but aquaculture development has so far been slower than expected especially in Africa where no traditions exist in this field. In Asia, where the development has been faster, the extensive use of pesticides in agriculture has become a threat to aquaculture, because of the toxicity of organochlorines to marine organisms.

Thus, protection of fish resources emerges as a major environmental task if the fishing industry is to sustain its development. To achieve this, the countries involved need to formulate and imple-

ment national management policies for sustainable use of their resources.

While capture fishery, aquaculture and fish processing may be hampered by environmental problems, the fisheries sector itself causes few problems to other industries.

Pollution control within the fishing industry is relatively easy to apply and often inexpensive. The production of wastes in processing industry is in many cases a sign of inappropriate production planning and loss of revenue. Often waste discharge into the environment can be avoided, or even better, the waste can be reused for fish meal or silage.

Destruction of habitats is a major problem associated with fisheries. Shallow waters like mangroves, lagoons and lakes are especially vulnerable to extensive fishing activities and therefore demand careful protection against over-exploitation and inadequate use of equipment.

Development of the fisheries sector may have adverse long term effects on the sustainability of the natural resource, and support to development projects within this field should only be endorsed after careful considerations. Potential negative effects should be identified by an environmental impact assessment of the project.

Donor supported projects may often increase already existing problems in the fisheries sector. This emphasizes the need for coordination and dialogue between donors, government institutions, local communities, private enterprises and others involved in these activities.

2. Constraints

A number of constraints may be identified in relation to the solution or alleviation of problems in the fisheries sector. The following issues should be addressed:

- Data on fish stocks and estimates on sustainable yields are inadequate or unutilized. In the case of tropical waters, reliable data may not become available for many years;
- Fish resources are part of a larger ecological system which is not fully known and understood;
- Various social groups and economic interests, with different time horizons and nationality, depend on the same natural resources. This often leads to serious conflicts of interest;
- Institutions established to plan and implement development projects, and to control the use of resources are often extremely weak, and their work is hampered by compartmentalization;
- Development projects often lack coordination;
- While the fishing industry and the industrialized fisheries move beyond the point of economic viability development of small-scale projects may be constrained by lack of finance, training and extension.

Specific constraints to aquaculture include:

- Competition for pond-use between aquaculture and domestic purposes;
- Competition of land-use and use of water resources between aquaculture and other sectors such as agriculture;
- Conflicts with capture fisheries over resources in shallow waters or within mangrove areas, where agriculture may cause damage to natural breeding grounds;
- Shortage of fry for stocking of ponds;
- The small number of potential species which are cultured.

3. Action to be taken

As a donor which has traditionally supported fisheries projects, DANIDA should in principle be prepared to consider assistance at international, national and project level. The projects should however, consider and include actions to eliminate potential problems and constraints.

3.1 Action at the national level

Actions associated with activities at the national level will include:

- Promotion of sector strategies based on an integrated system management approach which will include elaborating sector studies and formulating consistent policies and legislation for the fisheries sector, based on a comprehensive ecological understanding, as well as on analysis of the interaction with other sectors, and of major socio-economic issues.
- Applying a phased approach in the expansion of project activities, supported by continuous monitoring of effects and supplemented by provision of missing information.
- Development and introduction of more effective control measures where "classical" fisheries inspection services may be too expensive and inappropriate.
- Development of relevant training programmes covering the needs within capture fishery, aquaculture and processing, preferably in the environment where the target group is operating.

• Strengthening of research and development activities in relation to capture fishery, aquaculture and processing.

• Assistance to existing institutions in generating and analyzing data, developing adequate legislation, strategies and plans in order to enable more effective control.

• Establishment of more effective coordination of individual projects, to ensure that all available information and other management experiences are taken into account.

• Strengthening of extension services.

• Ensuring the availability of credits for small-scale fisheries and aquaculture, and technical assistance for large-scale activities if necessary.

3.2 Action at the international level

DANIDA will strengthen activities in the following areas:

• Promoting of international agreements on the use of marine resources for example in the framework of the United Nations Conference on the Law of the Sea.

• Provision of technical assistance for collection and analysis of data on issues relevant to system management.

• Assistance in developing integrated management systems.

• Strengthening of the institutional capacity to deal with research and development (R&D) and training at regional level.

• Promotion of acceptance among donors of established national development objectives, strategies and plans.

• Coordination of donor efforts at both national and project level, ensuring that information is made available to other donors, and that cooperation in implementing sector plans takes place.

3.3 Action at the project level may include:

• Ensuring clear formulation of objectives and identification of target groups, as well as clear specification of priorities between industrial or small-scale operations.

• Respecting national development objectives, strategies and plans in the planning and implementation of programmes.

• Analyzing environmental aspects as part of all project planning.

• Carrying out baseline studies in all projects to ensure that environmental effects are monitored.

• Carrying out careful monitoring of project activities, both in terms of exploitation of resources, and potential effects of pollution, especially where analyses have indicated that environmental problems may arise.

• Activating target groups in preparing and implementing small-scale fisheries projects, whenever this is justified by the potential scope and benefits thereof.

4. Capture fishery

4.1 Specific action at national level may include:

• Generation and presentation of information on:
  - Data collection
  - Data management analysis
  - Stock assessment
  - Assessment of maximum sustainable yield
  - Assessment of the level of potentially harmful substances in the environment
  - Assessment of effects of pollutants on marine organisms
  - Formulation of management options
  - Analysis of socioeconomic and other consequences of selected options
  - Presentation of options to decision-makers
• Establishment of control measures such as:
  - Restriction on gear types
  - Restrictions on vessel size
  - Maximum quotas
  - Closed seasons
  - Closed areas
  - Licensing systems
• Control measures such as establishing "classical" inspection services and other more decentralized management systems involving small-scale fishermen directly.
• Promotion of legislation in relation to
  - Safeguarding traditional users rights
  - Banning of fishery with explosives
  - Banning of trawling on breeding and fishing grounds
  - Protection of mangrove areas
  - Restrictions on collection of wild fry
• Gear development, for example introduction of selective trawls.
• Development and introduction of less damaging fishing techniques through extension.
• Building of awareness on the consequences of destructive or non-sustainable techniques.

4.2 Specific action at international level may include:

- Promotion of agreements among neighboring countries on the sharing of resources, for example through the United Nations international or regional subsidiary institutions.
- Assistance in the development of stock assessment techniques.
- Assistance in the development of selective fishing gear.
- Provision of technical assistance for training at higher level, in formulation of development policies, strategies and planning.

4.3 Specific action at project level may include:

- Expansion of fishing fleets only where this is environmentally acceptable in terms of carrying capacity of the resources, and their potential alternative uses.
- Presentation of incentives, where appropriate, for industrial-scale fisheries to reserve coastal and in-shore waters for small scale fisheries.
- Provision of technical assistance to integrate resource management through:
  - Collection of data on catches
  - Introduction of improved gear
  - Introduction of registration numbers on vessels
  - Building awareness amongst fishermen
  - Training
- Improved donor coordination and direct contact between project personnel at project level.

5. Aquaculture

5.1 Specific action at the national level may include:

- Establishing priorities for the use of resources, including analysis of alternative options.
- Research and development activities, including identification of additional species for potential cultivation.
- Collection and analysis of data on the impact of aquaculture on the environment and human health.
- Careful consideration of potential risks prior to introduction of exotic species.
- Actions against collection of wild fry.
- Research and development of suitable feed.
- Pollution control in relation to introduction of cage culture.
- Assessment of biological effects of the accumulation of pesticides and other contaminants in fish.
- Assistance to the development of legislation on the control of users rights to ponds and other water bodies.

5.2 Specific action at international level may include:

- Promotion of international cooperation in activities that may affect more than one country, such as:
  - Introduction of exotic species that may spread to inland waters of bordering countries
  - Activities in relation to breeding grounds, for example fry collection and fish pens, that may cause adverse effects on recruitment and breeding of commercially important species
  - Development of water reservoirs and irrigation schemes
- Identification and study of potential benefits associated with controlled aquaculture activities, such as food and feed production or weed control in bilharzia-infested areas.

5.3 Specific action at project level may include:

- Baseline studies and project monitoring, including analysis of:
  - The impact of project activities on the environment and human health
  - The use of waters for aquaculture and other purposes
  - Ownership and user rights
  - Economic aspects of alternative use of natural resources
  - Access to feed
  - Access to fry and fingerlings
- Extension activities, to be implemented in the project area close to relevant target groups, may include:
  - Introduction to appropriate culture methods
  - Introduction to higher yielding techniques, for example by using more appropriate species
  - Fry production
  - Feeding techniques
  - Disease control
  - Pollution control
  - Awareness building

– Guidance on access to credit facilities

• Development and dissemination of training materials

6. Handling, processing, and marketing

6.1 Specific action at national level may include:

• Balanced investments in industrial infrastructure and processing facilities, considering market size and sustainable exploitation of the fish resources.

• Development of ways and means to reduce post-harvest losses through:

– Increased use of ice
– Improvement of preservation methods
– Prevention and reduction of insect infestations
– Improvement of market facilities
– Improvement of vessel design

• Product development to increase incomes within the fisheries sector

• Utilization of waste from the fishing industry for production of fish meal and fish silage, etc.

• Introduction of better techniques for preservation of catches for fish meal production, and more hygienic processing methods.

• Utilization of organic waste for aquaculture.

6.2 Specific action at international level may include:

• Donor support to expand processing and marketing capacities with due consideration given to sustainability of the natural resources and established national priorities.

• Promotion of technical cooperation on a regional basis and between developing countries in general in the fields of research and development and training.

6.3 Specific action at project level may include:

• Clear definition of target markets and projects.

• Postponing major processing and marketing activities until reliable stock assessments are available.

• Development of plans for dealing with environmental aspects prior to industrial-scale processing.

• Careful monitoring of the effects of industrial-scale activities on the small-scale sector.

• Introduction of small-scale fisheries project components, supporting sustainable resource utilization through:

– Establishment of adequate ice supply
– Erovision (sic) of improved fishing gear
– Introduction of more fuel-efficient smoke ovens
– Improvement of salting and sun-drying methods and other fish preservation techniques
– Introduction of locally available, renewable energy sources
– Assessment of risks involved in the use of insecticides in fish processing
– Establishment of credit facilities for introduction of new techniques
– Support to marketing
– Training and extension services

UNDP: Fisheries development—review of support by the United Nations Development Program

7. Conclusions: The experience gained

Throughout this chapter, certain conclusions have been drawn with respect to the various types of activities assisted by UNDP during the period under review. The purpose of the present section is to draw together the more important and general conclusions which emerge from the experience examined above.

Many of the UNDP-assisted projects were aimed at strengthening the countries' infrastructure for fisheries development. Examples are projects concerned with manpower development, resource management, fisheries, legislation, certain kinds of institution building, fish marketing and distribution. Data collection and resource analysis are being improved but much remains to be done to ensure that the gains will be translated into effective management programmes. Numerous countries will need their fishery planning and management capacities strengthened through the assistance provided by UNDP, leading to more efficient exploitation of such resources as available to them.

The past gains achieved in fish production through UNDP assistance have been almost exclusively in the marine commercial sector. A minor but increasing amount of the total support provided has been directed towards the development of small-scale fisheries and aquaculture. In retrospect, a better balance between commercial and artisanal fisheries would have been desirable, given the fact that the latter provide most of the

fish consumed in developing countries and are a major source of protein in those countries. The emphasis that was placed on commercial fisheries was a response to government's own priorities rather than policy decisions of UNDP or FAO, but more could probably have been done to stimulate interest in small-scale fisheries development.

Assistance for aquaculture development has also represented a very small proportion of the total assistance provided, but has increased significantly in the past few years. Interest of governments in aquaculture development is rising steadily, and fish culture is now the fastest growing sector of world fisheries. This trend can be expected to continue. The UNDP/FAO interregional Aquaculture Development and Coordination Programme has undoubtedly contributed significantly to the promotion and support of aquaculture development in numerous countries.

Very few of the projects supported can be considered to have been outright failures, although there are a number of projects which failed to achieve their objectives fully, or otherwise fell short of original expectations. In such cases the shortcomings have generally been due to one or more of the following factors: the project was not realistically adapted to the country's needs and was too ambitious in its objectives, given the existing stage of fisheries or overall development in the country; insufficient attention was paid to the limits of the resources or to the economic constraints; there was an inability to provide the quality of expatriate expertise needed in a timely fashion; the government was unable to provide the necessary counterpart support. In some cases poor project management was a significant factor, but given the large number of projects implemented, such instances are surprisingly few. In some cases, unexpected and abrupt reductions in UNDP assistance hampered projects' effectiveness particularly during the Programme's financial crisis in the mid-1970s.

The large multi-purpose national projects supported throughout the period have shown good results in a number of countries, but the design and efficient management and implementation of such projects poses many difficult problems. A more manageable and cost-effective approach in most situations would seem to be a series of projects having more limited scope and objectives targeted on specific needs, and implemented over time according to a carefully planned sequence.

The record indicates that several of the large-scale regional and interregional projects have been among the most cost-effective activities supported during the period. Those projects have been a major source of assistance to large numbers of countries in analyzing common problems affecting their fisheries development, in promoting technical cooperation affecting their fisheries development, in promoting technical cooperation among themselves (TCDC), in designing projects and programmes to deal with them, and in strengthening the regional fishery bodies concerned. Several of the projects, in particular the Indian Ocean Programme, the South China Sea Programme and the Aquaculture Development and Coordination Programme have been highly successful in generating follow-up investment. But not now supported.

In order to produce a significant impact, intercountry projects of an inter-disciplinary nature should concentrate on those problems which can only or best be solved by joint action. Examples are: survey and appraisal of fish stocks; the development of principles and techniques for the management of shared stocks; harmonization of fisheries legislation; cooperation in the collection and exchange of data; and provision of marketing information. Intercountry projects can also provide valuable services to individual countries for the solution of short-term technical problems, but should not become involved at the operational level. The most successful projects have been those which have concentrated on the identification and formulation of national project activities required to deal with specific problems. Highly competent and enterprising management, with a large short-term consultancy component to ensure flexible and expeditious response, are essential elements in a successful umbrella project. It is essential that they are funded on a long term basis.

Towards the end of the period, FAO adopted an assistance strategy based on the creation of sub-regional technical support modules as a way of meeting needs arising from the establishment of the EEZs. The Organization further decided that the most effective way to provide technical help to these units would be through separate sub-regional projects, rather than within the existing framework of the interregional umbrella projects. While there is a clear need for a sub-regional approach to groups of countries sharing common interests and problems, the approach is not incompatible with the broad umbrella project structure.

The resource surveys supported during the period have had mixed results. Resource information from resource surveys, particularly acoustic

surveys can be useful for planning purposes, but because of their general nature such surveys are usually of only limited value for investment purposes. Follow-up test fishing of a quasi-commercial nature must be carried out, and species breakdown and catch rates determined, unless, of course, there is already an established fishery. In many cases this was not done. Where there is an ongoing fishery, acoustic surveys are useful components of the management programme. Furthermore, surveys of restricted areas, such as a single country's EEZ, are of limited value where there are migratory species of fish which are exploited by more than one country. Consequently, more reliance should be placed on well-designed and intensive intercountry surveys such as have been conducted under the UNDP-supported umbrella programmes. In the future, the primary need will be for follow-up of the results produced by the previous surveys through test fishing and additional survey work in shallow inshore waters.

A major constraint upon achieving effective implementation of projects has been the lack of satisfactory information on the economic and social aspects of fisheries, particularly of small-scale fisheries. Projects have encountered problems because markets for the products were inadequate; the costs of adopting the new technologies were too high; or there were social and cultural impediments to the adoption of the new techniques. Furthermore, the initial success of some projects has carried the seeds of subsequent difficulties. Technological improvements applied to limited resources have led, in some cases, to an uneven acquisition of the technology, benefitting a few to the detriment of many. This has also been a source of conflicts between different users of the same stock or area. In order to deal with these problems effectively, it is necessary to have considerably more social and economic information than is presently available in most countries. In addition, there is an urgent need to find improved techniques for controlling fishing effort in order to prevent over-fishing of stocks and to achieve socially and economically rational use of limited resources.

Although the training activities assisted during the period, either as separate projects or as components of multi-purpose projects, have undoubtedly been useful to countries, insufficient information is available on the numbers and categories of persons trained, and their eventual employment, to assess fully the impact of these activities on countries' fisheries development.

The establishment of training institutions for fisheries development is useful, provided certain other conditions are present. These include adequate fisheries resources to support increased exploitation; investment sources for expansion of the industry; adequate markets, either domestic or foreign; and a pool of properly motivated persons from which to draw trainees.

A final conclusion that emerges, is that fisheries development is by its nature a long term and rather costly process, particularly when countries are starting from a relatively low level of development and with little resource information. UNDP's experience indicates that at least 10 years of sustained support has often been needed to achieve substantial results. In addition, a minimum critical mass of assistance is required to make an impact, and this can represent a large annual project expenditure. Inadequate support and stop-and-go financing or the premature termination of assistance can do more harm than good. Major projects should not be embarked upon unless it is foreseen that the necessary support will be available over a considerable period of time. This is the case for regional projects and small-scale fishery development projects. A corollary of this conclusion is that much greater efforts need to be made in monitoring and evaluating fishery projects.

World Bank: Harvesting the waters — a review of Bank experience with fisheries development (extract from World Bank 1984)

Common problems experienced with fisheries projects

Reference has been made to the range of problems experienced in the course of implementing the fisheries lending program. The kinds of problems which have occurred, in some cases repeatedly, can be categorized as follows:

(1) *Cost escalation* especially from 1973 onwards, affecting most projects, in particular, boat building and port construction.

(2) *Fish catches* lower than appraisal estimates, resulting from inadequate resource information, insufficient attention to level of exploitation, or over-optimistic appraisal estimates about catches and fishermen's capabilities.

(3) *Government actions* detrimental to project aims, such as changes in government fisheries policy and price controls.

(4) *Design faults in harbor construction.*

(5) *Poor construction and inadequate maintenance of shore facilities.*

(6) *Poor construction of boats,* causing delays while defects were being rectified.

(7) *Design faults in boats,* discovered after entering service, such as inadequate carrying capacity for economic use, insufficient power and wrong type of engine.

(8) *Poor project management,* caused by local institutional inadequacy or lack of trained local personnel.

(9) *Delays in procurement* (affected most projects).

(10) *Delays in recruitment* (affected many projects).

(11) *Noncompliance with covenants.*

(12) *Faulty record-keeping* and failure to comply with Bank procedures (affecting most projects, at least initially).

(13) *Poor rate of sub-loan repayment,* a common and major problem.

E. Resolution of the ACP-EEC Council of Ministers on Fisheries Evaluation, Fiji, March 28-29, 1990*

The ACP-EEC Council of Ministers,

Having regard to the third ACP-EEC Convention, signed in Lomé on 8 December 1984,

Having regard to the Resolution of the ACP-EEC Council of Ministers of 25 April 1986 on evaluation,

Having regard to the draft Resolution submitted by the Article 193 Committee,

Having regard to the recommendations of the meetings of ACP and EEC experts on fisheries development, held in Lilongwe, Malawi, from 17 to 21 April 1989 and after the examination by the Article 193 Committee of the proposals arising from this meeting,

• NOTES the attached Basic Principles resulting from the joint discussions on evaluation.

• RECOMMENDS that the relevant departments of the ACP and EEC partners take account of these Basic Principles when devising, studying, carrying out, monitoring and evaluating new projects and action programmes in the fisheries sector.

• REQUESTS the Article 193 Committee to monitor closely the implementation of this Resolution and to report periodically to the ACP-EEC Council of Ministers.

Basic Principles

I. Project planning and preparation

1. Available Documentation: Project proposals should always be based on project dossiers that are as complete as possible. To this end, feasibility studies should take into account institutional, sociocultural, economic and technical aspects. Existing guidelines and established procedures should be followed carefully.

2. Fisheries Development Policy: Beneficiary countries should always analyze their existing potential in fisheries development within the framework of an overall policy geared to a rational exploitation of the countries' fisheries resources and define alternative options to respond to well identified priority needs.

II. Objectives, purposes, strategies

3. General Goals: Fisheries projects should clearly contribute to broader programme or sector goals which are defined in the national or regional indicative programme, either as separate projects or as part of an integrated strategy. In both cases, it is important to specify the process of fulfilling mutual commitments referring to EEC and ACP contributions (in financial terms or in kind) and to determine mechanisms ensuring the timely availability and phasing in of these contributions from the start.

4. Quantifiable Purpose: The principal project objective (purpose) and the intermediate objectives as well as the relevant time scale should be formulated in precise, coherent and realistic terms that can, as far as possible, be measured quantitatively.

5. Alternative Strategies: Strategies should be guided by the fact that artisanal fisheries projects are the predominant providers of high-quality protein food for local populations, while industrial fisheries projects contribute more to foreign exchange revenues. Support for aquaculture projects may be considered in medium and long term development perspectives. In the design of

* Fisheries is used here in the broad sense as the utilization of living aquatic resources aiming primarily at the improvement of living conditions of the fishing communities and at maximizing the benefits developing countries can derive from the rational use of their aquatic resources. It is understood that in many rural areas artisanal fishing or aquaculture are part of more diverse food production and income generating activities and are therefore more often supported in the framework of integrated rural development programmes.

fisheries projects, the interests of people who are only involved in fisheries part-time should be taken into account. Integrated rural development projects relating to fisheries might better serve such interests than projects concerned solely with fisheries. Strategies should not aim simply at increases in production, but also at the improved utilization of catches (e.g. by the reduction of postharvest losses) and a better fisheries management, making full use of research and marketing involving also the private sector.

6. Large-scale Projects: In the case of large-scale projects, it is often preferable that implementation should be phased. Each successive phase will then be planned on the basis of experience gained in the preceding phase. The approach should, however, not lead to interruptions in project financing.

7. Coordination: More effective coordination (i) between different Commission Directorates dealing with fisheries policies, and (ii) between different donors working in the fisheries sector in a given country and the ACP government concerned should also contribute to higher aid efficiency.

III. Factors needed to achieve project objectives

8. Sustainability Factors: Appraisal should focus on the entire spectrum of factors that have proven to be of vital importance for the sustainability of projects including:

a. political priority and support for the sector;

b. protection of the environment and rational use of renewable resources;

c. compatibility with socioeconomic and cultural values;

d. appropriateness of technology;

e. adequate managerial capacity and promotion of institution building;

f. financial and economic viability;

g. project resilience vis-a-vis uncontrollable adverse influence.

These elements have to be kept in mind all through the project life-cycle, from project identification, appraisal, financing, implementation and monitoring of evaluation.

9. Referring to fisheries projects, these aspects imply the following principles:

a. Political support: Government support should be assured by practical measures during project implementation.

b. Environment: Environment impact studies should be included in project preparation if such impacts can be anticipated. They should lead to measures for the prevention of over-fishing, water pollution and any activity that could endanger directly or indirectly the conservation of natural resources (e.g. excessive wood cutting for fish smoking). These measures have to be monitored during and after project completion.

c. Sociocultural Values/Target Group/Women: The socioeconomic and cultural context of each project has to be taken into account. The clear identification of target groups should be based on a thorough analysis of the different sub-groups of the fishing communities; the practical modalities of target group involvement in project planning, implementation and operation should be spelled out in project documents; the pilot project approach may help to define them. The importance of the role of women in fisheries development should be more efficiently translated into women's practical involvement in project preparation and project actions concerned e.g. with fish, production, conservation, and marketing, but also linked to women's wider responsibilities in areas like agriculture, health, nutrition, water supply, etc.

d. Technology: Technologies to be chosen should be adapted to the type of project (industrial or artisanal fisheries or aquaculture projects) and be based, as far as possible, on local materials and expertise. Imported equipment has to be fully adapted to local conditions and know-how with appropriate training.

e. Project Management/Institution Building: Strong management capacities are the key to timely and sound project performance. As far as possible local expertise should be mobilized at all stages of the project cycle in order to have the national capacity necessary for project survival beyond external funding. If local expertise is not available, expatriate technical assistance personnel should be selected on the basis of proven professional capacities in fisheries development and possess the required linguistic and human qualities. This personnel should supply to national staff adequate training as a prerequisite for durable project results; training has to be adapted to the practical requirements of specific target groups, of national staff and of managerial personnel. Retraining of trained personnel should be provided and its employment in activities corresponding to their skills acquired is essential. Joint ACP/EEC teams of fisheries experts should be encouraged and women's participation in such teams should be envisaged whenever required. For additional backstopping and supervision independent ACP/

EEC-TA is recommended, if it is useful. The EEC being one of the most important development agencies in the field of fisheries, should increase its expertise at the headquarters and delegation level, combined with an extended recourse to ACP, EEC and Member States, know-how contracted by framework contracts, when necessary. It should also be envisaged to train more ACP personnel charged with identification and designing of projects on fisheries development.

IV. Project implementation planning

10. Procedures: Project documents should describe the structure and procedures of project implementation and functioning, the distribution of responsibilities between national authorities, project managers, beneficiaries, and the Commission including delegations. From the start, efforts should be made to integrate the project activities into existing national entities or structures.

11. Implementation Problems: Allowances for cost escalation and contingencies should be realistic. Responsibilities of contractors (whether of EEC or ACP origin) involved in project implementation should be clearly defined to reduce the risk of undue delays because of poor project design, lack of coordination between construction works and supply of equipment or poor quality of goods badly adapted to climatic conditions.

12. Financing: Project sustainability and long-term project maintenance and operations especially those involving foreign exchange should be identified and appropriate solutions sought at the planning stage.

13. Privatization: Project design should make a distinction between profitable and non-profitable activities to avoid conflicting objectives and poor performance of either type. Privatization of money-making activities (acquisition of inputs, marketing of production) should be favorably considered, without, however, confining the public sector to exclusively non income-generating functions (training, extension, research); the latter are nevertheless essential for project success. Decision to favour privatization should be made case by case and planned from the beginning.

14. Support for Private Sector: Where fish marketing is undertaken by private traders public services should support these activities indirectly, e.g. by building and maintaining infrastructure, supporting cooperative ventures, offering training and establishing quality standards.

15. Credit Schemes: Projects including direct support for credit schemes to fisherfolk should consider in particular the following constraints: traditional credit relations between fishermen and private traders, limited covering of goods preferred by fisherfolk, favorable conditions not passed on to them, seasonal nature of fishing activities, etc. Indirect support for mobilizing own savings, creating credit groupings and establishing guarantee funds should receive at least equal attention.

V. Monitoring and evaluation

16. Reporting: Internal project reporting on a regular basis and in a standardized format should allow project management to monitor progress towards intermediate and ultimate project objectives by measuring key indicators of achievement. These indicators have to be defined early in a quantitative manner and must allow project management to react to changing situations. They can help to decide on longer-term EEC involvement in the extension and intensification of on-going successful operations, and thus enhance overall effectiveness of EEC aid. Technical reports should also be prepared according to standard formats and be published by the competent department. The cost for production and distribution of these documents should be reflected in the budget of the project.

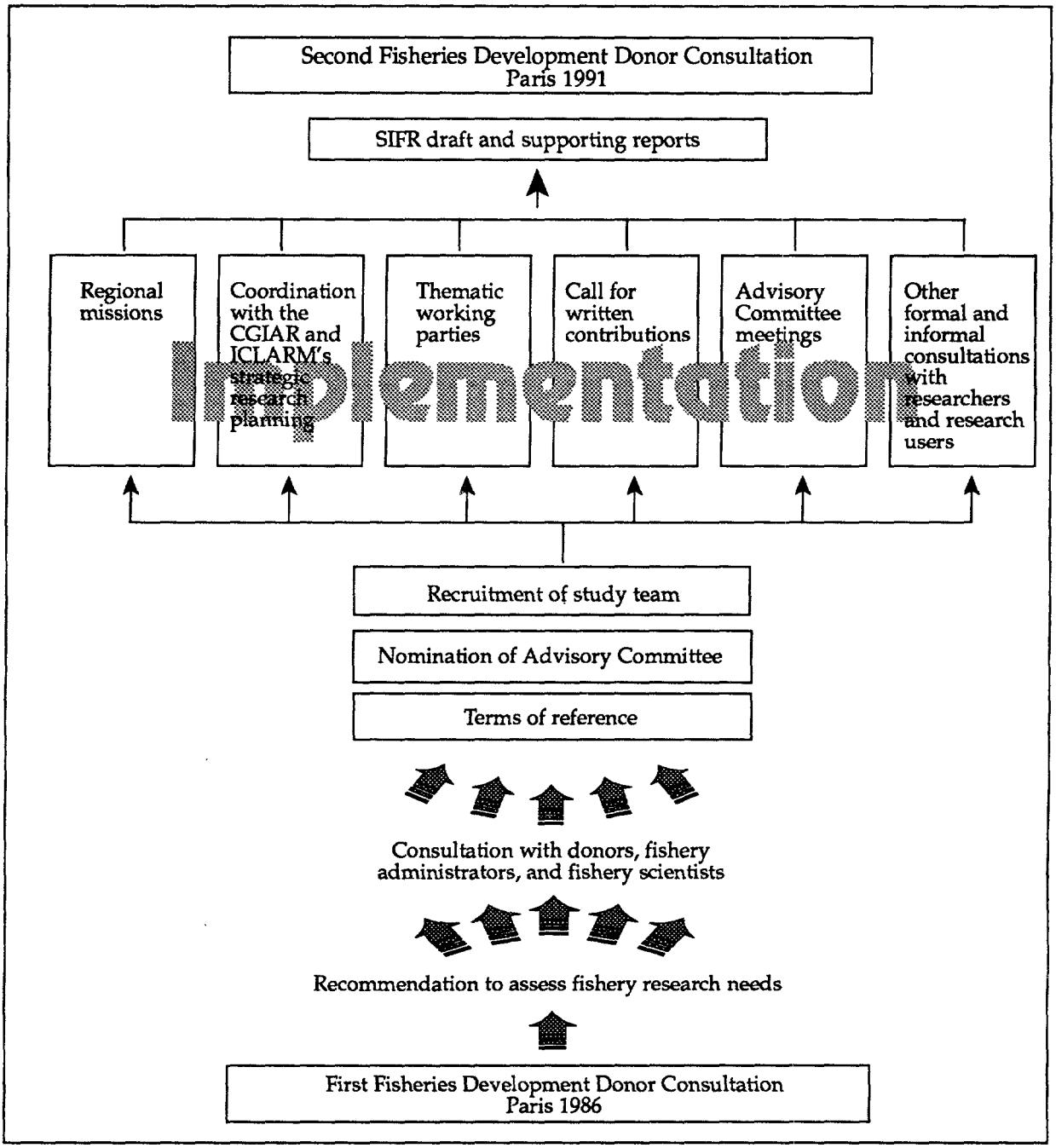
17. Evaluation: A sample of completed projects should be evaluated periodically.

Annex 6 Participation in SIFR activities by continent of nationality
(number of persons)

	International organizations	*Africa*	*Asia*	*Latin America*	*North America*	*Europe*	*Total*
Activities							
Steering Committee	3					1	4
Advisory Committee	3	2	5	1	4	10	25
Study Team					1	1	2
Missions							
NW Africa	1	4				4	9
SE Africa	2	1				1	4
SW America				1		3	4
SE America	2					1	3
India	1		2		2		5
ASEAN states	3		1				4
Working parties							
Aquaculture (2)	1	1	6	2		13	23
Small-scale	1		1		4	3	9
Small pelagics	1	1	3	1		1	7
International cooperation	1	2	2	1	3	2	11
Desk study							
Island states					1		1
Total	19	11	20	6	15	40	111

Annex 7 Graphic presentation of the SIFR process

Figure A7.1 Origin of the Study of International Fisheries Research Needs for Developing Countries



Note: The development of the SIFR was overseen by a Steering Committee composed initially of representatives of the World Bank, the UNDP, the CEC, and the FAO. The committee was expanded to include NORAD and the IDRC (Canada) at the Second Fisheries Development Donor Consultation.

Figure A7.2 Coordination between the SIFR and the CGIAR

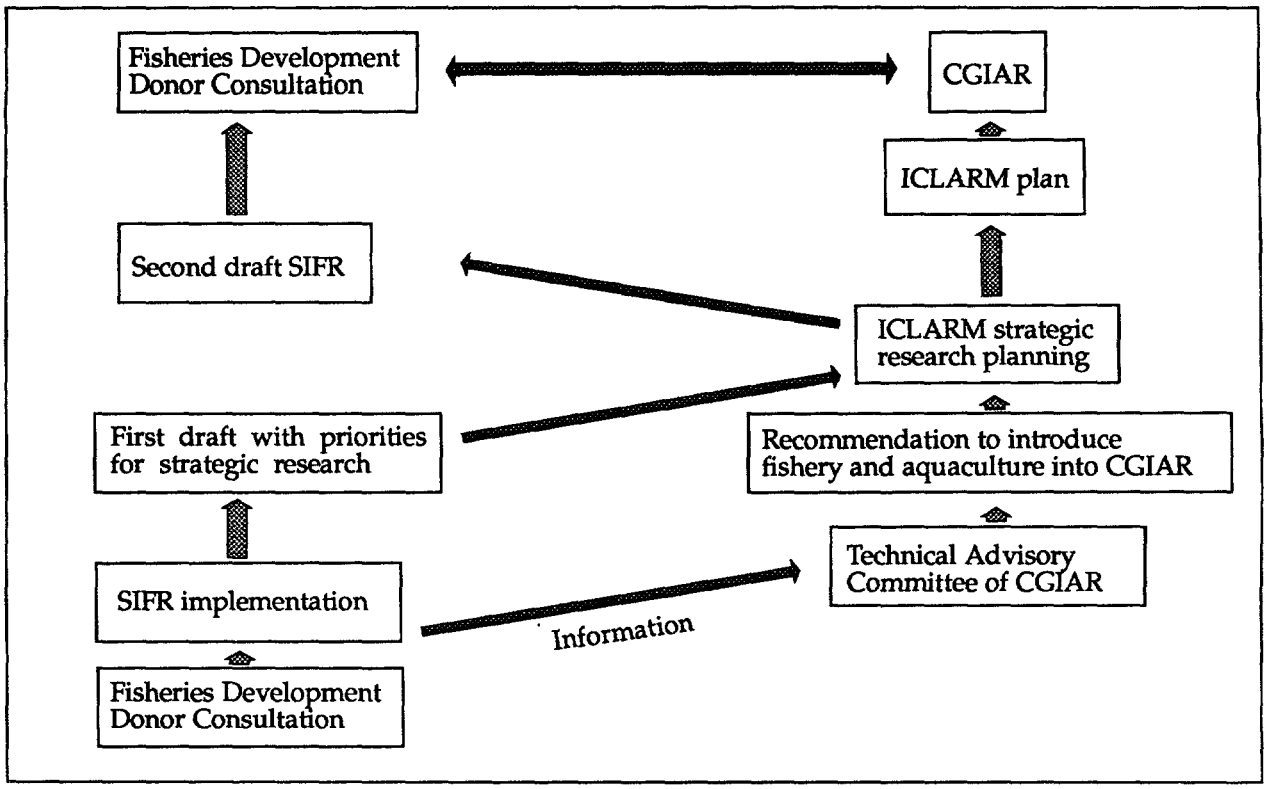


Figure A7.3 Research capabilities in developing countries and aspects requiring consideration to enhance their contribution to development

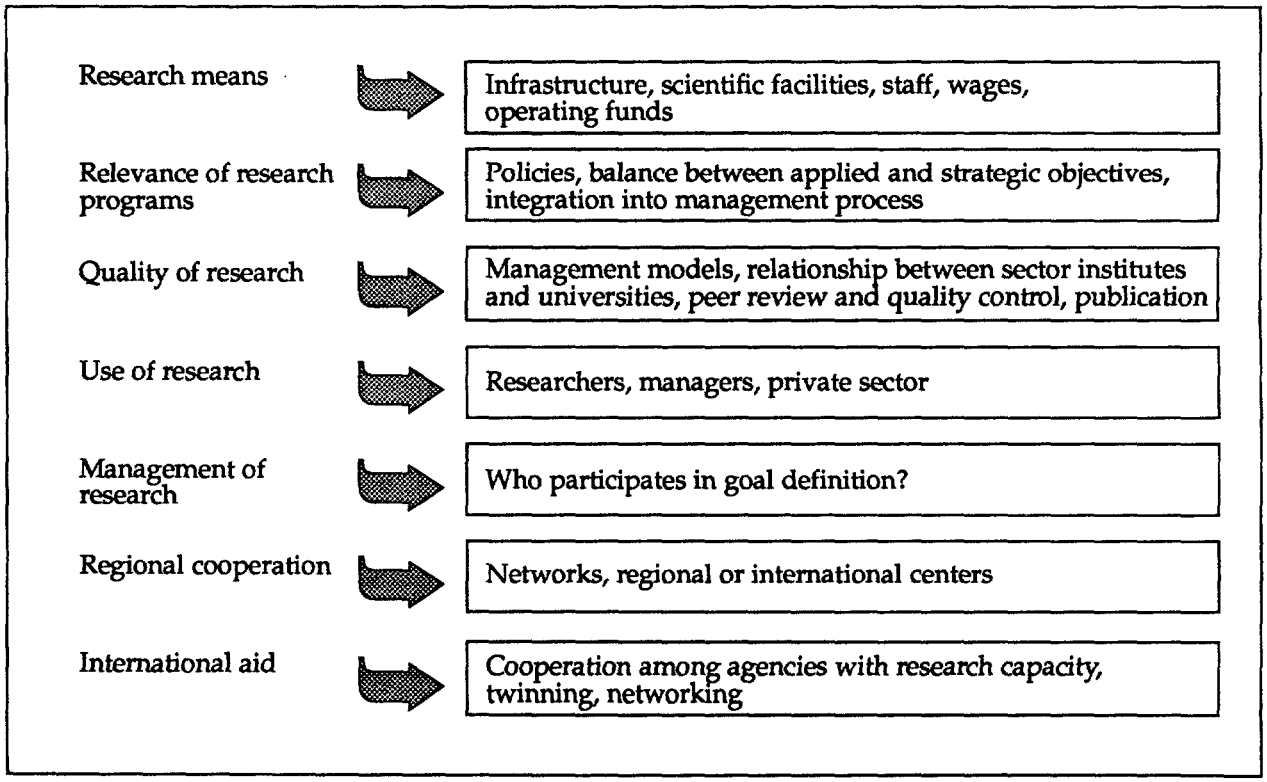


Figure A7.4 Improvements possible with existing knowledge

Action at national levels	*Action for donors*
Institutional changes	Revision of development strategies
Sector development and food policies	Dissemination of concepts
Strengthening of technical competence	Practical support for above
Increasing economic efficiency	

Figure A7.5 International fisheries research strategy

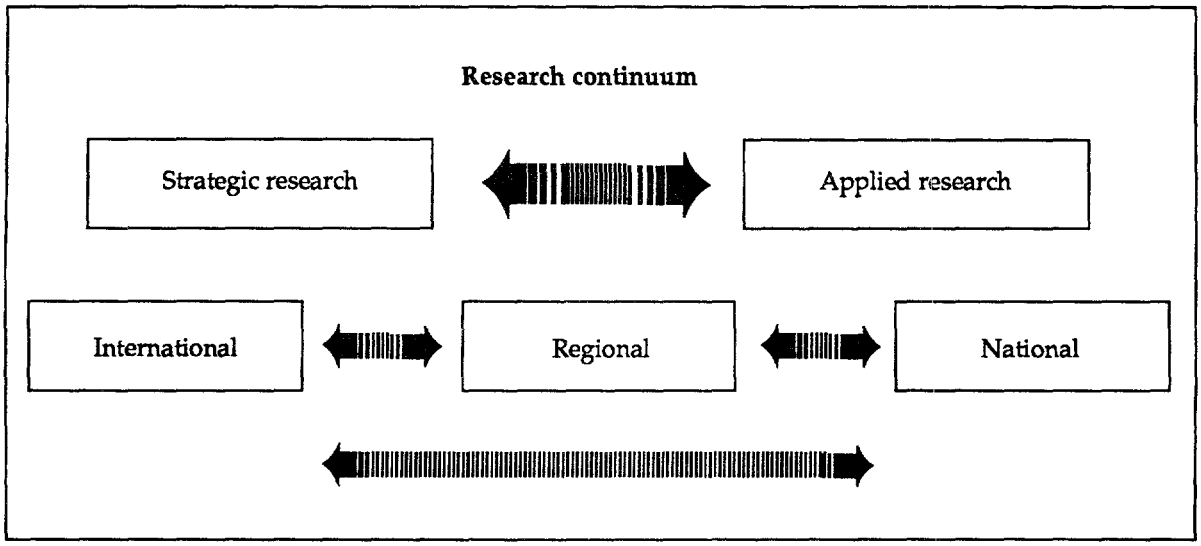


Figure A7.6 Main research areas

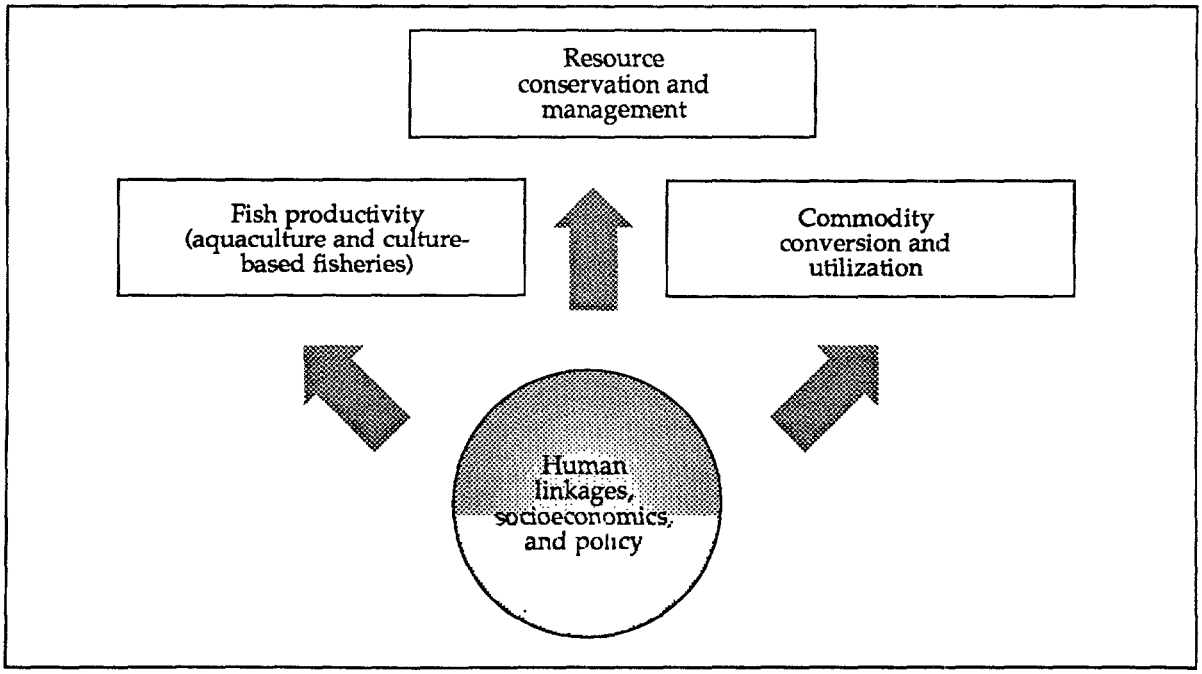
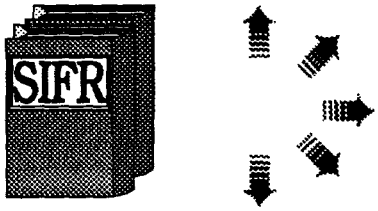


Figure A7.7 Plan for action

1. Disseminate the SIFR

Fisheries donor community

Fishery administrations in developing countries



Scientific community in developing countries

Bibliographical services; regional meetings of researchers

Scientific community in industrial countries

2. Provide support to strategic fisheries research under the CGIAR

1990	US$4 million	ICLARM
1992-93	US$6 million	ICLARM
1994-95	US$? million	International fisheries research institute

3. Provide complementary support for fisheries research policies and programs

- Developing countries to establish their fisheries research policy and programs
- National institutions linked to regional or wider networks
- Regional fisheries research mechanisms
- Access to scientific and technical information, including hardware
- Transfer and adaptation of technology resulting from research
- Additional research conducted by universities and advanced scientific institutes
- Exchange of information about fisheries research

Figure A7.8 Criteria for choosing national institutions to target for assistance

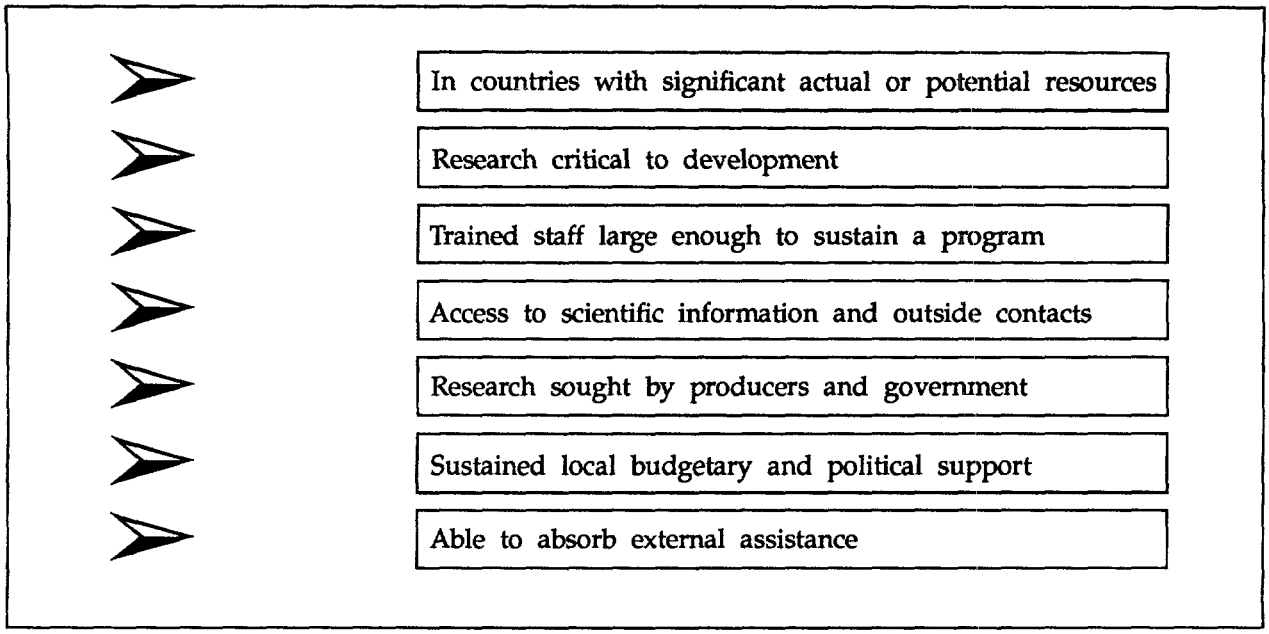


Figure A7.9 Means of implementation (additional to CGIAR)

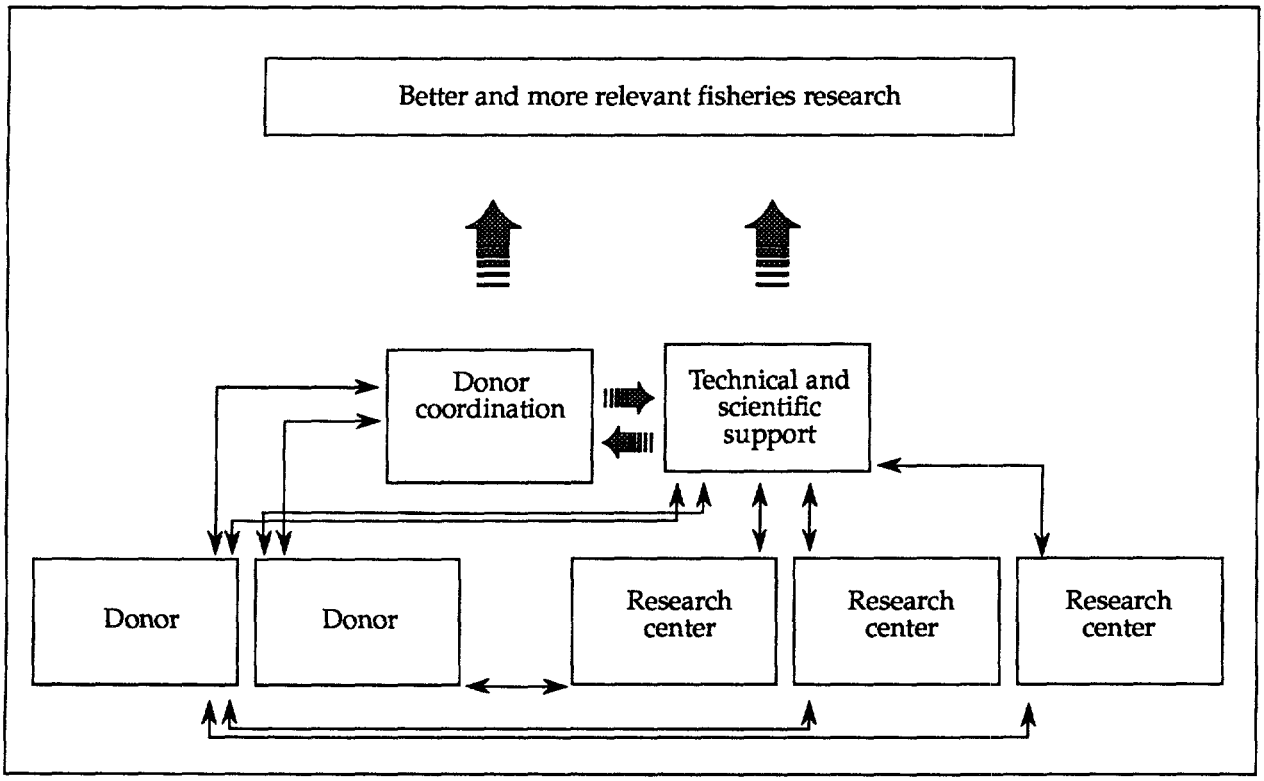
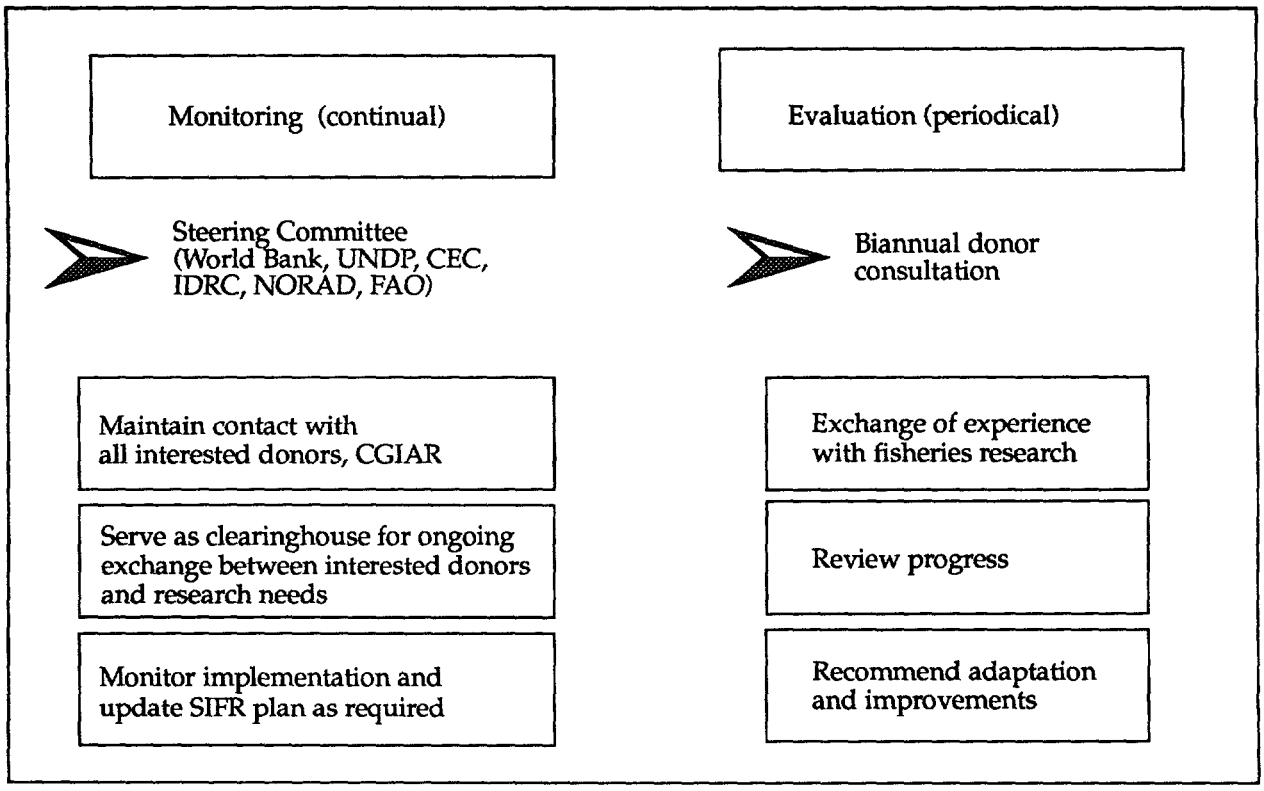


Figure A7.10 Fisheries donor coordination: An ongoing process



Annex 8 Tentative list of agencies and research centers funding or conducting research programs with a significant international component

Institution	*Fisheries development*	*Biological oceanography*	*Pollution*	*Impact of climate change*	*Integrated coastal zone management*	*Ecology conservation*	*Stock assessment*
AIT							
Auburn U. (U.S.)	•						
EC	•					•	
FAO	••		•	•	••		••
ICES		••	••	•		•	••
ICLARM	•				••		•
ICOD	••	•	•				
ICSM		•				•	
IDRC	••				•		
IFREMER (France)							•
IMO			•				
IMR (Norway)							••
IOC		••	•	••	•	•	
IUCN			•	•	•	••	
NRI (U.K.)	•						
N. Sea Centre (Denmark)	•						•
OECD	•		•				
Oregon State U. (U.S.)							
ORSTOM (France)		••		••			•
SEAFDEC	•				•		•
Stirling U. (U.K.)							
Technical U. (Bergen)							
Theoretical Ecology (Germany)					•	•	•
UNEP		•	••	•	••	••	
U. of Hull (U.K.)	•						
U. of Kiel (Germany)		•	•			•	•
U. of Newfoundland (Canada)							
U. of Washington (U.S.)							
U. of York (U.K.)			•		•	•	
USAID CRSP					•		

•• indicates that an institution is funding or conducting a major program; • indicates that an institution is involved in a research effort.

Institution	Fisheries management	Multispecies fisheries	Aquaculture	Fishing technology	Postharvest	Fishery economics	Fish marketing and trade
AIT			••				
Auburn U. (U.S.)			••				
EC	•		•				
FAO	••	••	•	•	•	•	•
ICES	••	••	••	•			
ICLARM	•	••	••			•	
ICOD	•		•				
ICSM							
IDRC	•		•		•		
IFREMER (France)					•	•	
IMO							
IMR (Norway)	•	•					
IOC							
IUCN							
NRI (U.K.)				•	••	•	•
N. Sea Centre (Denmark)	•	•		•			
OECD			•			•	•
Oregon State U. (U.S.)						•	•
ORSTOM (France)	•	•					
SEAFDEC	•	•	•	•	•		
Stirling U. (U.K.)			••				
Technical U. (Bergen)						•	•
Theoretical Ecology (Germany)	•	•					
UNEP							
U. of Hull (U.K.)	•						
U. of Kiel (Germany)			•				
U. of Newfoundland (Canada)						•	•
U. of Washington (U.S.)	•					•	•
U. of York (U.K.)							
USAID CRSP			•				

Annex 9 Regional fishery bodies

Atlantic Ocean and adjacent seas

International Council for the Exploration of the Sea (ICES)
North-East Atlantic Fisheries Commission (NEAFC)
North Atlantic Salmon Conservation Organization (NASCO)
Northwest Atlantic Fisheries Organization (NAFO)
General Fisheries Council for the Mediterranean (GFCM)
Fishery Committee for the Eastern Central Atlantic (CECAF)
Western Central Atlantic Fishery Commission (WECAFC)
Regional Fisheries Advisory Commission for the Southwest Atlantic (CARPAS)
International Commission for the Conservation of Atlantic Tunas (ICCAT)
International Commission for the South East Atlantic Fisheries (ICSEAF)

Indian Ocean and Indo-Pacific area

Indian Ocean Fishery Commission (IOFC)
Indo-Pacific Fishery Commission (IPFC)

Pacific Ocean

North Pacific Marine Science Organization (PICES)
International North Pacific Fisheries Commission (INPFC)
Inter-American Tropical Tuna Commission (I-ATTC)
Council of the Eastern Pacific Tuna Fishing Agreement (CEPTFA)
Eastern Pacific Tuna Fishing Organization (OAPO)
South Pacific Permanent Commission (CPPS)
South Pacific Forum Fisheries Agency (FFA)
South Pacific Commission (SPC)

Other areas

Latin American Organization for the Development of Fisheries (OLDEPESCA)
Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
International Whaling Commission (IWC)

Inland

Committee for Inland Fisheries of Africa (CIFA)
Commission for Inland Fisheries of Latin America (COPESCAL)
European Inland Fisheries Advisory Commission (EIFAC)

Notes

1. When not otherwise specified, *fisheries* includes aquaculture and capture fisheries.

2. This is not to deny that other benefits were achieved by many of the multinational bodies, such as facilitating research on stock-assessment methods and stimulating exchange of information.

3. There is extensive literature on the consequences of open access in fisheries. See, for example, Gordon 1954; Scott 1955; Turvey and Wiseman 1957; Emmerson 1980; FAO 1983; and IPFC 1987.

4. Economic rent is a surplus return to a factor of production. Economic rent is a measure of the relative value of the natural resource. In agriculture, for example, it is reflected in the price that someone is willing to pay for the exclusive right to use the land. It serves as the means for efficiently allocating the factors of production (land, labor, and capital) so that the most effective combination of the three factors is achieved. In fisheries and in other natural resource industries in which exclusive rights are not available, the economic rent is dissipated, with the result that there is serious misallocation among the factors of production.

5. Recognition of the existence of such systems goes back many years to some of the classic works by anthopologists. See Malinowski 1918 and 1922 and Firth 1966.

6. The World Bank has undertaken a number of important studies, including Emmerson 1980; Wade 1985; Bromley and Cernea 1989; Magrath 1989; and World Bank 1989. The FAO has also been involved in community forest management and community fishery management.

7. The ADCP was conducted by the FAO from 1977 to 1989, and funded mainly by the UNDP.

8. The comparability of national price statistics raises other difficulties.

9. The Kyoto strategy is incorporated in the proceedings of the FAO Technical Conference on Aquaculture held in Kyoto, Japan, May 26 to June 2, 1976.

10. When genetic technologies that have the potential to change basic characteristics of species are applied without fully controlling their side-effects, ethical principles and concerns must be given due consideration.

11. Past experience shows that experts involved in the formulation of fishery development projects had little training in the basic concepts of stock-assessment and bioeconomic modeling. Consequently, the stock-assessment information was generally poorly utilized and little bioeconomic modeling of unit fisheries was done before the levels of investment were determined.

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